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Effect of food safety systems on the microbiological quality of beef

by

Papiso Ariette Tshabalala

Thesis submitted in partial fulfilment of the requirements for the degree

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Declaration of independent work

I, PAPISO ARIETTE TSHABALALA declare that the thesis herewith submitted for the degree of PhD (Food Science) at the University of Pretoria, is my own independent work and has not been previously submitted by me for a degree at any other institution of higher education.

Papiso Ariette Tshabalala

Signature of student Date

Dedication

My husband, mother, children, siblings, nephews, nieces, and friends: you showed me everlasting love and supported me throughout, mostly by putting me under tremendous pressure. For all of you, the younger generation, a life strategy and formula: always strive to see the end to everything that you start. For the older generation: everything is possible.

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Above all, I have grown in faith and know that the strength, the perseverance and the blessing of all the wonderful people in my life are a gift from God the Almighty.

Abstract

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Papiso Ariette Tshabalala

Supervisor: Professor Elna M. Buys
Co-supervisor: Doctor Henriette L. de Kock
Degree: PhD Food Science

Contamination of meat with microorganisms during slaughter is inevitable. Hygiene management systems (HMSs) such as the Hygiene Assessment System (HAS) and Hazard Analysis Critical Control Point (HACCP) are used to prevent the contamination of beef with both spoilage and pathogenic microorganisms during slaughter. This study compared the effect of the HAS alone and a combination of HAS + HACCP on the microbiological quality of beef and investigated the survival of *Escherichia coli* O157:H7 co-cultured with different levels of *Pseudomonas fluorescens* and *Lactobacillus plantarum* on fresh beef.

HAS alone and HAS combined with HACCP systems were each represented by two abattoirs. Sponge swab samples were collected from chilled beef carcasses for indicator organisms: Aerobic Plate Counts (APC), Enterobacteriaceae, *Pseudomonas* spp., and lactic acid bacteria. Swabs were also collected for pathogenic bacteria: *E. coli* O157:H7, *Staphylococcus aureus* and *Salmonella* spp. There was no significant difference between the microbiological quality of beef carcasses processed in the abattoirs with the HAS and that of beef carcasses processed in abattoirs with combined HAS + HACCP. *E. coli* O157:H7 was isolated from carcasses processed in an abattoir with the combined HAS + HACCP system. Moreover, although overall *S. aureus* counts at all abattoirs were comparable, a higher incidence (47% of carcasses) was obtained from an abattoir with combined HAS + HACCP. *Salmonella* spp. was not detected during the study. The microbiological quality of beef at HAS abattoirs is not significantly different to that of beef processed at HAS + HACCP abattoirs. The combined HAS + HACCP did not prevent contamination of beef carcasses with *E.*

coli O157:H7 and *S. aureus*. Effective implementation of HAS can reduce contamination of beef with spoilage and pathogenic microorganisms.

The effect of different levels of *P. fluorescens* (10^2 and 10^6 $\log_{10}$ cfu/ml) and *L. plantarum (*10^2 and 10^4 $\log_{10}$ cfu/ml) on the survival of *E. coli* O157:H7 on beef loins was investigated. Sterile beef loins inoculated with *E. coli* O157:H7 and *P. fluorescens* were aerobically stored for 7 days at 4 °C, while those inoculated with *E. coli* O157:H7 and *L. plantarum* were vacuum-packaged and stored for 8 weeks at 4 °C. APC, *E. coli* O157:H7 and either *P. fluorescens* or *L. plantarum* counts were determined at different storage intervals. For the aerobically packaged beef loins, *E. coli* O157:H7 was detected throughout the 7-day storage period regardless of the *P. fluorescens* level in the inoculum. For the vacuum packaged beef loins, similar inoculum levels of *E. coli* O157:H7 and *L. plantarum* allowed *E. coli* O157:H7 to survive until week 5 of storage, while a higher inoculum level of *L. plantarum* inhibited *E. coli* O157:H7 from week 3. Once fresh beef has been contaminated with *E. coli* O157:H7 the level of *P. fluorescens* in the background flora does not inhibit its survival and growth. However, under vacuum storage, the application of *L. plantarum* as a biopreservative inhibits the survival of *E. coli* O157:H7 on beef. Comprehensive strengthening of preventive strategies is required to eliminate contamination of beef carcasses with *E. coli* O157:H7.

Bacterial contamination of carcasses during slaughter is inevitable. Effective implementation of HAS at abattoirs produces beef carcasses of microbiological quality comparable to that produced through the use of combined HAS and HACCP. While the level of *P. fluorescens* on beef does not inhibit the survival of *E. coli* O157:H7 on aerobically stored beef, the combination of *L. plantarum*, and low storage temperature inhibits the survival of this pathogen on beef under vacuum storage.

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List of abbreviations

AHRS	Abattoir Hygiene Rating Scheme
ANOVA	Analysis of variance
APC	Aerobic Plate Count
CE	Competitive Exclusion
CCP	Critical Control Point
CFS	Cell free supernatants
CPS	Coagulase-positive staphylococcus
DWAF	Department of Water Affairs
DoA	Department of Agriculture
E. coli	*Escherichia coli*
EHEC	Enterohaemorrhagic *E. coli*
EIEC	Entero-invasive *E. coli*
DAEC	Diffuse adhering *E. coli*
DNA	Deoxyrobinucleic acid
EAEC	Entero-aggregative *E. coli*
EFSA	European Food Safety Authority
EPEC	Enteropathogenic *E. coli*
FITA	Federation of International Trade Associations
GPDoA:VPH	Gauteng Provincial Department of Agriculture: Veterinary Public Health
HACCP	Hazard Analysis and Critical Control Point
HAS	Hygiene Assessment System
HMS	Hygiene Management System
LPS	Lipopolysaccharides
OM	Outer Membrane
RMAA	Red Meat Abattoir Association
RNA	Ribonucleic acid
SAMIC	South Africa Meat Industries Company
TCC	Total coliform count
VPH	Veterinary Public Health
VTEC	Verotoxin-producing *E. coli*
VFA	Volatile Fatty Acids