JOURNAL OF FOOD QUALITY & HAZARDS CONTROL
SHAHID SADOUGHI UNIVERSITY OF MEDICAL SCIENCES & HEALTH SERVICES

Journal of Food Quality and Hazards Control 7 (2020) 163-169

Causes, Patterns, and Economic Implications of Carcass Condemnation of Cattle Slaughtered at Oshana Region, North of Namibia Based on Post-Mortem Inspection

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HIGHLIGHTS

- Overall, 0.37% (120 out of 32 648) beef carcasses were condemned during the period of this study in Oshana, Namibia.
- The major causes of condemnation of carcasses were bruising (60 out of 120; 50%), followed by pus contamination.
- Bovine carcass condemnation rate in this region varied with the year, season, and age.

Article type
Original article

Keywords
Cattle
Abattoirs
Food Inspection
Animal Diseases
Public Health
Namibia

Article history
Received: 5 Mar 2020
Revised: 9 Aug 2020
Accepted: 18 Aug 2020

ABSTRACT

Background: Meat inspection is one of the essential tools for ensuring good quality and safe meat. The objective of this study was to evaluate carcass condemnation of cattle slaughtered in Oshana region, North of Namibia.

Methods: In this 4-year retrospective study, causes, patterns, and economic implications of carcass condemnation of cattle slaughtered in Oshana region, North of Namibia were evaluated based on post-mortem inspection procedure. The SPSS software version 25 was used for statistical analysis.

Results: Overall, 0.37% (120 out of 32 648) beef carcasses were condemned during the period of this study. The major causes of condemnation of carcasses were bruising (60 out of 120; 50%), followed by pus contamination. The condemnation rate in female cattle (65%) was significantly (p<0.05) higher than male cattle (35%). Overall, a significantly greater number (p<0.05) of carcasses were condemned in summer (74.2%) than in winter (25.8%).

Conclusion: This study identified bruising, pus contamination, and cachexia as the major causes of bovine carcass condemnation in North of Namibia and showed that carcass condemnation rate varied with the year, season, and age.

Introduction

Namibia has a largely agricultural economy that contributes about 3.9% to gross domestic product (Mbiri et al., 2020; MEATCO, 2019; Shiimi et al., 2012). Within the agricultural sector, livestock production plays a central role, accounting for over 76% (70% commercial and 6% communal) of the output (Kruger and Lammerts-Imbuwa, 2008; Togarepi et al., 2016). Cattle production is by far the most dominant activity in the livestock production sub-sector in Namibia (Kandiwa et al., 2017; Madzingira et al., 2018). Abattoirs located in Northern

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To cite: Mbiri P., Mushonga B., Madzinga C., Madzingira O., Samkange A., Hikufe E., Kandiwa E., Kamwi J.A. (2020). Causes, patterns, and economic implications of carcass condemnation of cattle slaughtered at Oshana region, North of Namibia based on post-mortem inspection. *Journal of Food Quality and Hazards Control*. 7: 163-169.

DOI: 10.18502/jfqhc.7.4.4843 Journal website: http://www.jfqhc.com

Communal Areas of Namibia supply the local formal and informal markets (Shiimi et al., 2012), although they previously exported beef under a commodity-based risk mitigation arrangement. Records of ante and post-mortem inspection of cattle provide useful epidemiological data for the evaluation of animal and zoonotic diseases in populations of origin and for environmental monitoring (Akkina and Estberg, 2019; Haredasht et al., 2018; Jaja et al., 2017a).

Previous studies from different continents and sub regions analyzed the prevalence, nature (total or partial), reasons, causes, patterns (annual, monthly and seasonal), and economic impact of carcass condemnation (Folitse et al., 2017; Shaibu et al., 2017). The prevalence rates for partial and total condemnation of carcasses in literature vary from 0% (Garcia et al., 2008) to over 50% (Huertas et al., 2015). The rate of condemnation varies by geographical location, age, and sex of animals (Dupuy et al., 2014; Vial et al., 2015), production system (pasture or range beef, feedlot, dairy; Akkina and Estberg, 2019), season (Haredasht et al., 2018), month of study (Mohammed et al., 2018; Noronha et al., 2019), level of animal healthcare, marketing, transport, and slaughter conditions (Ferreira et al., 2020; Garcia et al., 2008; Huertas et al., 2015; Vimiso and Muchenje, 2013).

Bovine carcass condemnation may be due to infectious or non-infectious causes (Garcia et al., 2008; Hoffman and Lühl, 2012; Junqueira Junior et al., 2020; Noronha et al., 2019). Some main infectious conditions include abscesses (Dupuy et al., 2014; Jaja et al., 2017b), pneumonia, mastitis, septicemia, and peritonitis (Akkina and Estberg, 2019; Webb et al., 2020); and specific conditions such as bovine tuberculosis (Junqueira Junior et al., 2020; Noronha et al., 2019; Shaibu et al., 2017), cysticercus cysts (Nzeyimana et al., 2015), lumpy skin disease, and parafilariasis (Tlhapi, 2013). Major non-infectious causes of condemnation include bruising (Cruz-Monterrosa et al., 2017; Ferreira et al., 2020), emaciation (Garcia et al., 2008; Moje et al., 2014), poor bleeding (Mummed and Webb, 2015), jaundice or icterus (Yibar et al., 2015), branding injuries (García et al., 2008; Hoffman and Lühl, 2012), neoplasia (Haredasht et al., 2018), and adhesions (Kelo and Alemu, 2018).

At present, there is little information on the causes, patterns, and economic implications of carcass condemnation at high throughput abattoirs sourcing cattle primarily from communally managed herds in Northern Communal Areas of Namibia. Therefore, the objective of this study was to evaluate the causes, patterns, and economic implications of carcass condemnation of cattle slaughtered in Oshana region, North of Namibia based on post-mortem inspection procedure.

Materials and methods

Study area

The study was carried out at an abattoir located in the Northern Communal Areas of Namibia, Oshana Region (17°47'1"S, 15°41'57.8"E). The Northern parts of the country comprise of communal farmers (Togarepi et al., 2016) that are separated from the south and central commercial farming areas by a veterinary cordon fence (Schneider, 2012). The study area is semi-arid with extremely variable and unreliable precipitation averaging 200 to 500 mm annually (Shikongo-Kuvare, 2007). Winter in Namibia begins in May and ends in October, while summer begins November and ends in April.

Animals

The studied animals were cattle reared by communal farmers of the Northern Communal Areas of Namibia and slaughtered at the study abattoir. Slaughter animals were transported to the abattoir by road on approved transport vehicles. Upon arrival, ante-mortem examination was carried out in holding pens prior to slaughter.

Study design and data collection

Routine ante-mortem inspection was carried out a day before slaughter by visual inspection for disease or lesions, and detaining sick animals for further investigation. Healthy animals were passed for slaughter. Slaughter and dressing was followed by post-mortem meat inspection involving visual examination, palpation and systematic incision of carcasses and visceral organs according to procedures described in the Red Meat Regulations of the Meat Safety Act (2000). Gross diagnosis was based on the pathological changes such as color, size, morphology, consistency, and presence of lesions or parasites. Meat inspection procedures were carried out and recorded by qualified veterinary hygiene inspector assistants under the overall supervision of the State Veterinarian from the Directorate of Veterinary Services, Ministry of Agriculture, Water and Land Reform. All carcasses condemned at post-mortem inspection were temporarily stored in the condemnation room, from where they were disposed of under veterinary supervision at the end of the day's slaughter. For the purposes of this study, the reasons for condemnation of carcasses were categorized into bruising, pus and miscellaneous (faecal contamination, digesta contamination, cachexia, icterus, cysticercosis or beef measles). Carcasses were graded into A, B, and C after meat inspection based on age (year).

In this 4-year retrospective study, carcass condemnation records from 2008 to 2011 were retrieved with per

mission of the abattoir operator and the Directorate of Veterinary Services and analyzed to identify the causes/reasons for condemnation, determine condemnation rates, and risk factors for condemnation.

Estimation of economic losses

Economic losses were estimated using records of the total number of carcasses condemned, individual carcass weight and grade and the average producer prices per kg for each carcass grade. The average price paid per kg (N$ 38/kg) and the average weight of a bovine carcass (220 kg) was estimated using data in the Meat Board Annual Report (Meat Board, 2019). A rate of US$ 1 to N$ 15.55 was used to convert the total financial losses to US dollars.

Statistical analysis

Pivot tables were used to categorize data. Chi square analysis was used to test for association of categories, including condemned carcasses, passed carcasses, year of study, season of study, sex of carcass, and grade of carcass and reason for condemnation. The Z score test was used for comparison of population proportions. The SPSS software version 25.0 was used whereby p values ≤0.05 were considered significant.

Results

As shown in Table 1, a total of 32 648 cattle were slaughtered at the abattoir over the study period (2008-2011). The overall condemnation rate of carcasses was 0.37% (n=120), representing an estimated loss of revenue of US$ 64 515.99. The outcome of post-mortem inspection was dependent on the year of study [$X^2(3)=23.82$; $p<0.05$], with the proportion of condemned carcasses in 2010 and that of passed carcasses in 2011 greater than the other studied years (0.15 and 34.73%, respectively; $p<0.05$).

More female than male carcasses were condemned (65 and 35%, respectively; n=120, $p<0.05$) and the proportion of condemned carcasses per sex category was significantly dependent on the year of study [$X^2(3, n=120)=8.95$; $p<0.05$] as illustrated in Table 2. The proportion of condemned carcasses in 2010 was greater than those in 2009 and 2011 (40.0, 10.0, and 20.0%, respectively; $p<0.05$), while the proportion of condemned carcasses in 2009 was lower than those in 2008 and 2011 (10.0, 30.0, and 20.0%, respectively; $p<0.05$).

Overall, condemnations due to bruising were significantly higher than those due to miscellaneous causes and pus (50, 33, and 16.7%, respectively; $p<0.05$). The proportion of carcasses condemned for bruising, miscellaneous reasons, and pus contamination was significantly dependent on the year of study [$X^2(6)=27.56$; $p<0.05$].

Overall, the proportion of condemned carcasses according to reason for condemnation was independent of the sex of carcass [$X^2(2)=4.58$, $p>0.05$] which is indicated in Table 3. Throughout the study period, more carcasses were condemned in summer than in winter (74.2 and 25.8%, respectively; $p<0.05$). The proportion of carcasses condemned due to pus in winter was significantly higher than summer (15.0%, $p<0.05$).

Condemnation of carcasses was dependent on the grade of carcass [$X^2(4)=13.28$, $p<0.05$]. Older carcasses (grade C) than younger carcasses (grade A and B) were condemned due to pus contamination (4.2, 4.2, and 25.0%, respectively; $p<0.05$), bruising and miscellaneous reasons (48.3 and 15.0%, respectively; $p<0.05$).

Out of the 20 miscellaneous causes of carcass condemnation, cachexia (13 cases) was the greatest reason for condemnation followed by icterus (3 cases), bovine cysticercosis (2 cases), faecal contamination (1 cases), and digesta contamination (1 case).

Table 1: Carcass condemnation of cattle slaughtered at Oshana region, North of Namibia during 2008 to 2011

Year	Outcome of post-mortem inspection		
	Passed carcasses (%)	Condemned carcasses (%)	Total (%)
2008	8 957 (27.44)	36 (0.11)	8 993 (27.55)
2009	4 671 (14.31)	12 (0.04)	4 683 (14.34)
2010	7 562 (23.16)	48 (0.15)*	7 610 (23.31)
2011	11 338 (34.73)*	24 (0.07)	11 362 (34.80)
Total	32 528 (99.63)	120 (0.37)	32 648 (100.00)

*Values were greater than expected since $p<0.05$.

Table 2: Number (%) of carcass condemnations of cattle slaughtered at Oshana region, North of Namibia according to sex, grade of carcass, and reason for condemnation

Category	Year				
	2008	2009	2010	2011	Total (%)
Sex					
Female	25 (20.8)	4 (3.3)	36 (30.0)	13 (10.8)	78 (65.0)
Male	11 (9.2)	8 (6.7)	12 (10.0)	11 (9.2)	42 (35.0)
Grade of carcass					
A	1 (0.8)	0 (0.0)	0 (0.0)	6 (5.0) *	7 (5.8) [a]
B	1 (0.8)	2 (1.7)	0 (0.0)	4 (3.3)	7 (5.8) [a]
C	34 (28.3)	10 (8.3)	48 (40.0) *	14 (11.7)	106 (88.3)
Reason for condemnation					
Bruising	26 (21.7)*	7 (5.8)	22 (18.3) *	5 (4.2)	60 (50.0)
Pus contamination	7 (5.8)	5 (4.2)	12 (10.0) *	16 (13.3) *	40 (33.3)
Miscellaneous	3 (2.5)	0 (0.0)	14 (11.7) *	3 (2.5)	20 (16.7)
Total	36 (30.0) [ab]	12 (10.0)	48 (40.0) [a]	24 (20.0) [b]	120 (100.0)

*Value were greater than expected since $p<0.05$.
Values within the same row or column with different letters were significantly different since $p<0.05$.

Table 3: Number (%) of condemned carcasses of cattle slaughtered at Oshana region, North of Namibia based on sex, season, and carcass grade

Category	Reason for condemnation			
	Bruising	Miscellaneous	Pus	Total
Sex				
Female	44 (36.7)	13 (10.8)	21 (17.5)	78 (65.0)
Male	16 (13.3)	7 (5.8)	19 (15.8)	42 (35.0)
Season				
Winter	10 (8.3)	3 (2.5)	18 (15.0)*	31 (25.8)
Summer	50 (41.7)	17 (14.2)	22 (18.3)	89 (74.2)
Grade				
A	0 (0.0)	2 (1.7)	5 (4.2)*	7 (5.8)[a]
B	2 (1.7)	0 (0.0)	5 (4.2)*	7 (5.8)[a]
C	58 (48.3)*	18 (15.0)*	30 (25.0)*	106 (88.3)
Total	60 (50.0)	20 (16.7)	40 (33.3)	120 (100.0)

*Value were greater than expected since $p<0.05$.
Values within the same row or column with different letters were significantly different since $p<0.05$.

Discussion

A low overall carcass condemnation rate of 0.37% determined in this study is in agreement with rates of 0.1 to 1% reported by several studies in Southern Africa (Phiri, 2006; Tembo and Nonga, 2015; Tlhapi, 2013), East Africa (Moje et al., 2014), the Middle East (Yibar et al., 2015), South America (Junqueira Junior et al., 2020), and North America (Akkina and Estberg, 2019; Haredasht et al., 2018). The prevalence of carcass condemnation reported herein is, however, several times higher than those reported by researchers in Ghana (Mohammed et al., 2018) and much lower than the prevalence of 1-17% from Chile (Strappini et al., 2010), Ethiopia (Kelo and Alemu, 2018), and South Africa (Webb et al., 2020). An earlier study conducted at another high throughput abattoir in Namibia reported a lower condemnation rate of 0.2% than in the current study (Madzingira et al., 2018), despite receiving higher rainfall levels than in our study area and sourcing cattle for slaughter from domestic-wild animal interface areas. Other factors such as experimental design, length of study, geographical location, months, seasons and even years of study may have contributed to the observed differences in carcass condemnation rates (Folitse et al., 2017; Mummed and Webb, 2015; Noronha et al., 2019).

Overall, generalized bruising was the major cause of carcass condemnations (50%) in this research. This rate of condemnation was higher than what reported in Chile (Strappini et al., 2010) and Ghana (Folitse et al., 2017),

but lower than the rate reported in Uruguay and the USA (Huertas et al., 2015). High levels of condemnation due to bruises possibly arose from injuries during long distance transportation on rough gravel roads that are prevalent in the rural areas. Personal communication with procurement personnel at the abattoir revealed that farmers often overloaded transport vehicles to reduce transport costs and also mixed unfamiliar animals, which almost always results in fights for dominance during transportation. Overloading of cattle has been reported as a cause of bruising in Namibia (Hoffman and Luhl, 2012). Mixing of animals was also reported to occur in the lairages at the abattoir. However, poor management at the farm, injuries sustained during loading, transportation or offloading cannot be ruled out and thus require further investigation to alleviate the pain and suffering inflicted upon the animals. Most farmers send unwanted, old, and emaciated cattle to the abattoir for slaughter (Shiimi et al., 2012). Such cattle tend to be weak and lie down on the truck due to fatigue from long distance transportation (and are trampled and injured causing bruises that become apparent at slaughter (Huertas et al., 2015; Strappini et al., 2010). According to a number of studies, the process of loading, distance of transportation, conditions during transportation (such as loading density and lying down during the trip) have a serious impact on bruising and the welfare of animals (Ferreira et al., 2020; Hoffman and Lühl, 2012). Bruising is an important indicator of poor animal welfare (Huertas et al., 2015). Stress associated with poor animal welfare during transportation leads to glycogen depletion and results in a high pH (Strappini et al., 2010; Vimiso and Muchenje, 2013) which may cause the meat to be Dark, Firm and Dry (DFD), thus affecting the keeping quality of the meat (Cruz-Monterrosa et al., 2017). In addition, the trimming of bruised meat leads to reduced carcass yield (Huertas et al., 2015) and loss of income for the farmer. There is, therefore, a need for intervention, either by the abattoir or the supplying farmers, to minimize the occurrence of bruising.

Condemnations due to miscellaneous causes, which included faecal contamination, ingesta contamination, icterus, measles and cachexia together, had a relatively high contribution to condemnations. Among these conditions, cachexia accounted for the highest rate (13 out of 20 cases) of carcasses condemned at meat inspection during this survey.

Furthermore, it should be noted that cachectic domestic animals may be old animals, as it was established by previous reports that communal farmers in these regions tend to slaughter old animals. The carcass condemnation of more grade C carcasses than grade A and B carcasses is expected in this setting. In Namibia, cattle are generally in their worst body condition from September to the beginning of the rainy season in late December or early January and often this is the time that farmers cull some animals to avoid losses due to starvation. The occurrence of high levels of condemnation due to emaciation and bruising in summer is thus not a coincidence (Garcia et al., 2008; Moje et al., 2014).

Despite being the third highest cause of condemnation within the miscellaneous category at 10%, *Cysticercus bovis* is a zoonotic parasite of public health importance (Nzeyimana et al., 2015). However, the rate of bovine cysticercosis reported in this study was lower than the 1.2-2.8% reported in Zimbabwe (Sungirai et al., 2014) and much lower than that reported in studies from neighboring Zambia (20.1%; Phiri, 2006) and Botswana (12-15%; Mosienyane, 1986). Our finding is comparable to the findings of Dzoma et al. (2011) in the North-West Province of South Africa. In Namibia, a previous study documented a lower condemnation rate (8%) of beef carcasses due to cysticercosis (Shikongo-Kuvare, 2007). Prevention and control measures including awareness campaigns on cysticercosis, and treatment of infected individuals are recommended to reduce meat condemnations and prevent human infection with *Taenia saginata*.

The direct financial losses (US$ 64 515.99) due to the condemnation of beef carcasses recorded in our study were higher than those reported by Madzingira et al. (2018) in a study carried out in another region of Namibia. Higher financial losses have been reported by studies in Nigeria (Cadmus and Adesokan, 2009) and Zambia (Tembo and Nonga, 2015). It is generally difficult to make comparisons of revenue losses between studies due to differences in study designs, abattoir throughput, beef carcass prices, animal production practices, and disease prevalence (Assefa and Tesfay, 2013). However, revenue losses of any magnitude have a negative effect on farmer and abattoir income earnings.

Conclusion

This study identified bruising, pus contamination, and cachexia as the major causes of bovine carcass condemnation in North of Namibia. We showed that carcass condemnation rate varied with the year, season, and age.

Author contributions

P.M., B.M., and C.M. designed the study; E.H. and J.A.K. collected the data for the study; E.K. analyzed the data; B.M., P.M., C.M., O.M., and A.S. drafted and finalized the manuscript. All authors read and approved the final manuscript.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

The authors would like to thank the abattoir manager and the Ministry of Agriculture, Water and Land Reform, Namibia for providing the data that was used in this study. Special thanks are also given to the University of Namibia for funding the publication of this manuscript.

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