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The Effect of Seasonal Variation on the Hygienic Standard of Beef Carcasses in Al Baha Region, Kingdom of Saudi Arabia

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Abstract

The present study was designed to monitor the microbiological quality of beef from local and imported cattle in the main slaughterhouse of Al Baha, Kingdom of Saudi Arabia and the effect of seasonal variation on it. The total aerobic viable count (TAVC) was calculated on samples collected from six different sites of carcasses during winter and summer. The mean TAVC (log 10 CFU/cm^2), during winter, in the local breed ranged between 2.65 to 3.02 and for the imported cattle ranged between 2.97 to 3.47. During summer, the count for the local breed was between 3.34 – 3.86 and between 3.77 – 4.09 for imported cattle. There was a significant difference in microbial contamination between samples collected during summer and winter from local and imported cattle. As well, the difference was significant between samples from imported and local cattle. The findings further demonstrated that the sampling site may affect the rate of microbial contamination. TAVC indicated increased microbial contamination in the sir loin, neck and top site; these sites are near the ground, during carcass hanging, which may increase the rate of microbial contamination. Effect of microbial contamination on food safety were discussed, conclusions drawn and methods to improve meat hygiene practice in the region were recommended.

Keywords: Beef, Season, Hygiene, Microbial, Counts, Slaughterhouse, Carcass, Meat hygiene, Saudi Arabia.

INTRODUCTION

Meat is described as the most important source of protein available for human consumption. At the same time, meat is the most perishable of all foods since it contains sufficient nutrients needed to support the growth of different types of microorganisms. Microbial contamination of meat may affect its quality, lead to food poisoning or transmission of food-borne pathogens to man. Spoilage can be defined as any change in a food product that makes it unacceptable to human consumption from a sensory point of view (Gram et al., 2002). The development of organoleptic spoilage is related to microbial feeding on meat nutrients such as sugars and free amino acids and the release of undesired volatile metabolites. Microbial loads from 10^7 cfu/cm^2 are usually associated with occurrence of unpleasant odours. These may turn to putrid smells as the result of free amino acid metabolism at loads as high as 10^9 cfu/cm^2 (Dainty et al., 1985; Jay, 2000).

A challenging problem to the meat industry is the microbial population that comes in contact with fresh meat during slaughtering, dressing and processing. Therefore intermittent microbial analysis and constant monitoring are necessary to produce hygienic and wholesome meat to ensure safe public health. A recent study in Cote d'Ivoire, (Koffi-Nevry et al., 2011) monitored the bacteriological quality of retail beef at regular intervals. It was reported that the mean counts (log 10 cfu/g) of total aerobic microorganisms, faecal coliforms, *Staphylococcus aureus*, Pseudomonas, were 4.93, 1.83, 1.53 and 1.29 at 6: am and at 8.1, 4.73, 2.43 and 2.79 at 6: pm, respectively. Another study from Ghana reported that in beef samples obtained from five meat shops, the mean log counts were 6.22, 5.76, 5.64, 5.59 and 5.57 log 10 cfu/cm^2 .Bacterial species isolated from the beef samples were *Escherichia coli ,* Streptococcus species, Salmonella species and Staphylococcus species (Adzitey et al., 2011). Superficial bacterial contamination of bovine carcasses was studied at El- Harrach slaughterhouse in Algeria; quantitatively by counting the total viable bacteria and qualitatively by the research for Salmonella spp. at 3 different bovine carcasses sites. Carcasses were examined just after eviscerating. Wet-dry double swab sampling was used. The results showed that the brisket area and the posterior side of the foreleg were the most contaminated areas. Salmonella was isolated on 7 bovine carcasses (10%) (Nouichi and Hamdi, 2009). In South Australia, 523 chilled beef and lamb carcasses were sampled from four abattoirs and 13 very small plants (VSPs) in order to develop a microbiological profile of meat produced for domestic consumption within the State. Aerobic viable counts (AVCs) and *E. coli* counts were obtained from samples taken by sponge-sampling of the muscle-adipose tissue. On beef carcasses (n=159) mean log AVC/ cm^2 was 1.82 and *E. coli* was detected on 18.8% of carcasses (Sumner et al., 2003). Another study of the microbiological load of beef showed that most of the parameters of the score sheet observed for evaluating hygienic operations were classified as being of maximum risk C. The aerobic plate counts of enterobacteriacea, mold and yeast and staphylococci increased insignificantly after cutting to 9.7x10^2 , 6.4x10, 2.6x10^2, and 3.7x10 cfu/cm^2, respectively. Washing of the carcasses decreased counts insignificantly to 6.4x10^2, 2.0x10, 1.7x10^2, and 2.0x10 cfu/cm^2, respectively (Gomaa et al., 2003).

During the slaughtering process, the main sources of contamination are the slaughtered animals themselves, the staff and the work environment (Bell and Hathaway., 1996).

The effect of the season on microbial contamination has been studied by Dennai *et al.,* (2001), Barkocy_Gallagher *et al.,* (2003) and McEvoy *et al.,* (2003) who have all shown that the peak of bacterial contamination of carcasses in particularly for the total aerobic viable count (TAVC) is observed in summer.

Beef production in the Kingdom of Saudi Arabia has characteristics typical of a warm climate and intensive animal husbandry practices. Beef farming in Al Baha Province does not exist as such; cattle are reared by native people in small farms for milk production and culled cows and calves are sent for slaughter. Shortage of cattle supply for slaughtering is compensated for by imported cattle. The present study was designed to compare microbial load of local and imported cattle produced for domestic consumption in Al Baha Province and to determine the seasonal effect on microbial prevalence. And to identify potential hazards associated with animal slaughtering.

MATERIALS and METHODS

Specimen Collection

Specimens for total aerobic viable count (TAVC) were taken from local and imported cattle carcasses in Al Baha slaughterhouse. A total of 24 beef carcasses, 12 of local breed cattle and 12 of imported cattle were randomly selected. From each breed, six carcasses were tested during winter and six during summer for 11 weeks in each season. They were sampled at six sites (shank, thin flank, loin, neck, top site, sir loin) for each carcass. Samples were collected by swabbing an un-delimited area of approximately 50 cm² with sterile cotton swabs. Samples were immediately transported to the laboratory for microbiological investigation.

Microbiological Investigation:

Contents of each sterile cotton swab were homogenized into solution by stirring into a sterile test-tube containing 10 ml of 0.1 % (wt/vol) pH 7.0 peptone water. A 1-ml portion of each homogenate was used to prepare 10-fold dilutions to 10^{-3} in 0.1% (wt/vol) peptone water. Portions of 0.1 ml of the homogenate and each dilution were spread on duplicate plates of plate count agar (Oxoid), and incubated for 48 h at 30ºC (APHA, 1992), to determine the levels of aerobic bacteria (TAVC). The enumeration method had a minimum detection limit of 5 Colony Forming Unit (CFU) cm². Counting is done using automatic colony counter. For each site, 11 counts were obtained during each season as C.F.U. per 1cm², the mean was calculated and from it log 10 CFU/cm² was obtained.

Statistical Analysis

Univariate analysis of variance was carried out to compare groups and determine level of significance using SPSS statistical package software.

RESULTS

Microbial Contamination

The TAVC was counted on six sites from local breed and imported cattle during winter. Sampling was done 11 times and the mean and log 10 CFU/cm² were obtained. In the local breed, the count ranged between 2.65 to 3.02 log 10 CFU/cm² (Table 1) and for the imported cattle ranged between 2.97 to 3.47 log 10 CFU/cm² (Table 2). During summer, the count for the local breed was between 3.34 – 3.86 log 10 CFU/cm² (Table 3) and between 3.77 – 4.09 log 10 CFU/cm² for imported cattle (Table 4). The effect of breed on microbial contamination was compared between the local and imported breeds in

Table 1. The total microbial load, mean and log 10 CFU/cm² in six carcasses' sites from local breed cattle during winter in Al Baha slaughter house

Sample	Shanks	Thin flank	Loin C.F.U. per 1cm²	Neck	Top site	Sir loin
Total	11556	8162	4923	5599	8380	7306
Mean	1050.54	742	447.55	509	761.82	664.18
Log 10 CFU/cm²	3.02	2.87	2.65	2.71	2.88	2.82

Table 2. The total microbial load, mean and log 10 CFU/cm² in six carcasses' sites from imported cattle during winter in Al Baha slaughter house

Sample	Shanks	Thin flank	Loin C.F.U. per 1cm²	Neck	Top site	Sir loin
Total	21178	10376	25603	30116	12540	32624
Mean	1925.27	943.27	2327.55	2737.82	1140	2965.82
Log 10 CFU/cm²	3.28	2.97	3.37	3.44	3.06	3.47

Table 3. The total microbial load, mean and log 10 CFU/cm² in six carcasses' sites from local breed cattle during summer in Al Baha slaughter house

Sample	Shanks	Thin flank	Loin C.F.U. per 1cm²	Neck	Top site	Sir loin
Total	24194	68009	78836	69684	53663	33577
Mean	2199.45	6182.64	7166.91	6334.91	4878.45	3052.45
Log 10 CFU/cm²	3.34	3.79	3.86	3.80	3.69	3.48

Table 4. The total microbial load, mean and log 10 CFU/cm² in six carcasses' sites from imported cattle during summer in Al Baha slaughter house

Sample	Shanks	Thin flank	Loin C.F.U. per 1cm²	Neck	Top site	Sir loin
Total	128222	126060	65110	120316	131836	134623
Mean	11656.54	11460	5919.09	10937.82	11985.09	12238.45
Log 10 CFU/cm²	4.07	4.06	3.77	4.04	4.08	4.09

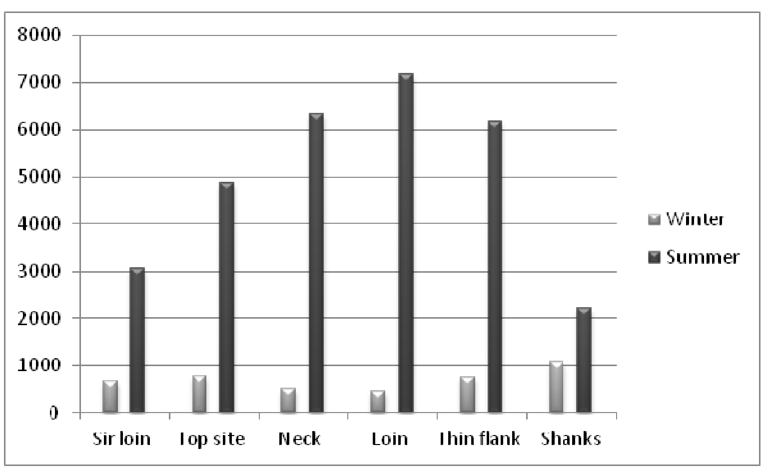

Figure 1. Comparison of the viable aerobic bacterial count in six carcasses' sites of local breed cattle in Winter & Summer in Al Baha slaughter house

winter and summer. The finding shows that the rate of microbial contamination in all sites was higher in samples from the imported cattle than the local breed in both winter (Figure 1) and summer (Figure 2). The effect of season was tested for the local breed where it was demonstrated that the rate of microbial contamination in all sites was higher in samples collected during summer than winter (Figure 3). As well, the contamination rate in

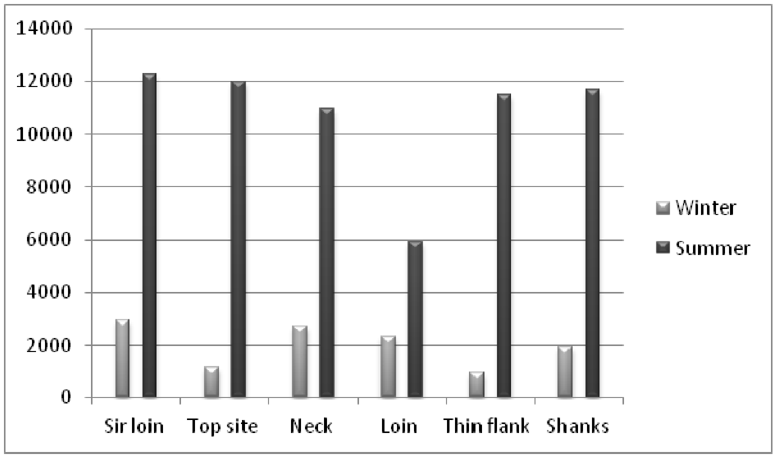

Figure 2. Comparison of the viable aerobic bacterial count in six carcasses' sites of imported cattle in Winter & Summer in Al Baha slaughter house

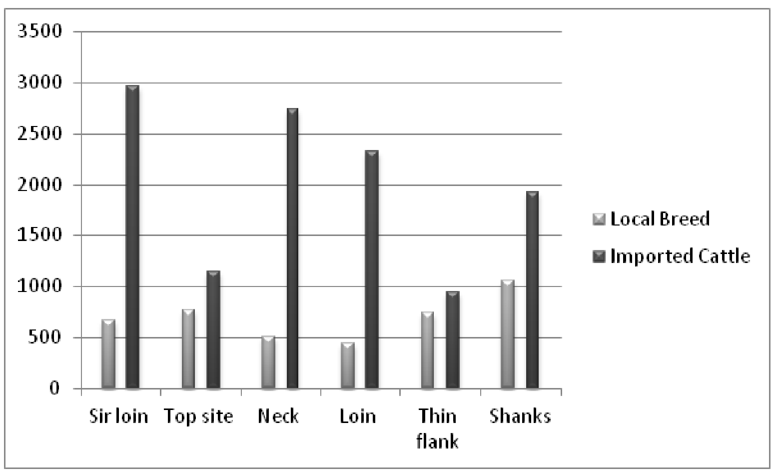

Figure 3. Comparison of the viable aerobic bacterial count in six carcasses' sites from local and imported cattle during winter in Al Baha slaughter house

the imported cattle was higher in samples collected during summer than winter (Figure 4).

Statistical analysis of the effect of seasonal variation on microbial contamination in the different sites of both breeds is displayed on table (5). For the local breed, in samples from the shank and loin, the difference between winter and summer was not significant while in samples from the thin flank, neck, top site and sir loin the difference was significant. For the imported cattle, in samples from the shank, loin and top site, the difference between winter and summer was not significant but in samples from thin flank, neck and sir loin the difference was significant.

The effect of breed variation, statistically, on microbial contamination in the different sites is shown on table (6). During winter, in samples from the shank, thin flank, neck and top site, the difference between local and imported breeds was not significant but in samples from the loin and sir loin the difference was significant. In summer, in samples from the shank, loin and neck the difference was not significant while the difference was significant in samples from thin flank, top site and sir loin.

DISCUSSION

Microbial contamination of meat is a route through which pathogenic microorganisms may enter the food chain of man causing a potential hazard of disease transmission. In the present study, the total aerobic viable count (TAVC) was calculated and compared in meat samples from local breed and imported cattle during winter and summer to examine the effect of seasonal and breed variation. The level of the total aerobic viable count is generally accepted as a criterion for microbial contamination of carcasses, and a useful indicator of hygiene (Zweifel and Stephan, 2003). In general, in the present study, the criteria used for comparison showed

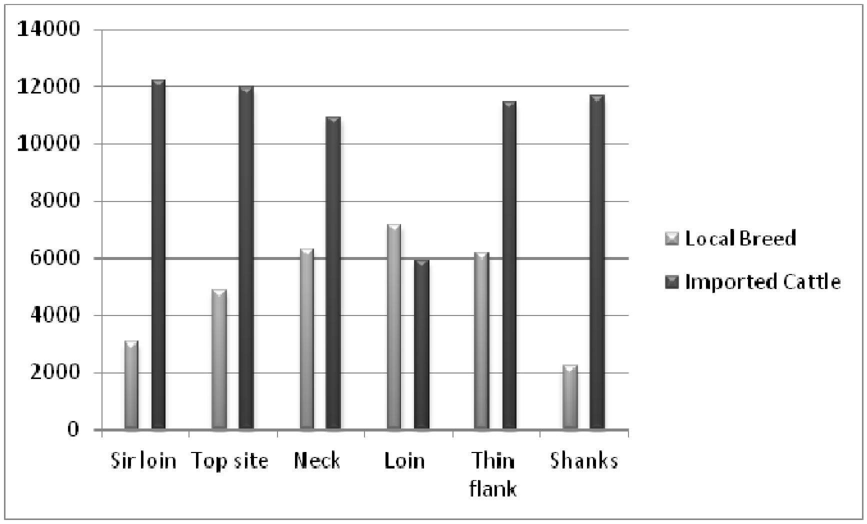

Figure 4. Comparison of the viable aerobic bacterial count in six carcasses' sites from local and imported cattle during summer in Al Baha slaughter house.

Table 5. Statistical analysis by a paired sample test to detect the effect of seasonal variation on microbial contamination of local and imported meat from Al Baha slaughterhouse.

No.	Sample site	Type of Breed	Mean of C.F.U. per 1cm^2		Mean difference	Sig(2tailed)
			Winter months	Summer months		
1	Shanks	Local	1050.55	2199.45	-1148.90	0.086
		Imported	1925.27	11656.55	-9731.28	0.000
2	Thin flank	Local	742	6182.64	-5440.64	0.001
		Imported	943.27	11457.18	-10513.9	0.000
3	The loin	Local	447.55	7166.91	-6719.36	0.000
		Imported	2327.55	5919.09	-3591.54	0.035
4	The neck	Local	509	6334.91	-5825.91	0.001
		Imported	2737.82	10937.82	-8200.00	0.001
5	The top site	Local	761.82	4878.45	-4116.63	0.002
		Imported	1140	11985.09	-10845.1	0.000
6	The Sir loin	Local	664.18	3052.45	-2388.27	0.003
		Imported	2965.82	12238.45	-9272.63	0.004

Table 6. Statistical analysis by a paired sample test to detect the effect of breed variation on microbial contamination of meat during winter and summer from Al Baha slaughterhouse

No.	Sample site	Breed cattle's sources and seasons	Mean of C.F.U. per 1cm^2		Mean difference	Sig(2tailed)
			Local source	Imported sources		
1	Shanks	During winter	1050.55	1925.27	-874.73	0.213
		During summer	2199.45	11656.55	-9457.09	0.000
2	Thin flank	During winter	742	943.27	-201.27	0.327
		During summer	6182.64	11457.18	-5274.55	0.006
3	The loin	During winter	447.55	2327.55	-1880	0.008
		During summer	7166.91	5919.09	1247.82	0.453
4	The neck	During winter	509	2737.82	-2228.82	0.000
		During summer	6334.91	10937.82	-4602.91	0.077
5	The top site	During winter	761.82	1140	-378.18	0.326
		During summer	4878.45	11985.09	-7106.64	0.001
6	The sir loin	During winter	664.18	2965.82	-2301.64	0.017
		During summer months	3052.45	12238.45	-9186	0.002

differences in counts obtained during winter and summer between local and imported breeds. During winter, counts of samples from local breed cattle ranged from 2.65 – 3.02 log 10 cfu/ cm², imported ranged from 2.97 – 3.47 log 10 cfu/ cm² in different sites. During summer, the range was 3.34 – 3.86 log 10 cfu/ cm² in local breed and 3.77 – 4.09 log 10 cfu/ cm² in imported cattle. The average level of superficial bacterial contamination of bovine carcasses during winter was 3.10 log 10 cfu/ cm² and in summer was 3.76 log 10 cfu/ cm² . The results of the present study from beef carcasses are relatively lower than those of El-Hadef *et al.* (2005) who found a mean log TAVCs of 5.34 cfu / cm² at Constantine slaughterhouse, and those of Dennai *et al.* (2001) who have obtained a contamination level of 5.15 log cfu/ cm² at Kenitra slaughterhouse in Morocco. Our results are higher than those of Phillips *et al.,* (2001), Sumner *et al.* (2003), and Phillips *et al.* (2006) in Australia, who recorded respectively mean log counts of 2.42 cfu/ cm², 1.82 cfu/ cm2 and 1.3 cfu/ cm². However, in Switzerland, the superficial contamination of bovine carcasses through five slaughterhouses was estimated at an average level ranging from 2.1 to 3.1 log cfu/ cm² (Zweifel *et al.,* 2005) which is comparable with the results of the present study especially during winter. On the other hand, it has been proposed that microbiological performance criteria for samples taken by swabbing be set at 20% of the values set for excision samples. Therefore, log mean TVCs in carcass swab samples taken before chilling are acceptable, marginal and unacceptable when they are < 2.8, 2.8–4.30 and >4.30 cm², respectively (McEvoy *et al*., 2004). Based on this criteria, TAVC on carcasses in the present study were in marginal range. It was further suggested that the marginal result was in most part due to hide removal processes (McEvoy *et al*., 2004).

The effect of season on TAVC is shown on figures (1) and (2) which indicate that counts recorded in summer are higher than in winter for both breeds. This finding of the present study is in agreement with the results of other studies by Dennai *et al.,* (2001), Barkocy_Gallagher *et al.,* (2003) and McEvoy *et al.,* (2003) who have all shown that the peak of bacterial contamination of carcasses in particularly for the TAVC and *Salmonella* is observed in summer. Rise of temperature during summer may constitute optimum conditions for microbial growth and division in meat. Statistical analysis using a paired sample test of the effect of seasonal variation on microbial load in the different sites of the carcasses is shown on table (5). In general, it showed that there was a significant difference (p<0.001) between counts in winter and summer in the slaughter house. Going through results of the test on different sites of carcass, in the shanks, samples collected in winter and summer indicated no significant difference between local and imported breeds. The local breed showed no significant difference in microbial contamination in summer compared to winter. Also there was indication that in the thin flank, the local breed showed a significant difference (p<0.01) in microbial contamination in summer compared to winter. For the loin, the difference was not significant. In the neck, the top site and sir loin it showed a significant difference (p<0.01) in microbial contamination in summer compared to winter.

From imported cattle during summer there was a significant difference (p<0.05) with samples obtained in winter. In samples from the shank, thin flanks and top site, the difference between winter and summer was not significant. In the loin, there was a significant difference (p<0.05) between samples obtained in summer and winter. As well, there was a significant difference between samples collected in winter and summer from the neck (p<0.001) and sir loin (p<0.01).

The findings of the present study indicate that the sampling site may affect the rate of microbial contamination. TAVC indicated increased microbial contamination in the sir loin, neck and top site. During carcass hanging, the neck, shank and brisket are near the ground which may increase the rate of microbial contamination. In addition, skinning and evisceration are processes that may increase contamination of meat if strict hygienic measures are not observed. The differences in superficial bacterial loads depending on the anatomic sampling sites were reported by some authors (McEvoy *et al.,* 2000; Dennai *et al.,* 2001; Yalçin *et al.,* 2001; El-Hadef *et al*., 2005). Results of the present study are in agreement with those of McEvoy *et al.,* (2000) who indicated that the brisket has always been the most contaminated area regardless of the hygienic condition of the skin. Yalçin *et al.,* (2001) have also shown that the coliform contamination was mostly located on the brisket and shoulder, while the thigh was the least affected. El-Hadef *et al.,* (2005) have shown that the thigh presented the lowest level of contamination for both species ovine and bovine. Finally, Zweifel and Stephan, (2003) have noted that the collar and the brisket are the most contaminated sites, and that differences in levels of contamination between different sites are more significant in the bovine species.

Comparison of effect of the breed on TAVC, in the present study, is shown on figures (3) and (4) where counts of the imported cattle are higher than local breeds. This could be explained by the effect of transportation stress for imported cattle and husbandry techniques' variation from country to country. Smith et al., (1997) reported that pen maintenance was considered a good management practice to reduce exposure of cattle to microbial contamination. The effect of breed variation, statistically, on microbial contamination in the different sites is shown on table (6). Samples from the shanks and neck showed no significant difference between the two breeds. There was a significant difference between the two breeds in samples from thin flank in summer (p<0.05) and the sir loin in winter and summer (p<0.001). The results of the present study demonstrated that there was microbial contamination of beef samples from Al Baha slaughterhouse and further studies are needed in this issue. Based on these results, intervention is necessary to implement scientific procedures as Pre-requisite programmes, Good Manufacturing Practices and perhaps the Hazard Analysis by Critical Control Points (HACCP) to make the product more safe. The production of safe food is being increasingly based on the use of risk analysis, and this process is now in use to establish national and international food safety objectives (Rajic et al., 2007). HACCP is a systematic approach to the identification, assessment, and control of hazards in the food chain. One part of the overall risk analysis procedure is the scientific process in which the hazards and risk factors are identified, and the risk estimate or risk profile is determined. It is strongly recommended to apply Pre-requisite programmes, Good Manufacturing Practices and the HACCP system in the slaughter house of this area.

CONCLUSION

The results of the present study revealed that microbial contamination of meat at the slaughterhouse were of a marginal range. TAVC increased during summer compared to winter as rise in temperature and humidity may promote microbial multiplication. It is clear that variability in microbial count in different anatomic sites and between local and imported cattle, indicate the need for use of Pre-requisite programmes, Good Manufacturing Practices as a base to introduce HACCP programme in meat hygiene. Improved surveillance of the slaughterhouse is important to preserve high standards of food hygiene and public health.

RECOMMENDATION

Further research and studies are needed to assess knowledge, attitude and behaviors of worker in slaughters and meet butchers regarding food hygiene and safety. Policy makers should implement more safety and hygiene policy to promote healthy and safer food. For example they may require proof of training from slaughters and meet butchers to obtained their license.

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