Shiga toxin-producing *Escherichia coli* in beef

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Prevalence and risk factors of Shiga toxin-producing Escherichia coli serotypes in beef at abattoirs and retail outlets in Gauteng

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EXECUTIVE SUMMARY

Shiga toxin-producing *Escherichia coli* (STEC), particularly the O157 strains, are food-borne zoonotic pathogens of public health importance worldwide. Foods of cattle origin have been implicated in various outbreaks and epidemiological studies have revealed that cattle are major reservoirs of STEC. We conducted cross-sectional surveys from Nov 2015 to Nov 2016, to investigate the prevalence and molecular characteristics of O157 and non-O157 strains of STEC in beef and beef products in the Gauteng province of South Africa.

A total of 265 swab samples of beef carcasses from 12 abattoirs and 399 beef products from 31 retail outlets were screened for STEC using a multiplex PCR. The overall prevalence in abattoir samples was 37% (55/149) in summer and 34% (39/116) in winter. In beef products at retail outlets, it was 20% (27/137) in autumn, 14% (18/130) in winter and 17% (22/132) in summer; the highest prevalence was detected in boerewors (35%) followed by mincemeat (21%). The predominant serotypes detected were O113 (19.4%) and O157 (14.9%) in beef products, and O113 (14%) from abattoirs.

Our results demonstrate that STEC is present in South African beef and beef products, and that this may pose a real food-borne disease threat. Further investigation of the epidemiology of the pathogen is required; it is proposed that this takes the form of longitudinal studies to investigate the prevalence of shedding of STEC by cattle in the feedlot, following them through to the abattoir to determine factors associated with carcass contamination.

Project Aims

To determine the prevalence O157 and non-O157 Shiga-toxin producing *Escherichia coli* (STEC) in beef abattoirs in Gauteng

To determine the prevalence O157 and non-O157 STEC in beef and beef products at retail outlets in Gauteng

To identify the important STEC serotypes present in beef and beef products in Gauteng

To identify risk factors for STEC contamination of carcasses and beef products in Gauteng

Popular Article

Title for Popular Article

ASSESSING THE PREVALENCE OF SHIGA TOXIN-PRODUCING *ESCHERICHIA COLI* IN BEEF AT ABATTOIRS AND RETAIL OUTLETS IN GAUTENG

Introduction

The production of safe and wholesome beef and beef-derived food products is the highest priority for the beef industry in South Africa. There are potential risks associated with the possible presence of harmful pathogens in the food production chain; however, clear guidelines and regulations have been implemented to reduce these risks to a minimum and ensure a safe product for consumers. Nevertheless, it remains important to continually assess these risks and to ensure effective implementation of control measures.

Shiga toxin-producing *Escherichia coli* (STEC) are bacteria associated with food and waterborne diseases and have been recognized as causing public health problems worldwide. The WHO Foodborne Disease Burden Epidemiology Reference Group (FERG) reported that 'Foodborne STEC' caused more than 1 million illnesses and 128 deaths in 2010 (8).

Of the over 470 different serotypes of STEC detected in humans, the O157:H7 serotype is the most frequently associated with large food and water-borne outbreaks (7). However, non-O157 STEC have been increasingly isolated from cases of haemorrhagic colitis (severe GIT infection and bloody diarrhoea) and as well as some fatal kidney failure (HUS; haemolytic uraemic syndrome) cases.

Although the first report of the occurrence of HUS in South Africa dated as far back as 1968 (6), the causative agent was poorly understood at that time. The first clinically proven incidence of *E. coli* O157:H7 in South Africa was later linked with haemorrhagic colitis (3). The importance of the pathogen in South Africa and other southern African countries has, however, been highlighted by subsequent major outbreaks of bloody diarrhoea in which *E. coli* O157 strains were implicated (4). Of particular interest was a study in Gauteng province in 2011, in which 7.7% of children with diarrhoea were positive for *E. coli* O157 (5).

Epidemiological investigations have revealed that cattle are a major reservoir of STEC. Many outbreaks of *E. coli* O157:H7 have been associated with beef, in particular ground beef, and analyses of some cases have identified undercooked beef as a significant risk factor. However, the fact that *E. coli*-associated conditions in humans, such as HUS, are not as yet notifiable in South Africa may mean that the occurrence of STEC-associated disease in humans is under-reported. In addition, given the weight of evidence from elsewhere in the world, it is possible that contamination of beef products is also a risk factor in South Africa.

Research problem and objectives

There is a dearth of current information on the frequency of occurrence of O157 and non-O157 strains of STEC, and on the risk they pose to consumers of beef products, in South Africa. Hence, the objective of this study was to determine the prevalence and characteristics of O157 and non-O157 STEC strains in beef carcass and beef products sold at retail outlets in the Gauteng province of South Africa.

Materials and Methods

During a one-year period from Nov 2015 to Nov 2016, two independent cross-sectional surveys were carried out to determine the prevalence of STEC at abattoirs as well as at retail outlets where beef-based food products are sold.

Study 1: Twelve abattoirs (six high throughput and six low throughput) were selected and each was visited during summer and winter months for sample collection. Five animals were randomly selected in each abattoir and tagged for sample collection. Firstly, samples were collected by swabbing the skin of the perineal area immediately after slaughter. Thereafter, carcass swab samples were collected from different parts of the carcass at various stages during processing, including pre-evisceration, post-evisceration, post-washing and 24 hours post-chilling.

Beef carcass sampling and processing at the abattoir

Study 2: A total of 31 retail outlets including both large supermarket chains and smaller butcheries were randomly selected. Visits were made to each of these outlets during autumn, winter and summer months of 2016 for sample collection. Sampling of five types of popular beef products (brisket, boerewors, mince, cold meat, and biltong) was done at each outlet during each visit.

Each sample was analyzed for the presence of Shiga toxin-encoding genes (stx1 and stx2) using conventional multiplex PCR. All samples positive for stx genes based on PCR were screened for the following O-serotypes: O26, O91, O103, O111, O113, O145 and O157 using a multiplex PCR assay.

Results and Discussion

Overall, the prevalence of STEC in beef carcass swabs collected from 12 red meat abattoirs across Gauteng province during summer and winter months was 35.5% (94/265). The highest prevalence (50%) was detected in perineal samples, which is hardly a surprise because cattle are an established reservoir of STEC; this may therefore reflect the prevalence of the pathogen in cattle arriving at abattoirs. Transportation stress is known to increase the shedding of enteric pathogens and could therefore be a contributing factor to the observed high prevalence in perineal samples. STEC was found in 39% of both pre-evisceration and post-evisceration carcasses, while washed carcasses and 24-hour chilled carcasses had a lower prevalence of 23% and 20% respectively. Therefore, although washing of carcasses at the abattoir removed much of the STEC contamination, the fact that the bacteria were still present on the surface of some chilled carcasses is of potential food safety significance, since cuts from these carcasses end up for sale in various forms at retail outlets.

Boerewors on display in a retail outlet

Of the 399 beef products sampled from 31 retail outlets, 67 (16.8%) were contaminated by STEC strains, an observation that is of food safety significance if such products were to be improperly cooked and consumed by highly susceptible individuals.

The highest prevalence of STEC was detected in boerewors (35%), followed by minced meat (21%). Ground beef ordinarily includes meat from many carcasses; consequently a few infected livestock could potentially contaminate a great quantity of ground beef. Biltong had the lowest prevalence of contamination (5%), while brisket and cold meat had 11% and 6% respectively. These results are in contrast to a previous study in South Africa, in 2009, involving biltong, cold meat and minced meat at retail outlets, which found that 2.8% of the samples were positive for *E. coli* O157 (1).

The prevalence of STEC in abattoir and retail outlet samples was somewhat higher during the summer months compared to the winter months. While many factors are believed to affect the prevalence of *E. coli* O157:H7, only season has been consistently shown to impact the shedding of this bacterium by cattle (2), and some previous studies have also observed a higher prevalence of shedding during the warmer months than the winter months.

The serotype analysis showed that O113 was the post prevalent serotype both on beef carcasses (14%) as well as in beef-based products (19%). This observation is of particular interest considering that O113 is an emerging serotype associated with human illness and sometimes with HUS in several countries including Spain, Belgium and Australia. Serotype O113 of STEC may therefore potentially be important in human diseases in South Africa and this requires further studies. Some of the other serotypes detected have also previously been implicated in human diseases elsewhere in the world.

Unlike in abattoir samples where the prevalence of serotype O157 was very low (1%), a higher prevalence of 15% was detected in retail meat samples. This finding may be explained in part by the fact that the current study was cross-sectional by design (giving a “snapshot” at a particular point in time) and not a longitudinal study. Therefore, serotype O157-contaminated beef products may have originated from abattoirs not sampled in the current study, and the prevalence may vary greatly between places and over time. There is also a possibility that it may partially also be a result of contamination from other sources at the retail outlet level.

Mince meat on display in a retail outlet

Conclusion

This study has shown that contamination of beef products with potentially harmful bacteria can occur during different processing stages. The low numbers of reported cases of food-associated disease in South Africa suggest that the risk to consumers is low; however, it is not known whether all cases are reported, or that all cases are correctly diagnosed. Therefore, further research is needed in order better understand the dynamics of foodborne pathogens in South Africa, to accurately assess the risk they pose, and to accurately inform control measures.

It is well known that efficient implementation of control measures during slaughter and processing procedures can greatly reduce meat surface microbial contamination and ensure the safety of the final product. The South African Meat Safety Act (2000) has addressed potential risk factors by adopting several internationally recognized preventive measures such as the Hazard Analysis Critical Control Point (HACCP) system and Good Manufacturing Practices (GMP) in order to promote safe meat for consumers. The application of GMP and HACCP principles during handling and processing of products, as well as the proper cooking of meat products before consumption, will effectively reduce the threat of food borne disease.

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References

1. Abong'o, B.O. and Momba, M.N., 2009. Prevalence and characterization of *Escherichia coli* O157: H7 isolates from meat and meat products sold in Amathole District, Eastern Cape Province of South Africa. Food Microbiology, 26(2), pp.173-176.

2. Berry, E.D. and Wells, J.E., 2010. *Escherichia coli* O157: H7: recent advances in research on occurrence, transmission, and control in cattle and the production environment. Advances in Food and Nutrition Research, 60, pp.67-117.

3. Browning, N.G., Botha, J.R., Sacho, H. and Moore, P.J., 1990. *Escherichia coli* O157: H7 haemorrhagic colitis. Report of the first South African case. South African Journal of Surgery, 28(1), pp.28-29.

4. Effler, E., Isaäcson, M., Arntzen, L., Heenan, R., Canter, P., Barrett, T., Lee, L., Mambo, C., Levine, W., Zaidi, A. and Griffin, P.M., 2001. Factors contributing to the emergence of *Escherichia coli* O157 in Africa. Emerging Infectious Diseases, 7(5), p.812.

5. Galane, P.M. and Le Roux, M., 2001. Molecular epidemiology of *Escherichia coli* isolated from young South African children with diarrhoeal diseases. Journal of Health, Population and Nutrition, 19(1), pp.31-38.

6. Kiibel, P.J., 1968. The haemolytic-uraemia syndrome: a survey in Southern Africa. South African Medical Journal, 42(27), pp.692-698.

7. Mora, A., Herrera, A., López, C., Dahbi, G., Mamani, R., Pita, J.M., Alonso, M.P., Llovo, J., Bernárdez, M.I., Blanco, J.E. and Blanco, M., 2011. Characteristics of the Shiga-toxin-producing enteroaggregative *Escherichia coli* O104: H4 German outbreak strain and of STEC strains isolated in Spain. International Microbiology, 14(3), pp.121-141.

8. WHO [World Health Organization], 2015. WHO estimates of the global burden of foodborne diseases. Available at http://apps.who.int/iris/bitstream/10665/199350/1/9789241565165_eng.pdf.

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