

Bacterial Hazards and Critical Control Points in Goat Processing at a Typical Tropical Abattoir in Ibadan, Nigeria

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Abstract: This study assessed bacteria hazards in goat processing line. Goat meat has become an important source of protein to the teeming Nigerian populace. Unhygienic processing of carcasses and inadequate sanitary conditions of the abattoir poses health risks to consumers. *Enterobacteriaceae* count and Total Aerobic Plate Counts were assayed along the processing line and facilities used in goat processing. *Enterobacteriaceae* count on goat carcasses increased from 12.70 logcfu/cm² before evisceration to 13.72 logcfu/cm² after singeing, while the Total Aerobic Plate Counts increased from 13.45 logcfu/cm² for tables after wash to 14.01 logcfu/cm² for tables or knives before wash and carcass after wash. These counts exceeded international limits (WHO/European Commission). The microbial assay showed a significant difference in *Enterobacteriaceae* count ($p < 0.05$) along the processing line of goat carcasses but there was no significance difference in the Total Aerobic Plate Counts ($p > 0.05$). A positive correlation ($r^2 = 0.0528$) ensued between the *Enterobacteriaceae* count and Total Aerobic Plate Counts. Important Critical Control Points (CCPs) include: goat's skin after singeing, evisceration, cutting (knife before use), display table before use and waste water generated during the processing. The findings in this study suggest that processed goat carcasses from the abattoir under study will pose serious health hazard to consumers. The public health implications and need to implement Hazard Analysis Critical Control system in goat carcass processing to ensure provision of wholesome meat for the human populace is therefore emphasized.

Key words: Abattoir, critical control points, *Enterobacteriaceae* counts, goat carcasses processing, total aerobic plate counts

INTRODUCTION

The most important issues in all meat processing plants are maintenance of proper hygiene and adequate sanitary conditions (Adeyemo, 2002). Sheep and goat form a very essential role in the supply of protein to man. The consumption of animal protein by the average Nigerian is very low (Olayide *et al.*, 1972; Gefu, 1982; Bender, 1992; Casey, 1992; Ojo, 2004). Small ruminants are increasingly becoming a major source of animal protein in Nigeria, contributing over 30% to the total meat consumption in the country (Ojo, 2004).

In developing countries, meat processing is very unhygienic with slaughtering, dressing and evisceration done on the floor in slaughter halls and slabs (Adeyemo, 2002). Wastes are disposed directly into streams or rivers and water from the same source is used in processing goat carcasses. Such is the situation in most private and government abattoirs in south-western Nigeria (Adelagan, 2002). Haines (1933) stated that microbes especially coliforms can inhabit goat carcasses and cause spoilage of

the meat and possible infections in humans. Slaughter house provide excellent opportunities for detecting diseases of both economic and public health importance (Ojo, 2004; Alonge, 2005).

The *Enterobacteriaceae* group of bacteria posse a great challenge to the production of raw and processed meat across the globe. They are small gram-negative, oxidase negative, non-spore forming enteric bacilli that ferment glucose with acid production, and reduce nitrates (NO₃ to NO₂ or all the way to N₂). Notable species incriminated in meat processing, meat products and abattoir environment are Salmonella, *E. coli*, *Shigella*, *Yersinia*, *Klebsiella* etc. During slaughter and dressing procedures, these pathogens, including *E. coli* O157 and other VTEC, *Salmonella* spp., and *Listeria monocytogenes*, can be directly or indirectly transferred onto the meat surface, but will not be visible to the meat inspection staff during conventional meat inspection of sheep/goats (Anonymous, 2004). They cause food borne illness arising from food contamination and poisoning. Contamination of raw meat is one of the main sources of

foodborne illnesses (Bhandare *et al.*, 2007) and death in developing countries costing billions of dollars in medical care, medical and social costs (Fratnico *et al.*, 2005).

The Hazard Analysis Critical Control Points (HACCP) concept is a systematic and scientific approach to process control (USDA, 1997). HACCP is used to describe an internationally recognized way of managing food safety and protecting consumers being a requirement of European Union (EU) food hygiene legislation that applies to all food business operators except farmers and growers (FDA, 2009; FSA, 2010). It is viewed as a means of preventing the occurrence of health and safety hazards in plants producing meat and poultry products. It does this by ensuring that controls are applied at any point (CCPs) in a food production system where hazardous situations could occur (USDA, 1997). These hazards may include biological, chemical, or physical adulteration of food products. The potential hazards that are reasonably likely to cause illness or injury in the absence of their control must be addressed in determining CCPs. Complete and accurate identification of CCPs is fundamental to controlling food safety hazards (FDA, 2009). Critical limits as well as monitoring procedures are set before corrective actions are instituted if there are deviations from the critical limits.

There is dearth of information on microbial load and quality of goat meat in Nigeria while no study has reported such from the Ibadan abattoir and therefore results of this study were compared with those from developed world and international standards. It is imperative to curb the rising incidence of illness resulting from foodborne sources and this depends largely in determining possible bacteria counts in meat while suggesting points along the processing line in which its presence could be eliminated which this study aims at addressing.

MATERIALS AND METHODS

This study was conducted between the month of March and August, 2010.

Study area: The Ibadan Municipal Abattoir selected for this study is located in Ibadan city, the capital of Oyo State within the Southwestern geopolitical zone of Nigeria. Ibadan city, with a dense population of 1,338,659 (NBS, 2006), is the biggest in Sub-Saharan Africa. It is located on a grid reference longitude 3° 5E and latitude 7°20N (Filani, 1994). The abattoir is built with the minimum capacity for slaughter and processing of 100 goats. However, the situation is different today. Average values of goats slaughtered daily are between 160 and 220 (Plate 1).



Plate 1: Study Area: Bodija Abattoir



Plate 2: Goat Carcass on table and after wash

Sampling: Swab along goat processing line, water and effluent samples (Plate 2) were collected for the laboratory procedure as given below:

- swab sample of the goat's skin immediately after slaughter
- swab sample of the goat's skin immediately after singeing
- swab sample of the goat's skin immediately after washing

- swab sample of the evisceration floor before use
- swab sample of the evisceration floor after use
- swab sample of the slaughtering knife before use
- swab sample of the knife after slaughtering and evisceration
- swab samples of the slaughtering table before use
- swab sample of the slaughtering table during display of carcass
- water used for the processing
- sample of the effluent/waste water generated during the processing

All samples were taken aseptically using sterile swabs soaked in sterile 0.1% peptone water from a 2 cm² area of carcasses and facilities sampled. 10 ml liquid samples were taken aseptically into sterile bijoux bottles. All samples were stored on ice in a cooler and transported immediately to the laboratory for microbial assay.

Microbiological procedure: 10 mL of 0.1% peptone water was added to each tube containing the swab and vortexed for 10 sec to assure proper mixture of the samples. Serial ten-fold dilutions (10⁻¹⁰) of the homogenates were made in peptone water (Lab M, UK) solution and subjected to counts by standard pour plate method. Appropriate dilutions were surface plated on MacConkey agar (Biotec lab. Ltd., UK) for *Enterobacteriaceae* count (EC) and on Plate count agar (Lab M, UK) for Total Aerobic Plate Count (TAPC). Plates were incubated at 37°C for 18-24 h.

Enumeration of counts: The number of distinct colonies on the plate was enumerated using a digital colony counter. The EC and TAPC were estimated and recorded in mean colony forming units per cm² determined using the following formula:

$$\text{cfu/cm}^2 = \text{No of colonies} \times \text{level of serial dilution} \times \text{factor bringing plated vol. to 1 mL}$$

Thereafter all values expressed in mean colony forming unit per cm² (Mean logcfu/cm²) of replicates for the counts were converted to log values.

Statistical analysis: Using the SPSS version 15, 2007 statistical package t-test was used to identify significant differences within and among groups. Mean differences were interpreted as significant a p<0.05. Multiple comparisons were used to identify significant correlations (r²) values of the 2 variables (EC and TAPC) which were obtained using the Microsoft office excel functions, 2003.

Table 1: Mean *Enterobacteriaceae* counts (logcfu/cm²) and Mean Total Aerobic Plate counts (logcfu/cm²)

Samples	Mean total Aerobic plate counts (logcfu/cm ²)	Mean <i>Enterobacteriaceae</i> counts (logcfu/cm ²)
After Slaughter	13.79	13.37
After Singeing	14.01	13.72
Carcass after wash	14.01	13.52
Table before wash	14.01	13.71
Table after wash	13.45	13.30
Evisceration floor before use	13.64	12.70
Evisceration floor after use	13.48	13.65
knife before use	14.01	13.58
knife after use	13.82	13.53
Water for washing	13.69	13.44
Waste water	13.93	13.38

RESULTS

The mean ECs and TAPCs recorded during laboratory analysis is given in Table 1. Average microbial load in the processing line are shown in Fig. 1. All counts in this study were very high. Generally, the bacterial counts for the TAPC were greater than that of the EC. The highest TAPC, 14.01 logcfu/cm² occurred after singeing of carcass, after washing of carcass, display table before wash/use, and the butcher's knife before use. The least TAPC was recorded for the water used for processing. The highest value of 13.72 logcfu/cm² occurred after singeing for EC. The lowest 12.70 logcfu/cm² EC was on the evisceration floor before use.

The EC decreased after the carcasses were washed. Also, a reduction in both counts was observed on table after wash though increased on the floor after evisceration where the EC was higher than the TAPC. The counts were equally lesser on knives after use than before use. Counts in the water used for washing carcasses were lower than those observed in the waste water generated during the processing. All counts obtained in this study exceeded the international standards set by the European Commission (2001) and other international food administration bodies (FDA, 2009; FSA, 2010).

A positive correlation (r² = 0.0528) ensued between both counts (Fig. 1) not significant at p<0.05.

DISCUSSION

Both EC and TAPC after singeing were higher than counts on the carcass after slaughter. This is probably due to recontamination from the singeing floor because the goats are kept on bare ground close to a major dump-hill in the abattoir. The higher values for both the mean log *enterobacteriaceae* and total aerobic plate counts of the carcasses after singeing than after slaughter were due to poor infrastructures such as lack of singeing facility, improper waste and dirt disposal facilities, drainage,

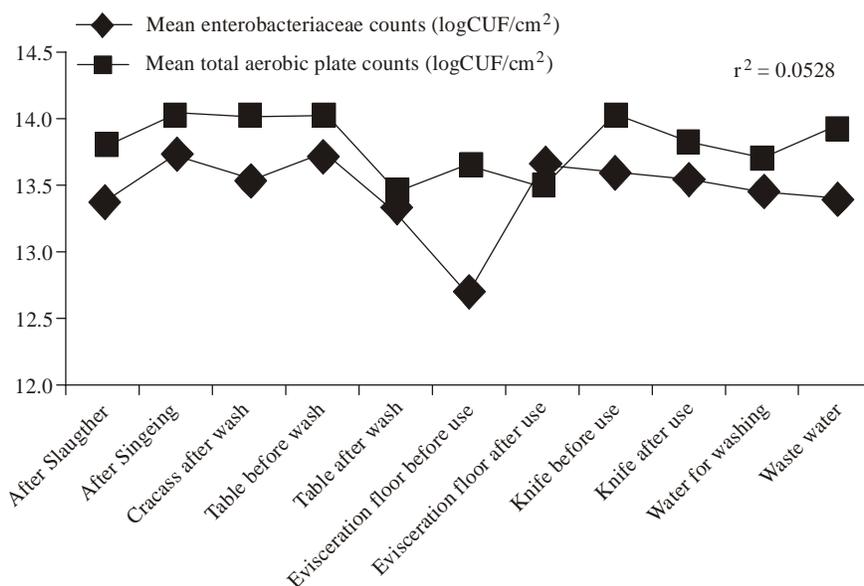


Fig. 1: Mean Logcfu/cm² of *Enterobacteriaceae* and total aerobic plate counts

differentiation between clean and unclean operations and lack of hygiene and sanitation. The time lapse from the time of singeing to the time of sampling may have also allowed a reduction in temperature with an associated microbial contamination and growth. Adeyemo *et al.* (2002) stated that the sanitary conditions under which carcasses are being dressed at the Ibadan abattoir is far from ideal.

The decrease in EC and TAPC after the carcass was washed is expected because of the mechanical removal of dirt and microbes through the process of washing with water. The abattoir workers usually carry out the washing process with little detergents which would have helped to reduce the microbial load a little. TAPC and EC reported by other workers from the developed world were much lower than counts obtained in this study (Hudson *et al.*, 1996; Gill *et al.*, 2000; Grad and Sheridan, 2002; Sumner *et al.*, 2002; Bhandare *et al.*, 2007). Other workers in the developing countries have also reported very high counts such as Okodugha and Aligba (1991).

Counts on the tables after wash/display were lower than before wash. The counts were higher before wash because the tables were usually left unwashed after the day's activity until the next day. Other possible factors is the fact that the tables were located in open areas which is not fenced and flies, stray dogs and other flying creatures can easily perch on the tables thus introducing microbes. The reduction of count on table after wash is as a result of the use of water at the start of the day's work by the butchers.

The floor before evisceration revealed lower mean EC (12.70 logcfu/cm²) than after evisceration (13.65

logcfu/cm²), a marked difference of 0.95 logcfu/cm². The higher counts of the floor after evisceration are due to contamination by enteric bacteria from the ruminal contents and improper handling of carcasses during the evisceration processing. Occasional ruptures of viscera do result in spread of gut contents on to the carcass, thus contributing to higher number of microbial flora (Patterson, 1969; Grau, 1986). Bhandare *et al.* (2007) similarly noted that fecal coliform levels were higher after evisceration than after washing of carcasses. The increases were 0.62±0.2 logcfu/cm² and 0.42±0.7 logcfu/cm² respectively for abattoir and retail meat shops. These results were moderately lower as compared to that obtained in this work (0.95 logcfu/cm²).

The butcher's knife before use had significantly higher counts than after use (>13.52 logcfu/cm²). Poor level of hygiene on the part of the butchers could have resulted in the higher levels of both counts. Meanwhile, butchers normally use the same knives throughout the line of processing of the carcasses. The butchers usually wash the carcasses or parts of the carcasses in limited amount of water. Cetin *et al.* (2006) sampled food contact surfaces on many types of equipment (knives, cutting boards, plates and choppers) in the retail packaging and fabrication lines and recorded total aerobic mesophilic counts to be between 2.23 and 3.0 logcfu/cm².

Total aerobic plate counts for the effluent/waste water (13.93 logcfu/mL) generated during the processing especially after washing of singed carcasses was higher than the water used for washing (13.69 logcfu/mL). In a similar study Adesemoye, *et al.*, 2006 reported a lower mean total bacterial count of 3.32×10⁷ (7.521 logcfu/mL)



Plate 3: Dirty operations

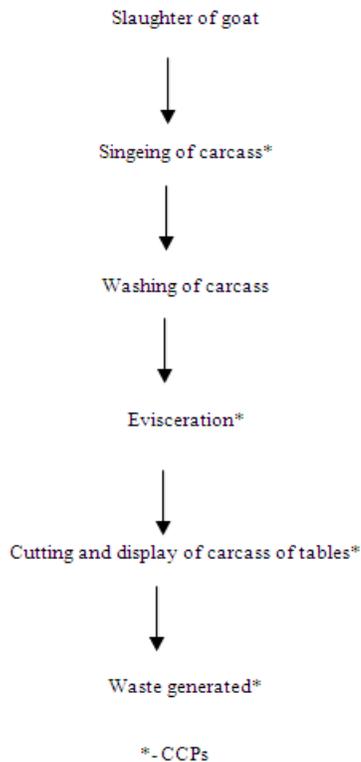


Fig. 2: CCPs along the processing line

and 2.7×10^7 cfu/mL (7.431 logcfu/mL) in effluent water respectively from Agege and Odo abattoir in Lagos, Nigeria. The significant high viable counts noticed in this study for waste water could be due to the waste generated from abattoir activities with associated gross unhygienic ways of processing goat carcasses in this poorly managed abattoir (Plate 3). Drains in the abattoir are open and unkempt due to inadequate supply of water in the Ibadan metropolis abattoir (Adeyemo *et al.*, 2002).

Critical Control Points (CCPs): Apart from the fact that the entire carcass processing chain at the abattoir

should be overhauled, important Critical Control Points (CCPs) along the goat processing chain at the Ibadan abattoir included goat's skin after singeing, evisceration, cutting (knife before use, display table before use and waste water generated during the processing. Surface carcass contamination is primarily a hygiene process issue, and can be reduced through a more preventative approach based on systematic development and implementation of: (a) general hygiene measures (GMP, GHP); and (b) specific measures based on the HACCP system (Anonymous, 2004). The abattoir design should be standardized while other corrective measures to be applied should include:

- **Singeing:** should be done properly, animal should not be placed on bare floor.
- **Evisceration:** dirty and clean operations should be separated.
- **Cutting and display:** More than one knife must be used and sterilized properly during the entire operation. Metal tables should be used instead of wooden table for display. This would reduce the possible accumulation of biofilm producing organisms like *Salmonella* spp., *E. coli*, *Listeria* spp. etc.
- **Waste water:** must be properly channelized, treated and disposed. Sufficient portable water should be made available for use in the abattoir (Fig. 2).

CONCLUSION

Overall, this study revealed that the level of contamination on goat carcasses was extremely high exceeding international standards. The acceptable EU specifications for swab values are < 2.8 logcfu/cm² and < 0.8 logcfu/cm² for total viable and enterobacteriaceae counts, respectively while the unacceptable values are > 4.3 and > 1.8 logcfu/cm², respectively (European Commission, 2001). Developing a good HACCP plan with the establishment of strategic critical control points along the processing line as well as provision of slaughter/processing facilities while encouraging effective cleaning programmes will change the situation of things for better in the abattoir. Wholesome meat, greatly short of microbes would be produced for human consumption thereby enhancing public health.

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