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EVALUATION OF GOOD HYGIENIC PRACTICES IN REDUCING BACTERIAL LOAD IN BUTCHER SHOPS IN KHARTOUM STATE, SUDAN

Sahar Ahmed Adam Yousif[1] and Elniema Abdelkhalig Mustafa*[1]

Department of Food Safety and Veterinary Public Health, College of Veterinary Medicine, University of Bahri, Sudan.

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***Corresponding Author**
Dr. Elniema Abdelkhalig Mustafa
Department of Food Safety and Veterinary Public Health, College of Veterinary Medicine, University of Bahri, Sudan.

ABSTRACT

This cross-sectional analytical study was carried out during the year 2019 in the three Khartoum State localities (Khartoum, Omdurman and Bahri), Sudan with the objective to assess the effect of good hygienic practices (GHPs) on reducing bacterial load of minced meat in butcher shops. Eighteen butcher shops (open and closed, 9 for each) from the three localities were investigated. Both checklists and microbiological tests were used in the evaluation. Eighteen minced meat samples were collected and examined bacteriologically. This study revealed good floor cleaning conditions in closed butcher shops, while open shops scored adequate conditions with no significant differences between them (p> 0. 223). The study also revealed poor hygienic practices concerning the antimicrobial solution (disinfection) used for washing down of preparation areas in both open and close shops with no significant differences between them (*p*= 0.11). Equipment such as mincers and weighing scales sanitation were assessed as good and adequate in all butcher shops with closed shops scored better conditions with no significant difference between them (p-value =0.526). This was evident by the negative correlation between GHPs regarding equipment cleaning and the prevalence of *E. coli* (R_2= -0.519, *p*=0.027). Khartoum locality scored less positive *E. coli* isolates (1, 16.7%) as compared to Bahri (2, 66.7%) and Omdurman (3, 100%). Whereas, in closed butcher shops there were adequate GHPs in Khartoum (100%) and Omdurman (66.7%) that prevented meat not to fall on the floor, these were totally absent in Bahri (0.0%). This was evident by the negative correlation between GHPs in terms of meat not found dropped on the floor (R2= -0.495, *p*=0.037) and the percentage of *E. coli*. While, the percentage of *E. coli*

distribution in the study area was 38.9%, the difference between the prevalence of *E. coli* in open and closed butcher shops was significantly different (p=0.025). It could be concluded that poor hygiene practices in open butcher shops was reflected in the exceeding limits of *E. coli* prevalence and high mean bacterial counts.

KEYNOTES: Butcher shops, Good Hygienic practices, E. coli count; total bacterial count.

INTRODUCTION

Meat is frequently implicated in the spread of food-borne diseases such as Salmonellosis, tuberculosis and pathogenic serotypes of *Escherichia coli*, such as O157:H7 (Olaoye and Nilude, 2010; Saad, 2009). On the other hand, minced beef meat which is usually made from lean meat is highly nutritious substrate with a_w (0.92- 0.95) and is considered suitable for the growth of most microorganisms (Dainty et al., 1975).

Contamination of meat can result from contaminated working surfaces, equipment and workers' hands used in the processing. Mustafa et al. (2016) reported that several factors contribute to meat contamination in Khartoum State, which are obviously seen from the poor handling during processing, distribution and display of meat to the consumers.

Hence, the objective of this study was to evaluate the implementation of good hygienic practices (GHPs) of minced meat in closed and open butcher shops in Khartoum State.

MATERIAL AND METHODS

Study area and design

A cross-sectional analytical study was carried out during the year 2019 in the three Khartoum State localities (Khartoum, Omdurman and Bahri).

Six open and closed butcher shops (three for each) in each locality with a total of 18 in the three localities were investigated.

Both checklists and microbiological tests were used in the evaluation.

Data collection

- **Checklist**

A structured and descriptive checklist was used to evaluate the GHPs in butcher shops. It contained the international standards set by Codex Alimentations Commission.

The "Points-Based Systems" which are usually scored on a 100 point scale were used.

The researcher determined the score by the number and severity of the health violations.

Health violations in butcher shops were categorized as high-risk and low-risk as appear in Table (1) below.

Table 1: General Points-Based Scoring.

Score	Condition	Violations
90 or higher	Good	One or two low-risk violations May have one high-risk violation
80-89	Adequate	Several low-risk violations May have one high-risk violation
70-79	Needs Improvement	Multiple low and high-risk violations
69 or lower	Poor	Many low and high-risk violations

Sample collection

The second method of evaluation of the GHPs was swab sampling of 18 butcher shops.

The criteria for selecting butcher shops were for shops only producing total supply of minced meat and/ or meat preparations of <500Kg/week as described by EC No.2073 (2005).

Sample size, collection and transport

Minimum sampling frequencies (One sample per facility) for butcher shops producing minced meat and meat preparations in small quantities as per Commission Regulation EC No.2073 (2005) on Microbiological Criteria for food stuffs was followed.

Eighteen minced meat samples were collected from both closed and open shops.

Because minced meat and meat preparations from red meat in Sudan are intended to be eaten cooked, therefore, a 5x10g samples from the batch of minced meat or meat preparations were taken.

Meat samples were transported to the laboratory of the College of Veterinary Medicine at University of Bahri using an insulated ice box contained an ice packs (4 ºC).

Methods

Microbial analysis

The plate count agar was used for the determination of total bacterial count according to Ramakant (2006).

Determination of Aerobic colony count (ACC) and *E. coli*

For minced meat in butcher shops, Process Hygiene Criterion (PHC) was followed for the microbiological analysis as per EC (2005).

The results of PHC usually provide an indication of performance and control of the production process at the time of sampling (Meat industry guide, Microbiological Criteria, 2017). ACC was determined by using ISO 4833 or valid alternative method. *E. coli* was determined by using ISO 16649-1, ISO 16649-2.

Statistical analysis

The collected data were coded and analyzed using Statistical Packaging for the Social Sciences (SPSS/PCversion21 for windows). Data were analyzed for Descriptive Statistical Analysis. Chi-square was also used with the hypothesis that the compliance with hygienic measures was uniform among all butcher shops.

RESULTS

Table (2) shows that the good floor cleaning in open butcher shops was reported in Bahri and Omdurman 2 (66.7%) and 1 (33.3%), respectively. While good floor cleaning in closed butcher shops was reported in Khartoum, Bahri and Omdurman 3 (100.0%), 3 (100.0%) and 2 (66.7%), respectively. The result shows no significant differences between open and closed butcher shops in terms of floor cleaning (p> 0. 223).

Table 2: Effect of GHPs on floor cleaning by locality and type of butcher shop.

Type of butcher shop			Locality			Total
			Khartoum	Bahri	Omdurman	
Open butcher shop	Floor cleaning	Good	0 (0.0%)	2 (66.7%)	1 (33.3%)	3 (33.3%)
		Adequate	3 (100.0%)	1 (33.3%)	2 (66.7%)	6 (66.7%)
	Total		3 (100.0%)	3 (100.0%)	3 (100.0%)	9 (100.0%)
Closed butcher shop	Floor cleaning	Good	3 (100.0%)	3 (100.0%)	2 (66.7%)	8 (88.9%)
		Adequate	0 (0.0%)	0 (0.0%)	1 (33.3%)	1 (11.1%)
	Total		3 (100.0%)	3 (100.0%)	3 (100.0%)	9 (100.0%)

$\chi 2$= 3.0; DF=2; p-value =.223 (Not significant)

Table (3) displays that a mincer cleaning condition was adequate (100%) in open butcher shops in the three localities. In closed ones the good conditions was reported in Khartoum (66.7%), Bahri (66.7%) and Omdurman (33.3%).

Table 3: Effect of GHPs on mincer cleaning conditions by locality and type of butcher shop.

Type of butcher shop			Locality			Total
			Khartoum	Bahri	Omdurman	
Open butcher shops	Mincer cleaning condition	Adequate	3 (100.0%)	3 (100.0%)	3 (100.0%)	9 (100.0%)
	Total		3 (100.0%)	3 (100.0%)	3 (100.0%)	9 (100.0%)
Closed butcher shops	Mincer cleaning condition	Good	2 (66.7%)	2 (66.7%)	1 (33.3%)	5 (55.6%)
		Adequate	1 (33.3%)	1 (33.3%)	2 (66.7%)	4 (44.4%)
	Total		3 (100.0%)	3 (100.0%)	3 (100.0%)	9 (100.0%)

P-value not computed because the variable is constant

The study also displays the effect of GHPs in terms of availability of paper towel, soap and nailbrush. Poor hygienic practices in terms of availability of paper towel, soap and nailbrush was reported among all (100.00%) open and closed butcher shops in the three localities.

Other vital items required in butcher facilities are cleaning material (detergents and disinfectants) availability. The study revealed that there was no significant difference ($p>0.136$; $\chi2= 7.2860$; DF=4) between both open and closed butcher shops.

The results also shows the effect of GHPs in terms of availability of antimicrobial solution used for washing down of preparation areas. Poor hygienic practices for antimicrobial solution used were found in open butcher shops in Khartoum (100.0%) and Bahri (33.3%). Most of closed butcher shops were found in need of improvement in Khartoum (66.7%), Bahri (33.3%) and Omdurman (33.3%). There was no significant difference (p-value =.112; $\chi2= 7.5$; DF=4) between open and closed butcher shops in the three localities.

Table (4) shows the effect of GHPs on keeping meat not to fall on butcher shop floor by locality and butcher type. All (100%) of open butcher shops in the three localities were found in need of improvements. Closed butcher shops were found adequate (100%) in Khartoum and (66.7%) in Omdurman (66.7%), while in Bahri they were totally absent (0.0%) and needed improvements.

Table 4: Effect of GHPs on keeping meat not to fall on butcher shop floor by locality and butcher type.

Type of butcher shop			Locality			Total
			Khartoum	Bahri	Omdurman	
Open butcher shops	Meat found dropped on floor	Needs Improvements	3 (100.0%)	3 (100.0%)	3 (100.0%)	9 (100.0%)
	Total		3 (100.0%)	3 (100.0%)	3 (100.0%)	9 (100.0%)
Closed butcher shops	Meat found dropped on floor	Adequate	3 (100.0%)	0 (0.0%)	2 (66.7%)	5 (55.6%)
		Needs Improvements	0 (0.0%)	3 (100.0%)	1 (33.3%)	4 (44.4%)
	Total		3 (100.0%)	3 (100.0%)	3 (100.0%)	9 (100.0%)

P-value not computed because the variable is constant

Table (5) shows distribution of *E. coli* isolated from minced meat in butcher shops. The high prevalence of *E. coli* was found 50% in both Bahri and Omdurman and 16.7% in Khartoum locality.

Table 5: Distribution of E. coli isolated from minced meat in butcher shops by Locality.

		Locality			Total
		Khartoum	Bahri	Omdurman	
E. coli	+ve	1 (16.7%)	3 (50.0%)	3 (50.0%)	7 (38.9%)
	Negative	5 (83.3%)	3 (50.0%)	3 (50.0%)	11 (61.1%)
Total		**6 (100.0%)**	**6 (100.0%)**	**6 (100.0%)**	**18 (100.0%)**

$\chi 2$= 1.870; DF=2; p-value =.393 (Not significant)

Table (6) reveals distribution of *E. coli* isolated from minced meat in butcher shops by type. There was significant difference between prevalence of *E. coli* in open and closed butcher shops (p=.025). However, the proportion of *E. coli* was significantly greater in open butcher shops (66.7%) compared to closed butcher shops (11.1%).

Table 6: Distribution of E. coli isolated from minced meat in butcher shops by type.

		Type of butcher shops		Total
		Open	Closed	
E.coli	+ve	6 (66.7%)	1 (11.1%)	7 (38.9%)
	Negative	3 (33.3%)	8 (88.9%)	11 (61.1%)
Total		**9 (100.0%)**	**9 (100.0%)**	**18 (100.0%)**

$\chi 2$= 5.844; DF=1; p-value =.025 (Significant)

As shown in Table (7) there was no significant differences among *E. coli* limits (p> 0.05). High prevalence of *E. coli* exceeding limits (>200 CFU) in minced meat in open butcher

shops was found in Omdurman 3 (100%), Bahri 2 (66.7%) and Khartoum 1 (33.3%). However, the exceeding limits of *E. coli* prevalence was not significantly absent in closed butcher shops (p-value =.667).

Table 7: Distribution of *E. coli* load/ cfu limits in minced meat in butcher shops according to locality and type.

Type of butcher shop	Area			Samples		Total
		Species	Status	Exceeding limits .>200 CFU	Within limits < 200 CFU	
Open	Khartoum	E.coli	+ve	1 (50.0%)	0 (0.0%)	1 (33.3%)
			Negative	1 (50.0%)	1 (100.0%)	2 (66.7%)
		Total		**2 (100.0%)**	**1 (100.0%)**	**3 (100.0%)**
	Bahri	E.coli	+ve	2 (100.0%)	0 (0.0%)	2 (66.7%)
			Negative	0 (0.0%)	1 (100.0%)	1 (33.3%)
		Total		**2 (100.0%)**	**1 (100.0%)**	**3 (100.0%)**
	Omdurman	E. coli	+ve	3 (100.0%)	0 (0.0%)	3 (100.0%)
		Total		**3 (100.0%)**	**0 (0.0%)**	**3 (100.0%)**
Close	Khartoum	E. coli	Negative	2 (100.0%)	1 (100.0%)	3 (100.0%)
		Total		**2 (100.0%)**	**1 (100.0%)**	**3 (100.0%)**
	Bahri	E. coli	+ve	0 (0.0%)	1 (50.0%)	1 (33.3%)
			Negative	1 (100.0%)	1 (50.0%)	2 (66.7%)
		Total		**1 (100.0%)**	**2 (100.0%)**	**3(100.0%)**
	Omdurman	E. coli	Negative	1(100.0%)	2 (100.0%)	3(100.0%)
		Total		**1 (100.0%)**	**2 (100.0%)**	**3 (100.0%)**

χ2= .750; DF=1; p-value =.667 (Not significant)

Table (8) shows the mean of total count of microbial load log (cfu/g x10^{10}) in minced meat in butcher shops. The mean total value of bacterial count Log (cfu/g) of minced meat was not significantly greater in open butcher shops (2.19) with maximum value of 2.32 compared to closed butcher shops (2.17) with maximum value of 2.32 (p> .696).

However, the mean bacterial count was not significantly greater in open butcher shops compared to closed butcher shops in Khartoum (2.25 vs. 2.03), Bahri (2.21 vs. 2.08) and Omdurman (2.32 vs. 2.18), respectively.

Table 8: Mean of total count of microbial load log (cfu/g x 10^{10}) in minced meat in butcher shops.

Locality	Type of Butchery	Mean Log (cfu/g)	Std. Error of Mean	Min	Max
Khartoum	Open	2.25	.287	1.46	2.32
	Closed	2.03	.074	2.10	2.32
	Total	**2.14**	**.142**	**1.46**	**2.32**
Bahri	Open	2.21	.107	2.00	2.32
	Closed	2.08	.184	1.72	2.32
	Total	**2.146**	**.1003**	**1.72**	**2.32**
Omdurman	Open	2.32	.00	2.32	2.32
	Close	2.18	.093	2.01	2.32
	Total	**2.25**	**.051**	**2.01**	**2.32**
Total	**Open**	**2.19**	**.097**	**1.46**	**2.32**
	Closed	**2.170**	**.068**	**1.72**	**2.32**

The study also displays the Pearson correlation between GHPs and presence of *E. coli.* There was a negative correlation between GHPs in terms of equipment cleaning (R2=-.519, p=.027), meat found dropped on floor of butcher shop floors (R2=-.495, p=.037), products clearly labeled and priced (R2=-.484, p=.042) and presence of E. coli. In summary, reduced or absence of *E. coli* was negatively correlated with GHPs.

DISCUSSION

This study revealed good floor cleaning conditions in closed butcher shops, while open shops scored adequate conditions with no significant differences between them (p> 0. 223). This result may be due to the fact that closed shops in larger cities and towns are designed to help maintain surfaces clean as there are Good Manufacturing Practices (GMPs) in place. This is also supported by the fact that the type and location of butcher shop and its cleanliness will certainly influence the type of customers who buy from it (Food and Agriculture Organization, 2001).

In this study the results of implementation of GHPs in butcher shops revealed that the disinfection solution used for wash down of preparation areas was found poor or needed improvements in both open and closed butcher shops in the three localities, with no significant differences between them (p-value =.112). This might be due to lack of workers' knowledge of plant sanitation. This finding is line with that reported by Heinz and Hautzinger (2007) who stated that the sanitation procedure is habitually neglected since it takes extra time and hard work to remove organic matter such as fats and protein particles from surfaces. The result is also close to that recorded by Shilenge *et al* (2011) who found that only 10% of

the butcheries in their study area used the sanitizing solutions, which indicates that in 90% of the butcheries a very high risk of meat contamination was posed. Therefore, this finding didn't comply with the primary objective of keeping the meat plant in a sanitary condition, which is to prevent the production of unattractive, tasteless products and also to control the microorganisms in order to reduce the health hazards that might be present as stated by Quintavalla (2010).

Even with good hygienic design features, equipment may still become contaminated by microorganisms, workers, bioaerosols and other materials during processing (Evans *et al*., 2004). In this study equipment such as mincers and weighing scales sanitation were assessed as good and adequate in all butcher shops with closed shops scored better conditions, but there was no significant difference between them (p-value =0.526). This finding proved true as this study revealed a negative correlation between GHPs in terms of equipment cleaning and presence of *E. coli* (R2=-.519, p=.027). The finding can also be explained by the fact that closed shops are trying to comply with the GHPs in order to attract the customers. Also, this finding is in agreement with that stated by Rivera-Betancourt *et al*. (2004) who reported that many foodborne disease outbreaks are associated with improperly cleaned utensils and equipment and that the prevailing micro-organisms on knives in their study was *E. coli.* This can also be attributed to the fact that equipment used were food grade and made of stainless steel. This finding is in line to that recorded by Pieternel and Willem (2011) who stated that hygiene design requirements of equipment must be easy to clean, disinfect and it should protect the product from microbial and chemical contamination. Also the good cleaning conditions of equipment found in this study was complying with the American Meat Institute (2008) which stated that meat processing equipment such as slicers, dicers and machinery for packaging, which are insufficiently cleaned and sanitized can harbor bacteria. Contrary to this, Aburi (2012) in his survey about hygiene practices used for cleaning equipment in open and closed butcher shops in South Sudan found poor hygienic practices with no significant difference found between both types.

This study revealed that Khartoum locality scored less positive *E. coli* isolates. This may be explained by the fact that Khartoum locality is the Capital of Sudan and more attention is given to these shops from the health authority inspectors. This finding proved true as this study revealed a negative correlation between GHPs in terms of meat found not dropped on butcher shop floors and presence of *E. coli* (R2=-.495, p=.037). The finding also coincided

with that recorded by Gill and McGinnis (2000) who stated that meat residues that are not removed from meat contact surfaces during cleaning have been indicated to be the primary source of *Escherichia coli* deposited on the meat. Also, this finding complied with that recorded by Collins and Setona (2011) and Nicolita *et al*. (2010) who stated that *Escherichia coli* among other different genera of bacteria is associated with contamination of meat and meat products and is thought to be attributed to poor sanitary and hygienic condition.

Noting that the percentage of *E. coli* distribution in the study area was 38.9%, the difference between the prevalence of *E. coli* in open and closed butcher shops was significantly different (p=0.025). However, the proportion of *E. coli* was much greater in open butcher shops compared to closed butcher shops. This result may be attributed to the fact that open shops are more predisposed to environmental factors than closed ones. The finding is also in agreement with Habimana *et al*. (2010) who stated that Enterobacteriaceae presence reveals faecal contamination and poor sanitary practices during meat processing.

However, in this study the high prevalence of *E. coli* exceeding limits in minced meat in open butcher shops was found greater than that in closed shops. Moreover, the exceeding limits of *E. coli* prevalence was not significantly absent in closed butcher shops (p-value =0.667). The reason for high prevalence of *E. coli* exceeding limits in minced meat in open butcher shops in both Bahri and Omdurman may be because open butcher shops usually have poor infrastructure and are not equipped with cooling facilities as reported by Lupien, (2007). This, in addition to the absence of food control authorities. These findings were also in agreement with Abdalla *et al*. (2009) and Abdalla *et al*. (2010) who reported that the presence of high counts for *E. coli* in meat was probably associated with the poor hygiene practices involved in meat processing in developing countries that result into higher chances of fecal contamination.

CONCLUSION AND RECOMMENDATIONS

It could be concluded that antimicrobial solution used for wash down of preparation areas was totally dependent on workers' knowledge and training of plant sanitation. Furthermore, poor hygiene practices in open butcher shops was reflected in the exceeding limits of E. coli prevalence and high mean bacterial counts.

The authors recommend that butcher shops must be designed with Good Manufacturing Practices to help maintain surfaces and equipment clean. In addition more stringent

inspection and regular supervision and or monitoring of hygiene practices in the butcher shops by the competent authorities is needed.

REFERENCES

1. Abdalla, A.M.A., Suliman, S.E., Ahmed, D.E and Bakhlet, A.O. (2009). Estimation of bacterial contamination of indigenous bovine carcasses in Khartoum (Sudan). Afr. J. Microbiol. Res., 3(12): 882-886.
2. Abdalla, A.M.A., Siham, S.E and Bakhiet, A.O. (2010). Method for reducing contamination of indigenous cattle carcasses during slaughtering. Assuit Vet. Med. J., 56(125): 86-93.
3. Aburi, Peter Andrea Samuel (2012). Assessment of Hygiene practices used by Small Butchers and Slaughter Slabs in beef value chain in Juba town-South Sudan. A Research Project to be done and submitted to Van Hall Larenste in University of Applied Science In Partial Fulfillment of the Requirement for The Degree of Master of Development Agricultural Production Chain Management Specialization in Livestock Chain.
4. American Meat Institute (AMI). (2008). Sanitary equipment design. AMI Fact Sheet. Retrieved from: http://www.meatami.com/ht/a/GetDocumentAct ion/i/11006. Accessed on 26 July 2013.
5. Collins, N.A and Setona, T. (2011). Isolation of enteric bacteria pathogen from raw mince meat in Mafikeng, north-west Province, South Africa. J Life Sci., 2011; 8: S2.
6. Commission Regulation (EC) No. 2073/2005. https://www.fsai.ie/uploadedFiles/Food_Businesses/
7. Dainty, R. H. Shaw, B.G. De Boer, K.A. and Scheps, E.S.J. (1975) Protein changes caused by bacterial growth on beef. Journal of Applied Bacteriology, 39: 72-81.
8. Evans, J.A., Russel, S.L., James, C. and Corry, J.E.L. (2004). Microbial contamination of food refrigeration equipment. Journal of Food Engineering, 62(3): 225-232.
9. Food and Agriculture Organization (2001). Marketing options for livestock products: a total systems cum-managerial perspective. Available at. http://www.fao.org/wairdocs/ILRI/x5485E/x5485e0s.htm. 2/9/2012
10. Gill, C.O. and McGinnis, J.C. (2000). Contamination of beef trimmings with Escherichia coli during a carcass breaking process. Food Research International, 33: 125-130.
11. Habimana, O., Heir, E., Langsrud, S., Asli, A.W. and Møretrø, T. (2010). Enhanced surface colonization by Escherichia coli O157: H7 in biofilms formed by an

Acinetobacter calcoaceticus isolate from meat-processing environments. Applied and Environmental Microbiology, 76(13): 4557-4559.

12. Heinz, G. and Hautzinger, P. (2007). Meat Processing Technology: for small-to medium-scale producers. Rappublication: 2007/20. Retrieved from: http://www.fao.org/docrep/010/ai407e/AI407E26.htm. Accessed on 12 October 2011.
13. Lupien. J. R (2007). Prevention and control of food safety risk: the role of government, food producers, marketers and academia: Asia Pacific Journal of clinical Nutrition, 16: 74-79.
14. Meat industry guide, Microbiological Criteria (2017). https://www.food.gov.uk/sites/default/files/media/document/Chapter13-Microbiological-criteria.pdf
15. Mustafa, E., A., Salman, A., M., A., and Hamad, I., M. (2016). Review on Food Safety System With Reference To Meat Operations in Khartoum State, Sudan. RA Journal of Applied Research, (2)(07): 491-504.
16. Nicolita, M., Brozan, A., Bordean, D., Radu, F and Popescu, R. (2010). Micorganisms quantitative indicators for meat products. Anim Sci Biotechnolog, 43(2): 346-349.
17. Olaoye, O.A and Nilude, A.A. (2010). Investigation on the potential use of biological agents in the extension of fresh beef in Nigeria. World J Microbiol Biotechnol, 2010; 26: 14.
18. Peter Andrea Samuel Abu right September (2012). A Research Project to be done and submitted to van Hall Larenstein University of Applied Science in Partial Fulfillment of the Requirement for the Degree of Master of Development.
19. Pieternel A. Lunging and Willem J.Marcelis (2011). Food Quality Management-Technological and managerial principles and practices. 2nd edition: Wageningen Academic publisher.
20. Quintavalla, S. (2010). Plant cleaning and sanitation. In Handbook of meat and processing. F. Toldrá (ed). Ames, Iowa: Blackwell Publishing.
21. Ramakant S. (2006). Production, Processing and Quality of Milk and Milk Products. International Book Distributing Co. Publishing Division. Production and Health Paper 85. FAO, Rome, Italy, 2006; pp: 333.
22. Rivera-Betancourt, M., Shackelford, S.D., Westmoreland, K.E., Bellinger, G., Rossman, M. and Koohmaraie, M. (2004). Prevalence of Escherichia coli 0157:H7, Listeria monocytogenes, and Salmonella in two geographically distant commercial beef processing plants in the United States. Journal of Food Protection, 67(2): 295-302.

23. Saad, K. S. F. (2009). Load and types of bacteria in meat during retail display at Khartoum Locality. Master Degree in Public and Environmental Health (Food Hygiene and Safety). University of Khartoum.
24. Shilenge, B.L. (2011). A typical layout of butcheries as depicted by the student. Own design as adapted from studied butcheries. Not published.