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Assessment of beef microbial contamination at abattoir and retail meat shops in Morogoro Municipality, Tanzania

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SUMMARY

A cross section study was conducted in Morogoro Municipality to assess microbial contamination in beef production chain from abattoir to retail meat shops during February to May, 2012. Questionnaire on abattoir and meat shop hygiene was administered to 60 respondents. Meat, meat in-contact surface swab and water samples at the abattoir (n=36) and 14 meat shops (n=56) were analyzed for Total Viable Counts (TVC), Total Coliform Counts (TCC) and Total Faecal Coliform Counts (TFC). It was found that the respondents had not attended to any training on meat hygiene, had no protective gears and do not perform regular health examination. The infrastructure appeared obsolete. Carcasses and meat handling environment at abattoir and retail meat shops were in unhygienic condition. Water was scarce in the abattoir and meat shops. Water analysis showed heavy microbial contamination (mean TVC log 5.2±0.3). All the meat and meat in-contact surfaces were at different levels of microbial contamination and were beyond FAO recommendations. The mean TVC in meat was Log 7.2±1 cfu/g with the highest count (Log 7.24±1.3 cfu/g) recorded in samples from meat shops. The mean TVC on meat in-contact surfaces was Log 6±1.3 cfu/cm² while mean TCC and TFC in meat were Log 6.1±1.6 and 5.9±1.7 cfu/g respectively. High microbiological loads in meat indicate gross contaminations along the whole meat value chain and pose potential risks for public health. Results obtained in this study provide information to the local government authorities and all stakeholders in the meat industry for proper management of the abattoir, retail meat shops and personnel; outlines key aspects for interventions and suggests future developments to prevent health risks associated with handling and consumption of contaminated meat.

Key words: Abattoir, retail meat shops, meat in-contact surfaces, microbial contamination

INTRODUCTION

The population of Morogoro Municipality in the year 2012 was estimated to be 315, 866 (URTNC, 2012), with an estimated increase at 2.4% per year. Most of the people in Morogoro depend on beef produced at the Morogoro Municipal abattoir as the main source of animal derived protein. The production and consumption of meat has increased parallel with increased human population. For example, in 1986 the average number of

cattle slaughtered at the abattoir per day was 20. Twenty years later (2006), the number of slaughtered cattle increased to 60 (Nonga *et al.*, 2010). Such steady increase in number of cattle slaughtered per day in the environment of unimproved abattoir infrastructure may encourage microbial contaminations.

Microbial contamination of meat can occur in multiple steps along the food production chain including production, processing, distribution, retail marketing and handling

or preparation (Zhao *et al.*, 2001). The abattoir environment and slaughtering processes play a vital role in the wholesomeness and safety of the meat. Unhygienic practices in abattoirs and post-process handling are associated with potential health risks to consumers due to presence of pathogens in meat and contaminated equipments (Abdullahi *et al.*, 2006). Microbial contamination on meat and meat products must not exceed recommended levels (FAO, 2007) otherwise may be sources of food-borne diseases and facilitate spoilage. Under tropical conditions, food of animal origin tends to deteriorate more rapidly because of high multiplication rates of microbes and become potentially dangerous to consumers (Akinro *et al.*, 2009). Fresh raw meat has been implicated in a number of meat-borne infections and intoxications (Mukhopadhyay *et al.*, 2009). This is correlated with lack of proper sanitary conditions, hygiene practices and, proper storage and mishandling of food (WHO, 2009). Food-borne pathogens are leading causes of illnesses in developing countries, causing deaths to about 1.9 million people annually at global level (Schlundt *et al.*, 2004). The high prevalence of diarrheal diseases in many developing countries suggests major underlying food safety problems (WHO, 2009). To There is a requirement to initiate and implement the Hazard Analysis and Critical Control Point (HACCP) system and food safety education at different stages from farm to fork in order to overcome food safety problems.

In spite of the increased consumer demand on food safety standards for beef in Morogoro Municipality, there are still poor hygiene and sanitary practices along the meat production chain which contribute to unacceptable level of microbial load in meat. It is recommended that there must be a continuous investigation and inspection

of meat along the production chain so as to provide safe and wholesome meat for human consumption (Kirton, 1989; Herenda *et al.*, 2000). Although several studies have been conducted to assess contamination of carcasses and offal in Tanzania (Mtenga *et al.*, 2000; Komba *et al.*, 2012; Nonga *et al.*, 2010), limited studies have been conducted to assess microbial load of beef along the production chain. Also, the need for assuring food safety to the public cannot be underestimated in this modern world. In order to minimize public health risks and possible losses due to condemnation of spoiled meat, this study was conducted to assess microbial contamination of beef along the production chain and point out the main contamination points that would require interventions through a HACCP system and education for different actors on beef enterprise.

MATERIALS AND METHODS

Study design and area

A cross sectional study was carried out in Morogoro Municipality. The Municipality is situated on the lower slopes of Uluguru Mountains whose peak is about 500 to 600 metres above sea level with estimated population of 315 866 (URTNC, 2012). It lies at latitude 5.7 to 10 °S and longitude 35.6 to 39.5 °E.

Questionnaire administration

Questionnaires were administered to 20 abattoir workers and 40 selected retail meat shop workers. The information collected included source of cattle slaughtered, meat transportation, meat storage facilities, level of education, use of protective gears, health check up to workers, hygienic status of abattoir and retail meat outlets, availability and accessibility to clean and safe water.

Sample collection and handling

A 500 g meat from the flank and neck regions of the carcass from abattoir was purchased and placed in sterile plastic zip bag (Ziploc®, Sc Johnson, USA). Meat in-contact surfaces were swabbed using moistened sterile cotton swabs. Swabbing was performed on 60 cm² surface areas of evisceration tables, walls, floors, meat van floors, meat wood cutting blocks, weighing pans and 20 cm² of knives (Barros *et al.*, 2007). The swabs were put into capped sterile tubes containing 10 ml of normal saline and stored in cool box with ice packs before transported to laboratory for analysis. Water samples at the abattoir were aseptically collected from the tap into sterile glass bottles. In total, four abattoir visits were made which involved collection of 8 meat samples, 24 meat in-contact surface swabs and 4 water samples. The same sampling procedure was done in meat shops. A total of 14 retail meat shops (butchery) were randomly selected in 29 wards located in Morogoro Municipality for this study. All the samples transported to the Faculty of Veterinary Medicine laboratory at Sokoine University of Agriculture for microbiological analysis.

Laboratory analysis of samples

Total viable count (TVC) of microorganisms in beef at 37 °C was performed using a protocol described previously (TZS, 2007). Briefly, 1 g of meat sample was grinded using sterile mortar and pestle and 10 ml of sterile normal saline was added and thoroughly mixed as described in EAS 217-1-3:2008 protocol. Ten sterile test tubes were dispensed with 9 ml of sterilized Phosphate Buffered Saline (PBS) (OXOID® Ltd., Basingstoke, U.K.). Serial ten-fold dilutions were prepared from 10⁻¹ to 10⁻¹⁰ in phosphate buffered saline (PBS).

Duplicate pour plates were prepared using 1ml from each dilution and mixed with 20 - 25 ml tempered (44 - 47 °C) nutrient or MacConkey agar (OXOID® Ltd., Basingstoke, U.K.). The plates were incubated aerobically at 37 °C for 24 hours for TVC. The same procedures for TVC analysis in meat in-contact surface swab and water samples were used as for meat. The samples were further inoculated on MacConkey agar and aerobically incubated at 37 °C and 44 °C for 24 hours to establish the TCC and TFC levels respectively (Bhandare *et al.*, 2009).

Microbial colony count on the plates was performed using a protocol described previously (ISO 721, 2007). Colony forming units (cfu) were counted on at least two critical dilution plates by the aid of colony counter. Two consecutive plates with 15 to 300 colonies were considered for record (ISO 4833:2003(E)). The countable colonies were converted into the weighted mean colony forming units per millilitre (cfu/g or cm²) using a formula: $N = \frac{\sum C}{(n_1 + 0.1n_2)d}$ where N = the number of bacteria counted, C = sum of colony counted in two successful dilutions, n₁ = the number of dishes retained in the first dilution, n₂ = the number of dishes retained in the second dilution and d = dilution factor corresponding to the first dilution (ISO 4833:1991(E)).

Data Analysis

The collected data were entered in MS Excel 2007 spreadsheet and analysed using Epi-Info™ 7.1.2, (Centre for Disease Control and Prevention (CDC), Atlanta, USA). A chi squared test was used to compare the proportions (%) of variables at a critical probability of $P < 0.05$. Descriptive statistics was used to compute means, standard deviations, median and range using log transformed colonies. Analysis of variance (ANOVA) was

adopted to compare differences in means of continuous variables.

RESULTS

Practices contributing to microbial contamination of beef at the abattoir and retail meat shops

The results from the study revealed that majority of abattoir and retail meat shop workers have attained no further than primary education, not attended to any training on meat hygiene, were using dirty protective gears and do not perform regular health checked-ups (Table 1). In abattoir, 70% of the respondents reported that water sinks used for washing their hands were in good hygienic condition. Eighty percent reported that there was no regular removal of manure from the lairage and most of the cattle slaughtered were soiled with faeces especially during rainy season. Eighty percent of abattoir workers reported that the septic tanks were always overflowing with effluents which were major sources of strong smell at the abattoir. The abattoir floor, slaughter area and drainage systems were in poor hygienic condition as reported by 75% of abattoir workers. The slaughter floor was not separated into clean and dirty areas. All processes of slaughtering, flaying, evisceration and splitting of carcasses were done on the same location of the floor which was always dirty. Washing of carcasses was not done except that intestines were being washed in buckets with very dirty water. Knives used for processing of carcasses were washed with tap water. Up to 75% of abattoir workers agreed with the general unclean condition of the abattoir though sometimes water for cleaning was not available. All the 20 respondents from the abattoir reported the scarcity of water at the abattoir due to frequent cut off water supply system. This made the work of carcass, offal and floor washing to be difficult.

A total of 92.5% of the beef retail workers reported that the meat vans were in good hygienic condition. Seventy percent of the surveyed retail meat shops were in poor hygienic condition despite of the daily cleaning. The meat sold was not chilled and the bony meat was being chopped with an axe on a dirty cutting piece of wood locally known as “*Kigogo*”. The control of house flies in meat shops was done by use of glass windows and daily cleaning (50%), while 50% of the meat shops were spraying insecticides mainly Rungu[®], the pyrethrin pesticide preparation. A total of 72.5% of retail meat outlets had no refrigerators in their shops. The meat that remains unsold on the day of slaughter is hanged on hooks overnight under room temperature. It was observed that some of the meat chopping tables were too dirty with some pieces of meat and solidified fats which appeared darkish brown to greenish in colour.

Microbiological results

All the meat and meat in-contact surfaces were contaminated with microorganisms at different levels. Microbiological results showed that the mean total viable count (TVC) in meat was Log 7.2±1 cfu/g with the highest mean count (Log 7.24±1.3 cfu/g) recorded in samples from meat shops (Table 2). All the values of TVC recorded were far beyond the FAO (2007) recommendation of Log 4.0 cfu/g. All the four water samples analysed were heavily contaminated with microorganisms with the mean TVC being Log 5.2±0.3. In the abattoir, the result of TVC showed that there were no significant difference between microbial load on evisceration tables, floors and meat from flank region while in walls, water, knives, and meat samples from neck region, levels of contamination were significantly different ($p < 0.05$). In retail meat outlets, the differences in levels of microbial

contamination between knives, weighing balances, meat chopping tables and wood cutting blocks were not statistically significant ($p > 0.05$) (Table 2).

The mean TVC on meat in-contact surfaces was $\text{Log } 6 \pm 1.3 \text{ cfu/cm}^2$. The mean TCC and TFC in meat samples were $\text{Log } 6.1 \pm 1.6$ and $5.9 \pm 1.7 \text{ cfu/g}$ respectively. All the samples examined for TCC had values exceeding the recommended level of $\text{Log } 3.0 \text{ cfu/g}$ (FAO, 2007). There were no significant differences ($p > 0.05$) in TCC load between knives, weighing balances, meat chopping tables and wood cutting blocks in the retail meat outlets. Also, there were no significant differences in TFC load between knives, weighing balances and wood cutting blocks ($p > 0.05$).

Analysis of variances between bacterial contaminations in the abattoir revealed significant differences ($P < 0.05$) for TVC, TCC and TFC while in retail meat outlets the TVC showed significant difference ($P < 0.05$) except for TCC and TFC which showed no significant difference ($P > 0.05$). In general the mean microbial loads were significantly different between the abattoir and retail meat outlets ($P < 0.05$).

Table 1. Frequency distribution of respondents according to level of education, routine health check up and wearing protective clothes in abattoir and retail meat outlets

Information of respondents	Abattoir workers (%) (n = 20)	Retail meat outlet workers (%) (n = 40)
Level of education and short course training		
• Informal education	35	7.5
• Primary education	65	85
• Secondary Education	0	7.5
• Other short course on meat hygiene	0	92.5
Wearing protective clothes		
• Not wearing protective clothes	60	0
• Wearing dirty clothes	70	62.5
Medical/ health examination		
• Every after 3 month	55	32.5
• Every after 6 month	35	62.5
• Do not check	10	5

Table 2. Mean log values for TVC, TCC and TFC in samples collected from the abattoir and retail meat shops

Location	Sample type	Unit	Microbial load			p-value
			Log TVC (mean±SD)	Log TCC (mean±SD)	Log TFC (mean±SD)	
Abattoir (n = 4)	Meat from flank region	cfu/g	6.60±0.37 ^a	5.74±0.29 ^b	5.56±0.17 ^b	< 0.05
	Meat from neck region	cfu/g	7.72±0.22 ^a	6.92±0.12 ^b	6.73±0.28 ^b	
	Walls	cfu/cm ²	6.05±0.11 ^a	4.99±0.31 ^b	4.93±0.29 ^b	
	Water	cfu/ml	5.18±0.25 ^a	0.00±0.00 ^b	0.00±0.00 ^b	
	Evisceration tables	cfu/cm ²	6.43±0.11 ^a	5.83±0.44 ^b	5.66±0.14 ^b	
	Floors	cfu/cm ²	6.59±0.05 ^a	5.85±0.22 ^b	5.83±0.15 ^b	
	Knives	cfu/cm ²	4.13±0.08 ^a	3.77±0.34 ^{ab}	3.63±0.25 ^b	
	Meat van floors	cfu/cm ²	5.00±0.41 ^a	4.22±0.23 ^b	4.20±0.28 ^b	
Retail (n = 14)	Meat	cfu/g	7.24±1.30 ^a	5.55±2.31 ^b	5.27±2.38 ^b	< 0.05
	Knives	cfu/cm ²	6.16±1.25 ^a	4.66±1.85 ^b	4.33±2.05 ^b	
	Weighing balances	cfu/cm ²	5.77±1.49 ^a	4.45±1.96 ^{ab}	3.98±2.42 ^b	
	Meat chopping tables	cfu/cm ²	5.86±1.53 ^a	4.13±2.21 ^b	3.47±2.71 ^b	
Outlets	Wood cutting blocks	cfu/cm ²	6.14±1.21 ^a	4.62±1.72 ^b	4.19±2.11 ^b	

^{ab}Means between the row with different superscript are significantly different $p < 0.05$

DISCUSSION

The present study evaluated the microbiological quality of raw meat at the abattoir and meat retail shops in Morogoro Municipality, Tanzania. The results show that all the meat and meat in-contact surfaces were contaminated with microorganisms which make the quality of raw meat sold in Morogoro to be poor that threatens the health of consumers. During the study it was observed that between 80 and 120 cattle are slaughtered at Morogoro Municipal abattoir per day and, the meat is distributed to different retail meat outlets within the Municipality for sale. This number of cattle slaughtered per day does not cope with capacity of the slaughter facility available which can hardly handle 30 cattle per day. This lead to confinement of slaughter animals in a small wrinkled dirty lairage. Bleeding, carcass dressing and handling of carcasses were done on small dirty floor which predisposed meat to contamination. The whole meat chain was unhygienic which was correlated with poor infrastructure and lack of education to the meat stakeholders on sanitary and safe handling of meat. This was supported by high values of microbial loads which were observed in meat and meat in-contact surfaces.

This study further revealed that, the abattoir and meat shop workers had low level of education and this could make it difficult to adopt transformation when modern slaughter practices coupled with hygienic and standard slaughter practices are introduced. From the survey conducted at Makelle City, Ethiopia (Haileselassie *et al.*, 2012), it was found that out of 26 abattoir workers interviewed, 7.7% were illiterate and 61.5% had no any training regarding meat hygiene. Bhandare *et al.* (2009) reported that workers working in the abattoir in most developing countries are untrained and thus, pay no attention to

the hygienic standards and as a result contribute immensely to bacterial contamination. Furthermore, the current study observed that most of abattoir workers had no protective gears is contrary to Tanzania Food and Drugs Authority (TFDA) Act of 2003. Indeed, all processes of slaughtering and carcass dressing were done on a dirty floor which predisposes the meat to contamination with microbes. These findings are similar to those reported by Adeyemo *et al.* (2009), Komba *et al.* (2012) and Adzitey *et al.* (2011). Efforts need to be done at Morogoro abattoir so that the situation is corrected otherwise the public will keep on eating contaminated meat.

A similar situation was also observed in retail meat shops which most of them handled meat in unhygienic way. The practice of wearing protective gears and washing hands before and after sales of meat is important for sanitary purposes. In this study, most of workers did not wear protective gears, sold unchilled meat and storage of meat was at room temperature which was full of domestic flies. Facilities for hand washing were not available in almost all meat shops. Based on these observations, the sources of meat contamination originated from the slaughter process in the abattoir due to poor hygienic environmental condition and unhygienic handling of meat in meat shops. Several other studies have published similar findings (Desmarchelier *et al.*, 1999; Ali *et al.*, 2010; Nervy *et al.*, 2011; Haileselassie *et al.*, 2012).

Microbiological results revealed that there was a marked growth of bacterial contaminants in meat samples with the high TVC values recorded in samples from the abattoir and meat shops suggesting gross contamination as previously reported by Gebeyehu *et al.* (2013). Primary microbial contamination may be from the

infected or sick slaughter animal. The secondary causes of microbial contamination occur along the meat chains especially unhygienic slaughter and handling of meat at abattoir and meat shops. According to FAO (2007) TVC exceeding Log 4.0 cfu/g in fresh raw meat are not acceptable and alarm signals and meat hygiene along the slaughter and meat handling chain must be urgently improved. According to Haileselassie *et al.* (2012) poorly organized farm to table production chain and poor standard sanitary operational procedures practiced by the abattoir personnel are some of the risk factors for high microbial load. In addition, microbial load of meat in-contact surfaces may also be driven by the slaughter animals, handling of wastes generated, personnel and, availability of cleaning and sanitation programs in the food chain (Nortjé *et al.*, 1989; WHO, 2009; Güngör and Gökoğlu, 2010). High microbial load on meat in-contact surfaces causes an increase in the microbial count of the meat along the chain (Nortjé *et al.*, 1989). Our results have confirmed this assertion. In general the results of the current study obtained from meat samples, abattoir floor, evisceration table and abattoir walls and those from beef retail outlets are higher exceeding the recommended set standards (ICMSF, 1985; FAO, 2007). The observed high microbial count in meat and the associated factors for contamination signifies that the consumers are at risk of getting food-borne diseases in Morogoro and the meat produced has short shelf-life. More education needs to be given to different stakeholders involved in the meat value chain.

It was further noted that TVC, TCC and TFC significantly varied between meat regions, meat in-contact surfaces at the abattoir and in meat shops ($P < 0.05$). The variation of these counts of microorganisms in meat and meat in-

contact surfaces may indicate the existence of non-consistent unhygienic carcass harvesting practices that are attributed to lack of standard operation procedures that help to control processing systems in the abattoir and meat shops (Gebeyehu *et al.*, 2013). Also this condition is attributed to lack of the basic Good Hygienic Practices (GHP) procedure in the abattoir and meat shops.

It has been observed that on the abattoir floor and meat, there are higher values of TCC compared to the retail meat shops and other samples. This could be contributed by several processing activities done on the dirty floor, appreciable large number of people and lack of proper separation between clean and dirty areas at the abattoir. The overall assessment of the meat and meat in-contact surfaces indicated high TCC which is comparable to the findings reported by Tarwate *et al.* (1993). In general the results obtained from meat samples from the study exceed the recommended set standard of coliform bacteria counts of less than Log 3.0 cfu/g (FAO, 2007). The presence of TCC in retail meat outlets was thought to have originated from the abattoir due to unhygienic practices undertaken.

The presence of faecal coliforms is an indicator of poor sanitary condition in the abattoir and retail meat outlets since these microorganisms originate from the gastrointestinal tract of animals. The results revealed the highest log mean values for TFC on meat samples from neck region, meat from flank region and in-contact surfaces of meat particularly abattoir floor, meat van floors, knives and abattoir walls. Faecal coliforms are enteric organisms and stay in the intestinal contents. Detection of TFC suggests contamination of meat with faecal materials because of poor slaughter and carcass dressing (Gannon, 1999; Hoar *et al.*, 2001). Our results are in line with a

work by Bhandare *et al.* (2009) which reported high TCC in meat and in-contact surfaces. According to FAO (2007) coliform bacteria counts exceeding Log 3.0 cfu/g on fresh meat are not acceptable. Referring to this standard, all the meat and in-contact surfaces analysed for TFC had bacteria counts beyond the recommended values by FAO and hence meat hygiene along the beef production chain should be improved.

In conclusion, the results obtained from this study show that there was high microbial load in meat and in-contact surfaces above allowable levels. Several risk factors for contamination were observed in particular the unhygienic practices of meat handling along the value chain. Stakeholders in beef industry should be educated on safe production and good hygienic practices accompanied with routine microbiological quality assessment of meat and enforcement of food laws.

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