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Microbial quality of mutton carcasses dressed in a model slaughterhouse and traditional slaughterhouses: A comparative study

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Abstract

The high nutritive value of meat also makes it a highly perishable commodity, susceptible to degradation and spoilage. Although the causes of meat spoilage vary, bacteria drive the overall process more than other factors, such as endogenous enzymes. External contamination is the main cause of microbes gaining access to meat and carcass. Poor operational techniques and facilities in any of the operations in transformation of animal to meat will result in unnecessary suffering and injuries to animals, reduced meat quality and spoilage of meat. Analysis of the slaughter process is of central importance for assessment of process performance in production of meat. Slaughter process analysis must also include abattoir-specific microbiological data on carcass contamination during slaughter to enable estimation of risks involved and institute appropriate interventions. A study was conducted to compare the efficiency of a few simple interventions adopted at a model slaughterhouse in improving meat quality by assessment of the microbial load of the mutton carcasses dressed in this slaughterhouse and comparing it with assessment of the microbial load of the mutton carcasses dressed in two traditional slaughterhouses that did not adopt these interventions, and also to study the effectiveness of chilling and freezing in decreasing microbial load of mutton carcasses. The study indicates that rodding (ligation of the oesophagus) and bunting (ligation of the anus) are effective interventions in limiting microbial contamination. Chilling and freezing for 24 hours are effective in reducing microbial load, except that of *Staphylococcus*

Keywords: Carcass characteristics, weaner pigs, meat quality, palm kernel cake

1. Introduction

Meat is a vital component of our diet. Meat and meat products play a significant role in ensuring optimal nutrition to the teeming masses of the globe. Global demand for meat is surging, projected to grow steadily over the next decade as developing economies experience rising incomes and urbanization. While high-income regions are shifting toward poultry and plant-based alternatives for health and environmental reasons, total meat consumption continues to rise, led by affordability and rapid population growth in the developing economies.

Unfortunately the high nutritive value of meat also makes it a highly perishable commodity, susceptible to degradation and spoilage. Food spoilage may be defined as any change that renders a food product unsuitable for human consumption. (Huis in't Veld, 1996) ^[17]. In the case of meat, spoilage is a complex event involving biological, physical and chemical activities that lead to product deterioration (Casaburi *et al.*, 2015) ^[4]. Therefore spoilage has an adverse effect on consumer acceptance and correlates strongly with food wastage (Pellissery *et al.*, 2019) ^[25]. The FAO estimates that one thirds of food produced for human consumption is wasted each year (FAO, 2011) ^[13]. A significant portion of meat and meat products are spoiled every year. Kantor *et al.* (1997) ^[19] reported that approximately 3.5 billion kg of poultry and meat were wasted at the consumer, retailer and foodservice levels which have a substantial economic and environmental impact. Significant portion of this loss is due to microbial spoilage.

Meat waste and losses are directly responsible for economic burdens, outbreaks, food recalls, human suffering, and mortality. In Europe and Northern America, approximately 21% of these food losses are meat and meat products, (Holl *et al.*, 2016) ^[15]. Microorganism-dependent spoilage during distribution, storage, and in the retail market account for up to 8% of meat losses in China (Chen, 2019) ^[6], causing billions of dollars in losses for the meat industry. Although the causes of meat spoilage vary, bacteria drive the overall process more than other factors, such as endogenous enzymes (Shao *et al.*, 2021) ^[29].

Prior to slaughter, healthy animal skeletal muscle has traditionally been thought to be sterile, with the exception of the lymph nodes (Darwish *et al.*, 2018) ^[10]. Although intrinsic bacteria may occasionally exist in muscle tissues at low levels, this is not the most frequent cause of contamination. By far, extrinsic causes are the main cause of meat and carcass contamination. During steps in the harvest stage where the external surfaces of the carcass are exposed to potential sources of contamination, bacteria may come into contact with the carcass. According to Lahr (1996) ^[20], feces, ruminal contents, and the hide can contaminate the carcasses microbiologically. Additional cross-contamination points in the slaughter process include carcass-to-carcass contact, human touch, structural elements of the facility, and processing tools and equipment. Fortunately, most of the microflora that is transferred to carcass surfaces is not pathogenic, despite being unsightly (Huffman, 2002) ^[16]. Pre-slaughter handling of livestock and post-slaughter handling of meat play an important part in deterioration of meat quality Dave and Ghaly, 2011 ^[9].

The transformation of animals into meat involves several operations: (a) handling and loading of animals on the farm, (b) transporting animals to slaughterhouses, (c) off-loading and holding of animals and (d) slaughtering of animals (Chambers and Grandin, 2001) ^[5]. Poor operational techniques and facilities in any of these operations will result in unnecessary suffering and injuries to animals which can lead to loss of meat, reduced meat quality and spoilage of meat (Chambers and Grandin, 2001) ^[5]. Therefore, prevention of contamination, after slaughtering, during meat cutting and processing is essential (FAO, 1991) ^[12]. Storage time can be extended through hygienic slaughtering and clean handling of the carcass (FAO, 1990) ^[14]. Different technical operations are involved in slaughtering: (a) stunning, (b) bleeding, (c) skinning, (d) evisceration and (e) carcass splitting. Inadequacy at one stage will result in a rigorous negative impact on the product and/or process in the following stage (FAO, 1991) ^[12].

Analysis of the slaughter process is of central importance for assessment of process performance in production of meat. Slaughter process analysis must also include abattoir-specific microbiological data on carcass contamination during slaughter to enable estimation of risks involved and institute appropriate interventions (Milios *et al.*, 2014; Spescha, *et al.*, 2006) ^[21, 31].

This study was conducted to compare the efficiency of a few simple interventions adopted at a model slaughterhouse in improving meat quality by assessment of the microbial load of the mutton carcasses dressed in this slaughterhouse and comparing it with assessment of the microbial load of the mutton carcasses dressed in two traditional slaughterhouses that did not adopt these interventions, and also to study the effectiveness of chilling and freezing in decreasing microbial load of mutton carcasses.

Materials and Methods

Abattoirs differ in their capacities, technology and equipment, hygiene training, staff and management motivation (Alveseike *et al.*, 2019; Djekic *et al.*, 2016) ^[1, 11], which can be correlated with different hygienic performances and potentially with Salmonella / verocytotoxin producing Escherichia coli presence on dressed carcasses (Blagojevic *et al.*, 2011) ^[2]. The study was conducted in three slaughterhouses. Three different slaughter houses: a model slaughter house, namely the slaughter hall of the department of Livestock Products Technology (Meat Science) Madras Veterinary College (MSH) and two traditional slaughterhouses, namely the Corporation Slaughter House, Perambur, (CSH,P) and the Corporation Slaughter House, Saidapet (CSH,S).

A total of 126 swab samples were collected from mutton carcass surfaces using HiMedia culture collecting device from the above slaughterhouses. Swab samples were collected from four different sites on the carcass such as rump, loin, shoulder and neck (3 slaughterhouses x 4 sites x 6 replicates = 72 samples) at the end of two dressing operations namely flaying and evisceration. Samples were not collected from the rump after evisceration in all the slaughter houses (3 slaughterhouses x 1 site x 6 replicates = 18 samples) and hence 126 swab samples ([72 x 2] -18).

Dressing operations, post - exsanguination was carried out completely on overhead rails in the model slaughter house unlike the traditional slaughterhouses where operations were carried out on the floor, too. Further, a couple of interventions were adopted exclusively in the model slaughterhouse alone, viz., rodding (ligation of the oesophagus) bunting (ligation of the anus) and washing of the carcass.

Further, at the model slaughterhouse, swab samples were collected from mutton carcass surfaces from four different sites namely rump, loin, shoulder and neck and composite meat samples were collected from different mutton cuts namely rump, loin, shoulder and neck before and after chilling the carcasses in a modular blast chiller for 24 hours (4 sites x 2 operations x 6 replicates = 48 swab samples) and before and after freezing the four different cuts in a modular blast freezer for 24 hours (4 sites x 2 operations x 6 replicates = 48 composite meat samples), respectively. The carcasses were washed with clean water subsequent to evisceration and before being placed in the chiller and swab samples were collected after drying of the washed carcass before being placed in the chiller. Chilling and freezing are not practiced in the other 2 slaughter houses.

Microbial assessment was undertaken based on the methods outline in Compendium of Methods for the Microbiological Examination of Foods, 2015. The swab was moistened using 0.1% peptone, prior to swabbing on the carcass surface, and samples were collected by rubbing the swab in a delineated area (25 sq.cm) in the designated sites. Samples once collected, were immediately transferred to a thermocole container containing ice and the samples were transferred over ice to the department of Livestock Products Technology (Meat Science) Madras Veterinary College, Chennai

The swab samples were placed in a test tube containing 0.1 percent sterile peptone water and vigorously shook to obtain an initial dilution of 10-1. In case of composite samples, five gram of meat was taken aseptically and homogenized with 45 ml of 0.1 percent sterile peptone water, in a stomacher to obtain an initial dilution of 10-1. Serial ten-fold dilutions were made up to 10-6 in pre-sterilized tubes containing 9 ml of 0.1 percent peptone water. The sample preparation and plating were carried out under laminar air flow.

One ml of the inoculum from each dilution was placed in pre-identified petri plates and the appropriate media was added to determine total viable count (Plate Count Agar), streptococcal count (KF Streptococcal Agar), staphylococcal count (Baird Parker Agar) and coliform count (Violet Red Bile Agar) and incubated at appropriate temperatures and duration, as specified by the manufacturer.

Results and Discussion

The microbial count of mutton carcass surfaces processed in model slaughterhouse and in traditional slaughterhouses is presented in Table 1. A significant difference ($p < 0.05$) in microbial counts was observed in carcasses obtained from two sources, with the counts being significantly ($p < 0.05$) higher at the end of both flaying and evisceration in all the sites in both the corporation slaughterhouses (CSH) than that of the model slaughterhouse (MSH). However, the difference in the total viable counts between that of corporation slaughterhouse, Perambur (CSH,P) and MSH was not significant ($p < 0.05$) after flaying in case of loin and after evisceration in case of shoulder. Similar findings were reported by Yashoda *et al.*, (2000) [32], who reported that TVC was greater by 1.94 log cfu/ cm² in buffalo carcasses processed by traditional practices than by the improved methods.

It was reported that beef carcasses processed under good hygienic conditions showed surface aerobic bacterial counts of $10^2 \pm 10^4$ /cm² (Nottingham *et al.*, 1982) [23] and $10^3 \pm 10^5$ /cm² (Ingram & Roberts, 1976) [18] and $10^3 \pm 10^4$ / cm² (Nortje *et al.*, 1989) [22]. It was stated that in broad terms, bacterial counts of $10^3 \pm 10^4$ / cm² seems very common and $10^2 \pm 10^3$ / cm² achievable with care in beef carcasses (Roberts & Hudson, 1987) [28]. The TVC of all the sites after both flaying and evisceration at the MSH was under 10^4 / cm² indicating that the hygienic practices adopted at MSH result in production of hygienic meat and even at the CSH's it is less than 4.6, indicating that it is quite acceptable. Rao (1992) also observed high microbial load on sheep carcasses processed in a traditional slaughter unit and attributed the increased microbial load to the floor slaughter practices, contamination from skin, floor washing water and mishandling during evisceration. The differential counts were also significantly greater at the end of both flaying and evisceration in all the sites in CSH than that of MSH. The results clearly highlight that rodding (ligation of the oesophagus) and bunging

(ligation of the anus) are effective interventions in limiting microbial contamination. The results are in corroboration with the report of Rao and Ramesh (1992), that sufficient care in handling during slaughter, dressing and evisceration in production of sheep meat minimises the microbial contamination.

Results of the present study indicate that the microbial counts were higher after evisceration than after flaying at all sites and in all the three slaughterhouses. A reduction in microbial counts was observed by washing with clean water in case of MSH (As already noted washing was not practiced in both CSH). The results reported as before chilling in table 2 are the same as the microbial counts after washing, as the swab samples were collected after drying of the washed carcass and before being placed in the chiller. A similar reduction in microbial counts was reported by Crouse, *et al.*, 1988 [8] in both beef forequarters and hindquarters on washing with cold water.

Whereas TVC have often been used to obtain general information of the surface contamination of carcasses, Enterobacteriaceae counts serve as indicator of fecal contamination. Coliforms and *E. coli* are indicators for the efficacy of the processing techniques (Pandey *et al.*, 1999) [24].

The microbial counts of mutton carcass surfaces before and after chilling in a modular blast chiller is presented in table 2. There is a decrease in microbial counts on chilling though the decrease is not statistically significant except in case of rump and shoulder in respect of TVC and neck in respect of coliform count. Proper chilling methods could directly reduce microbial contamination on carcasses and control their proliferation on carcass surface (Stopforth and Sofos, 2025) [12]. The number of bacterium on the post-chilled carcass was substantially lower than that of the post chilled carcass surface, However, Bolton *et al.*, (2002) [3] have reported an increase in total viable count of pork carcass surfaces after chilling, perhaps due to the steep decline in counts after singeing of pork carcasses. However, there was an increase in staphylococcal count after chilling in this study too.

There is a decrease in microbial counts on freezing though the decrease is not statistically significant. The microbial counts of mutton cuts before and after freezing in a modular blast freezer is presented in table 3. except in case of coliform count. However, an increase in staphylococcal count after freezing was noticed.

Mean $\pm$ S.E Microbial Counts (log cfu/cm²) in Different Sites of Mutton Carcass Surfaces during Different Stages of Slaughter and Dressing in a Modern and Traditional Slaughter Houses

Process	Site of Sampling	Microbial Counts											
		TVC			Streptococcus			Staphylococcus			Coliforms		
		MVC	PSH	SSH	MVC	PSH	SSH	MVC	PSH	SSH	MVC	PSH	SSH
After flaying	Rump	3.41 ^a $\pm$ 0.16	4.21 ^b $\pm$ 0.18	4.35 ^b $\pm$ 0.32	1.42 ^a $\pm$ 0.18	2.31 ^b $\pm$ 0.26	2.11 ^b $\pm$ 0.19	2.33 ^a $\pm$ 0.13	2.89 ^b $\pm$ 0.13	3.03 ^b $\pm$ 0.15	0.34 ^a $\pm$ 0.14	2.03 ^b $\pm$ 0.34	1.59 ^b $\pm$ 0.20
	Loin	3.26 ^a $\pm$ 0.08	3.70 ^{ab} $\pm$ 0.17	4.08 ^b $\pm$ 0.31	1.14 $\pm$ 0.16	1.29 $\pm$ 0.07	1.44 $\pm$ 0.15	2.22 ^a $\pm$ 0.07	2.88 ^b $\pm$ 0.11	2.90 ^b $\pm$ 0.19	0.17 ^a $\pm$ 0.11	1.34 ^b $\pm$ 0.44	1.10 ^b $\pm$ 0.18
	Shoulder	3.25 ^a $\pm$ 0.14	3.95 ^{ab} $\pm$ 0.24	4.58 ^b $\pm$ 0.32	0.86 ^a $\pm$ 0.18	1.96 ^b $\pm$ 0.20	2.09 ^b $\pm$ 0.14	1.86 ^a $\pm$ 0.20	2.71 ^b $\pm$ 0.18	3.24 ^b $\pm$ 0.19	0.21 ^a $\pm$ 0.21	1.79 ^b $\pm$ 0.42	1.65 ^b $\pm$ 0.20
	Neck	3.17 ^a $\pm$ 0.16	4.04 ^b $\pm$ 0.17	4.32 ^b $\pm$ 0.23	0.98 ^a $\pm$ 0.12	1.58 ^b $\pm$ 0.18	1.84 ^b $\pm$ 0.23	1.94 ^a $\pm$ 0.11	2.61 ^b $\pm$ 0.18	2.75 ^a $\pm$ 0.29	1.20 ^a $\pm$ 0.27	1.78 ^b $\pm$ 0.13	2.06 ^b $\pm$ 0.13
After evisceration	Loin	3.34 ^a $\pm$ 0.24	4.13 ^b $\pm$ 0.16	4.22 ^b $\pm$ 0.21	0.97 ^a $\pm$ 0.18	1.67 ^b $\pm$ 0.18	1.54 ^b $\pm$ 0.11	1.91 ^a $\pm$ 0.21	2.71 ^b $\pm$ 0.18	3.59 ^c $\pm$ 0.13	0.58 ^a $\pm$ 0.15	1.98 ^b $\pm$ 0.34	1.51 ^b $\pm$ 0.17
	Shoulder	3.61 ^a $\pm$ 0.14	4.19 ^b $\pm$ 0.16	4.49 ^b $\pm$ 0.23	0.76 ^a $\pm$ 0.16	1.86 ^b $\pm$ 0.22	1.62 ^b $\pm$ 0.08	2.16 ^a $\pm$ 0.21	3.01 ^b $\pm$ 0.21	3.59 ^b $\pm$ 0.20	0.28 ^a $\pm$ 0.24	2.25 ^b $\pm$ 0.36	1.69 ^b $\pm$ 0.21
	Neck	3.36 ^a $\pm$ 0.14	4.17 ^b $\pm$ 0.16	4.47 ^b $\pm$ 0.20	0.79 ^a $\pm$ 0.18	1.51 ^b $\pm$ 0.10	1.57 ^b $\pm$ 0.21	2.00 ^a $\pm$ 0.17	2.91 ^b $\pm$ 0.16	3.11 ^b $\pm$ 0.19	0.28 ^a $\pm$ 0.24	2.25 ^b $\pm$ 0.36	1.69 ^b $\pm$ 0.21

Means bearing different superscripts in columns (a, b) within the respective micro-organism concerned, differ significantly ($P \leq 0.05$)

MVC: Slaughter hall, Department of Livestock Products Technology (Meats), Madras Veterinary College, Chennai – 7 (Modern Slaughterhouse)

PSH: Corporation Slaughterhouse, Perambur, Chennai – 12 (Traditional Slaughterhouse)

SSH: Corporation Slaughterhouse, Saidapet, Chennai – 15 (Traditional Slaughterhouse)

Effect of Chilling on the Mean $\pm$ S.E Microbial Counts (log cfu/cm²) in Different Sites of Mutton Carcass Surfaces

Site of Sampling	Microbial Counts							
	TVC		Streptococcus		Staphylococcus		Coliforms	
	Before chilling	After chilling	Before chilling	After chilling	Before chilling	After chilling	Before chilling	After chilling
Rump	3.33 ^a $\pm$ 0.16	2.85 ^b $\pm$ 0.11	1.10 $\pm$ 0.40	0.80 $\pm$ 0.26	2.62 $\pm$ 0.30	2.71 $\pm$ 0.31	0.35 $\pm$ 0.17	0.16 $\pm$ 0.12
Loin	3.25 $\pm$ 0.18	2.88 $\pm$ 0.25	1.23 $\pm$ 0.29	0.97 $\pm$ 0.22	2.63 $\pm$ 0.06	2.70 $\pm$ 0.23	0.25 $\pm$ 0.12	0.01 $\pm$ 0.01
Shoulder	3.35 ^a $\pm$ 0.20	2.65 ^b $\pm$ 0.22	1.35 $\pm$ 0.40	1.11 $\pm$ 0.25	2.78 $\pm$ 0.19	2.65 $\pm$ 0.24	0.60 $\pm$ 0.15	0.36 $\pm$ 0.17
Neck	3.23 $\pm$ 0.23	2.93 $\pm$ 0.26	0.93 $\pm$ 0.36	0.59 $\pm$ 0.31	2.16 $\pm$ 0.39	2.15 $\pm$ 0.44	0.65 ^a $\pm$ 0.17	0.13 ^b $\pm$ 0.13

Means bearing different superscripts in columns (a, b) within the respective micro-organism concerned, differ significantly ($P \leq 0.05$)

Effect of Freezing on the Mean $\pm$ S.E Microbial Counts (log cfu/g) in Different Cuts of Mutton

Site of Sampling	Microbial Counts							
	TVC		Streptococcus		Staphylococcus		Coliforms	
	Before freezing	After freezing	Before freezing	After freezing	Before freezing	After freezing	Before freezing	After freezing
Rump	3.24 $\pm$ 0.26	3.03 $\pm$ 0.26	3.09 $\pm$ 0.18	2.29 $\pm$ 0.33	3.32 $\pm$ 0.18	3.58 $\pm$ 0.15	1.90 ^a $\pm$ 0.45	0.26 ^b $\pm$ 0.26
Loin	3.14 $\pm$ 0.28	2.96 $\pm$ 0.28	3.01 $\pm$ 0.22	2.59 $\pm$ 0.26	3.52 $\pm$ 0.18	3.50 $\pm$ 0.13	2.31 ^a $\pm$ 0.28	1.19 ^b $\pm$ 0.26
Shoulder	3.41 $\pm$ 0.33	3.05 $\pm$ 0.28	3.20 $\pm$ 0.18	2.34 $\pm$ 0.36	3.41 $\pm$ 0.11	3.57 $\pm$ 0.15	2.28 ^a $\pm$ 0.36	0.74 ^b $\pm$ 0.38
Neck	3.57 $\pm$ 0.34	3.14 $\pm$ 0.31	3.22 $\pm$ 0.20	2.50 $\pm$ 0.27	3.53 $\pm$ 0.11	3.54 $\pm$ 0.16	2.63 ^a $\pm$ 0.30	0.72 ^b $\pm$ 0.34

Means bearing different superscripts in columns (a, b) within the respective micro-organism concerned, differ significantly ($P \leq 0.05$)

Conclusion

The study indicates that rodding (ligation of the oesophagus) and bunging (ligation of the anus) are effective interventions in limiting microbial contamination. Chilling and freezing for 24 hours are effective in reducing microbial load, except that of *Staphylococcus*.

Conflict of Interest

Not available

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Not available

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