MICROBIAL CONTAMINATION AT DIFFERENT STAGES OF THE MEAT DISTRIBUTION CHAIN IN EASTERN CAPE PROVINCE, SOUTH AFRICA

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Abstract – The study was carried out to assess microbial contamination of meat at three stages of the distribution chain in the Eastern Cape Province of South Africa. A total of 108 swab samples (12 at each stage) from beef, pork and mutton carcasses were collected in a commercial abattoir during the loading of carcasses in trucks, when off-loading at the supply points and during marketing. All the samples were subjected to total bacterial count, coliform counts, *E. coli* count and *Staphylococcus aureus* detection. Results showed significant microbial contamination of carcasses with all bacterial groups except for S. aureus in all the stages. However, *E. coli* was the predominant microbial contaminant in the samples examined. The levels of *E. coli* contamination increased progressively between the loading and the off-loading points (2.7 to 3.7 log10CFU/cm2).Compared to the European Microbiological standards for meat, levels of contamination by total bacteria and Coliform count at all stages were found to be out of the acceptable range. Meat from middle class shops had higher levels of contamination for all tested bacteria. It was therefore concluded that microbial contaminats in raw meat exceeded the acceptable limits and this increases the rate of meat spoilage and the risk of foodborne illness.

Key words: Microbiological quality, distribution chain, meat safety

I. INTRODUCTION

Despite the controls that have been put in place, food-borne infection continues to be an immense problem with millions of cases occurring annually throughout the world [1]. In addition to the misery caused, financial loss associated with food-borne illnesses is enormous. Avoidance or detection of food-borne pathogens before contaminated foods can be consumed is therefore an essential feature of safeguarding public health. Therefore players in the meat supply chain should continue finding ways of delivering meat of high eating quality and meat that is safer. In South Africa, abattoirs which deliver meat to retailers for the consumers to purchase are governed by the Meat Safety Act of 2000 [2]. Meat processors at the abattoirs have adopted a range of protocols and adhere to regulations to ensure that meat produced is of high quality and is safe for consumption, and that chances of microbial contamination are minimised. However, it is important to note that when meat is being distributed from the abattoir to the supply points, it is out of the direct control of the abattoir of origin. Meat inspection is typically only carried out at the abattoir, yet the distribution stage is the most critical stage during which the quality of meat could easily be compromised. This could possibly allow foodborne pathogens to enter the distribution chain, resulting in consumers purchasing meat which has been exposed to spoilage micro-organisms. Sofos [3] identifies contamination from pathogenic microorganisms as the most serious meat safety issue as it causes immediate consumer health problems. According to Scallan [4] foodborne illnesses cause about 3,000 deaths in the United States and the cost of foodborne disease is estimated to exceed $5 billion per year. However in South Africa, food-borne disease in humans is common, but is generally under-reported and poorly investigated [5].It is generally agreed that determination of microbial counts and coliform counts is essential for monitoring hygiene status of the abattoirs and verifying the microbiological status of meat. Today, the main cause of foodborne disease is microbiological and microbiological analysis plays a central role as part of quality control in the food sector. In South Africa, meat inspection audit at the abattoir only covers the visual inspection, there are no microbiological tests which are done. Microbiological threats such as the bacteria

Staphylococcus aureus and *E.coli* cannot be adequately tackled by a naked eye [6].Moreover, if there are pathogenic micro-organisms that are introduced in meat at the abattoir, chances are during transportation and marketing they can continue to multiply as different microbes at each stage get introduced and these tend to contaminate the meat. Therefore improvement of meat safety which that will incorporate microbiological assessment in meat at the abattoir after slaughter and in shops is encouraged. Hence the main objective of this research was to determine microbial contamination of meat at different stages of the distribution chain in the Eastern Cape Province of South Africa.

II. MATERIALS AND METHODS

Study site and sampling procedure

The study was conducted in a commercial abattoir and four retail outlets in the Eastern Cape Province. A total of 108 swab samples were collected from beef, pork and mutton carcasses at three stages: loading, offloading and display (n=12 in each stage).. Sampling was carried out by swabbing the muscular surface of each carcass. Carcasses were randomly selected at the abattoir before loading the trucks for delivery to the retail shops. An area of 16 cm2 marked with a sterile frame of 4 cm × 4 cm on each site of the carcass was rubbed for 30 seconds and swabs were transferred to a screw-capped test tube containing 10 ml of sterile maintenance medium (0.85% NaCl and 0.1%peptone) [7]. All carcasses were loaded in the same truck and followed to the supply points. Bar codes were used to trace carcasses for identification purposes. Swab samples were then collected from the same carcasses during offloading at the supply points. Appointments were made with the butcher managers for purchasing of meat samples from the same carcasses at the display outlets where an area of 6.5 cm2 with a sterile frame of 2.5cm× 2.5cm was used for sampling.Test tubes were transported to the University of Free State in an ice box at 4˚C to prevent microbial growth during sample transportation.

Microbial counts

Samples were analysed immediately upon arrival in the laboratory. The samples were cultivated on standard plate count agar for total bacteria plate counts and chromocult coliform agar for coliform and E. coli counts without enrichment. *E. coli* were isolated after enrichment in MacConkey broth followed by cultivation on chromocult coliform agar. Baird Parker agar, a selective medium for the isolation and counting of coagulase positive staphylococci was used for the enumeration of *Staphylococcus aureus*.

Statistical analysis

Statistical analyses were carried out using SAS software [8] to determine the effect of meat distribution stage on microbial count. One-way analysis of variance (ANOVA) was applied to the $\log_2$ transformed total bacteria count, coliform count, *Escherichia coli*. Fisher's Least square difference test was used to compare the means when a significant variation was established by ANOVA at the significance level 0.05 ($P < 0.05$).

III. RESULTS AND DISCUSSION

Microbial counts as affected by meat type, distribution stage and shop class

Meat is regarded as an excellent source of protein in human diet but at the same time is highly susceptible to microbial contaminations, which can cause its spoilage and food borne infections in human[9].The meat, available at retail outlets comes through a long chain of slaughtering, and transportation, where each step may pose a risk of microbial contamination. In the present study, microbial contamination of beef, pork and mutton was monitored at different stages of the distribution chain.This study was conducted mainly to assess and compare microbial contamination of carcasses from the loading stage at the abattoir to the display point at the shops when ready to be purchased by the consumers. Targeted microbial contaminants were *E. coli* and *Staphylococcus aureus*. The study showed that *S. aureus* was not detected at all the considered stages whilst *E. coli* which is known as a human pathogen and an emerging public concern in most countries was the predominant microbial contaminant in the samples examined. The results of microbial analysis per meat type, stage and shop class are presented in Table 1. Significant differences among beef, pork and mutton on Total Bacteria Count (TBC), Coliform count (CC) and

Presumptive *E. coli* were observed. Beef had the highest levels of microbial contamination for all tested bacteria**,** followed by mutton and pork had the lowest levels.

Table 1: Least square means and (± SE) of beef, pork and mutton carcass contamination at different stages of the distribution chain

Description	Total Bacteria	Coliform count	Presumptive *E. coli*
Meat Type			
Beef	7.6^{c}±0.22	6.3^{c}±0.19^{c}	4.1^{b} ±0.35
Pork	6.3^{a} ±0.21	4.1^{a} ±0.19	2.1^{a} ± 0.34
Mutton	6.5^{b} ±0.22	4.3^{b} ±0.19	2.1^{a} ± 0.35
Stage			
Abattoir	7.1^{b} ±0.20	4.8^{a} ±0.18	2.7^{a} ± 0.32
Display	6.5^{a} ±0.20	5.1^{a} ±0.18	1.9^{a} ± 0.32
Offloading	6.9^{b} ±0.20	4.9^{a} ±0.18	3.7^{b} ± 0.32
Class			
Top	6.5^{a} ±0.16	4.3^{a} ±0.14	2.3^{a} ± 0.25
Middle	7.2^{b} ±0.22	5.5^{b} ±0.19	3.2^{b} ± 0.25

^{abc} Means in the same column for meat type, stage and shop class with different superscripts are significantly different ($p < 0.05$).

Similar results were reported by Bradeeba *et al.* [10] where beef showed high general viable counts than mutton and pork. The levels of TBC among beef, pork and mutton ranged between 7.6, 6.3 and 6.5 log10 CFU/cm2 respectively, and coliform counts were between 6.3, 4.1 and 4.3 log10 CFU/cm2 respectively. According to CE [11] compared to the European Microbiological standards for meat, these values were considered to be out of the acceptable range. The European Union recommends that the levels of contamination by total bacteria and total coliforms not to exceed 5.0 and 2.5 log CFU/g respectively. The observed levels of carcass contamination for TBC, and CC from abattoir to display also fell out of the acceptable range. Significant increase in levels of contamination for *E. coli* between loading and the offloading points was observed (2.7 to 3.7 log10 CFU/cm2). This could be associated with handling from the meat handlers who are responsible for loading and offloading carcasses and contact between the carcass and meat handler's protective clothing. It could also be associated with temperature fluctuations during transportation as doors when off-loading would be open for quite some time in each supply point resulting in temperatures inside the trucks to decrease. Top class and middle class shops had shown significant differences ($p>0.05$) for microbial contamination. Middle class shops were observed with highest levels of carcass contamination for TBC, CC and *E.coli* compared to the high class shops. This can be associated with handling of carcasses at the shops by the meat marketers and lack of hygiene. Also most butcher managers from the middle class shops had shown to have less knowledge on the proper storage temperatures that they are suppose to use. In a study by Rani *et al.*[12] consumers confirmed that meat quality cannot be detected by the class of shop, and Becker *et al.*[13] highlighted that for most consumers, quality goes beyond safety. However, Roberts *et al.* [14] stated that consumers cannot tell the risk of incurring a food-borne illness at the time of purchase or consumption of a food item, because the extent of microbial contamination or the level of chemical residues cannot be observed.Consumers use their senses in their descriptions of safe food, and feel that food that looks or smells bad should not be eaten [15].

Microbial contamination per each meat type at different stages of the distribution chain is presented in Table 2. Microbial contamination for *E.coli*, TBC and CC between abattoir and offloading points for beef increased progressively from 4.9 to 7.8; 7.7 to 7.8 and 5.9 to 7.8 log10 CFU/cm2 respectively. Observed higher levels of contamination could be due to the growth of the existing microorganism during transportation, cross contamination from the transportation vehicle to carcasses or from a carcass to another. However, at display a significant decrease was observed.

IV. CONCLUSION

It was therefore concluded that levels of contamination by total bacteria counts, coliform counts and *Escherichia coli* in raw meat were high at all the stages of the distribution chain and exceeded the acceptable limits and this increases the rate of meat spoilage and the risk of foodborne illness. Significant increase of carcass contamination between loading and the offloading points was observed. Therefore it is suggested that meat handlers and meat sellers to rigidly enforce standard hygienic practices throughout the distribution chain. It is also highly recommended that microbiological

Table 2: Least square means and (±SE) of microbial contamination per meat type at different stages of the distribution chain

		Microbial contaminants		
		Total Bacteria Count	Coliform count	Presumptive *E. coli*
Loading	Beef	$7.7^{b} \pm 0.33$	$5.9^{b} \pm 0.33$	$4.9^{c} \pm 0.52$
	Pork	$5.6^{a} \pm 0.33$	$3.9^{a} \pm 0.33$	$1.8^{a} \pm 0.52$
	Mutton	$7.3^{c} \pm 0.33$	$4.2^{b} \pm 0.33$	$1.1^{a} \pm 0.52$
Off-loading	Beef	$7.8^{c} \pm 0.33$	$7.8^{c} \pm 0.33$	$7.8^{\mathbf{b}} \pm 0.33$
	Pork	$5.8^{a} \pm 0.33$	$5.8^{a} \pm 0.33$	$5.8^{a} \pm 0.33$
	Mutton	$4.7^{b} \pm 0.52$	$4.7^{a} \pm 0.52$	$4.7^{b} \pm 0.52$
Display	Beef	$6.7^{a} \pm 0.33$	$6.7^{a} \pm 0.33$	$6.7^{a} \pm 0.33$
	Pork	$5.8^{a} \pm 0.33$	$5.8^{a} \pm 0.33$	$5.8^{a} \pm 0.33$
	Mutton	$1.8^{a} \pm 0.52$	$1.8^{a} \pm 0.52$	$1.8^{a} \pm 0.52$

^{abc} Means in the same column for beef, pork and mutton with different superscripts are significantly different ($p < 0.05$)

assessment of carcasses in abattoirs and during marketing be introduced to assure the safety of meat.

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