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Full Length Research Paper

Microbiological assessment of mutton intended for export from Elkadaro export slaughter house, Sudan

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The study is planned to evaluate the hygienic quality of mutton intended for export from Elkadaro slaughter house on basis of surface bacterial contamination. Seventy five samples were collected during five visits, 15 samples in each visit (five samples for each: slaughter hall, slaughter house chiller and the refrigerated vehicle at Airport after unloading). A metallic triangle was used as a template from which swabs were taken. The results of the bacterial counts revealed relatively high counts (ranges between 1 × 10^3 - 6 × 10^6 CFU/ cm^2), but without critical contamination levels according to the cut-off point for fresh meat (10^6 CFU/ cm^2) and chilled meat (10^7 CFU/ cm^2) except in the last visit (2 × 10^6 CFU/ cm^2).

Key words: Sudan, mutton, slaughter house, export.

INTRODUCTION

Sudan is the most spacious country in Africa and the first regarding animal resources. Animal resources in the Sudan comprise of sheep, goat, cattle, camel, poultry and wild-game. Most of the animals in the Sudan are raised on natural pastures by nomadic tribes. In irrigated projects and the area of mechanized farming animals feed on crops byproducts. So Sudanese animals are almost free from feed additives, hormonal and chemical residues, which give special preference to the Sudanese animal products. Live sheep and mutton represent an important component of the Sudanese exports (Table 1).

Establishing a hygienic program for exported mutton is required in order to enable the Sudan facing the international trade parameters. This entails a vital need to improve the slaughter houses and to impose strict hygienic measures to provide healthy and wholesome meat to fulfill the international requirements (International Committee of Microbiological Standards of Foods (ICMSF), 1986; Gracey et al., 1999). The present study is aimed to evaluate hygienic quality of mutton intended for export from Elkadaro export slaughter house.

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MATERIALS AND METHODS

The study site

The study was carried out in Elkadaro export slaughter house in Khartoum State, the most important export slaughter house in the Sudan.

Collection of informative data

(i) Data on number of animals entering in the slaughter house, the number of animals rejected, and the reasons for rejection, the number of animals passed for slaughter, and animal breeds were taken from Ante-morteum records of the slaughter house.
(ii) Temperature and hygienic conditions and average weight of animal carcass were recorded.
(iii) The chilled carcase temperature and duration of chilling were recorded.
(iv) The same in data (ii) and (iii) as well as the hygienic conditions of the refrigerated truck were taken while unloading the refrigerated vehicle at the airport.

Samples collection

Five visits were conducted, a total of 75 swabs (15 swabs in each visit: 5 samples for each: the fresh carcases, the chilled carcases and after unloading the carcase from the refrigerated vehicle at the

Table 1. Estimation of sheep population, exported live sheep and exported mutton.

Year	Sheep population head	Exported live sheep	Exported mutton (ton)
2000	46,095,000	731,242	6,157.8
2001	47,043,000	15,417	4,855.2
2002	48,136,000	1,602,638	7,113.8
2003	48,440,000	1,315,399	7,837.11
2004	48,910,000	1,703,562	5,570.9

Source: Animal resources economics administration ministry of animal resources and fisheries, information and statistics unit (2005).

Table 2. Cold storage and cold transportation records.

Visit	Chiller			Refrigerated vehicle			
	Temperature (℃)	Duration of chilling (h)	Hygiene condition	Temperature of vehicle (℃)	Average carcase temperature (℃)	Time in the vehicle (h)	Hygiene condition
First	-2	11	Good	-2	0.8	4	Good
Second	- 0.3	15	Good	(2 vehicles) -0.7, -5	-2	4	Good
Third	0.5	13	Good	(2 vehicles) -2, 0	0	2	Good
Fourth	0.5	14	Good	(2 vehicles) -2 , -0.2	-0	10	Good
Fifth	-1.4	12	Good	2.5	1.4	6	Good

air port) were collected to detect muscle surface contamination of the carcasses. Five carcasses were selected and identified by label fixation as such: A (thigh muscles), B (external abdominal muscles), C (chest area), D (shoulder muscles) and E (vertebral area). A hand-made right angled metallic triangle with an area of 10 cm^2 was used as a template and disinfected by using 70% alcohol (ethanol). Swabs were placed in ice box (0℃) and were transferred as soon as possible to the laboratory. Swabs were stored in deep freezer in laboratory at -20℃ till processing.

Bacterial count

Pour plate method was used for bacterial colony counts as described by Quinn et al. (2000). The swabs were taken from the deep freezer and immersed in test tubes containing 10 ml sterile normal saline and ten fold dilutions were prepared from the normal saline (10^{-2}, 10^{-3}, 10^{4} and 10^{-5}). A total of 100 µ (0.1 ml) was taken from the final dilution and pared in sterile Petri-dishes and then (15 to 20 ml) of sterile nutrient agar solution (N.A) were added to the Petri-dishes contents. Mixing was done by shaking the Petri-dishes. The contents were left to solidify before being incubated at 37℃ for 24 to 48 h for colony count. The average value from each duplicate from the same dilution was taken. The colonies were calculated using the following formula:

Colony count = [(Average value x 10 x Dilution factor) / 10] CFU/cm^2

10 refer to the area of the triangle used, CFU/cm^2 refer to colony forming unit per square centimeter

Cut-off (critical) point

Fresh meat (10^6 CFU/ cm^2), chilled meat (10^7 CFU/ cm^2) (ICMSF, 1986; Gracey et al., 1999).

RESULTS

The salient features of the ante-mortem record were: average number of the animals entering the slaughter house was 417, while average number of the accepted animals was 406; average number of rejected animals was 3. The major causes for rejection in the ante-mortem were lameness, tick infestation swelling of the lymph nodes, sheep pox and emaciation. Most of the popular breeds of sheep in the Sudan were brought to the slaughter house (Hamari, Kabashi, Butana). In the post-mortem the average number of carcases accepted was 402, while average number of unaccepted carcases was 4. The causes of unacceptance were Jaundice, hydatidoses, bruises, lymph nodes infection, haematomas and abscessations. The hygiene condition was good and average temperature in the slaughter hall was 34℃. The chiller showed good hygiene, and average temperature was -0.9, and average chilling time was 13 h. The average holding time in the refrigerated vehicle was 5 h, while the average carcases temperature was 0.02℃. The hygiene condition in the vehicle was good since neither rancidity nor dripping was observed (Table 2).

Bacterial counts of the first visit revealed no contamination level. In slaughter hall relatively low counts observed for the third and fifth carcase (9 x 10^3 and 1 x 10^3 10^6 CFU/ cm^2, respectively). Low counts also were recorded at the air port for first, second, third and fourth carcase (8 x 10^3, 1 x 10^3, 8 x 10^3 and 7 x 10^3 CFU/ cm^2, respectively). All the counts of the second visit were

Table 3. Bacterial count of the first visit.

Carcase	Sample site	Bacterial count CFU/cm^2		
		Fresh caracase in slauGhter-hall (temperature 37°C)	Chilled carcase in the slauGhter house (temperature0.2°C)	Chilled meat at the air-port (temperature -2°C)
First	A	2×10^4	1×10^5	8×10^3
Second	B	2×10^4	1×10^5	1×10^3
Third	C	9×10^3	1×10^5	8×10^3
Fourth	D	2×10^4	1×10^4	7×10^3
Fifth	E	1×10^3	1×10^5	1×10^4

A (thigh muscles), B (external abdominal muscles), C (chest area), D (shoulder muscles) and E (vertebral area),Duration of time: in the chiller 11 h and refrigerated vehicle 4 h. Cut-off (critical) point: fresh meat (10^6 CFU/ cm^2) and chilled meat (10^7 CFU/ cm^2) (ICMSF, 1986; Gracey et al., 1999).

Table 4. Bacterial count of the second visit.

Carcase	Sample site	Bacterial count CFU/cm^2		
		Fresh caracase in slaughter-hall temperature 33°C	Chilled carcase in the slaughter house temperature -0.3°C	Chilled carcase at the air-port temperature -2°C
First	A	2×10^5	4×10^5	8×10^5
Second	B	No growth	5×10^5	1×10^5
Third	C	5×10^5	3×10^6	3×10^5
Fourth	D	5×10^5	5×10^5	4×10^5
Fifth	E	5×10^4	9×10^5	8×10^5

A (thigh muscles), B (external abdominal muscles), C (chest area), D (shoulder muscles) and E (vertebral area)
Duration of time: in the chiller 14 h and refrigerated vehicle 7 h. Cut-off (critical) point: fresh meat (10^6 CFU/ cm^2) and chilled meat (**(**10^7 CFU/ cm^2) (ICMSF, 198; Gracey et al., 1999).

below the contamination level, in the slaughter hall relatively high counts were recorded for the first and fourth carcases (2 x 10^5 and 5 x 10^5 CFU/ cm^2, respectively). In the chiller similar readings were recorded for the first, second, fourth and fifth carcases (4 x 10^5, 5 x 10^5, 5 x 10^5 and 9 x 10^5 CFU/ cm^2, respectively). There was no contamination level in the five carcases in the three different stages of the third visit. Similarly, there was no significant contamination level during different stages of the fourth visit: for the slaughter-hall high bacterial counts were recorded for the first, second, and fifth carcase (2 x 10^4 CFU/ cm^2 for each). At the air-port relatively higher bacterial counts were recorded for the first, third and the fifth carcase (3 x 10^4, 2 x 10^4 and 1 x 10^4 CFU/cm^2 respectively). The results of bacterial counts of the fifth visit revealed contamination level to some extent in fresh meat (2 x 10^6 CFU/ cm^2). Bacterial counts of all visits showed no critical contamination levels according to the cut-off point for fresh meat (10^6 CFU/ cm^2) and chilled meat (10^7 CFU/ cm^2) except in last visit as described by international recommendations. All results are summarized in Tables 3, 4, 5, 6 and 7.

DISCUSSION

The study is planned to evaluate hygienic quality of mutton intended for export from Elkadaro export slaughter house. Strict ante-mortem and post-mortem inspection as well as good hygiene were observed in the slaughtering process during five visits, however, there was a contamination to some extent in fresh meat during last visit (2 x 10^6 CFU/ cm^2). The temperature of the chiller and the refrigerated vehicles were acceptable and the duration of chilling was satisfactory. Similarly, good hygiene condition in slaughter hall was observed. The results of the bacterial counts were less than the critical contamination levels (ranges between 1 x 10^3 - 6 x 10^6 CFU/ cm^2). The surface bacterial load on the sheep carcase surface is essential in mutton grading, in order to cope with the international standards. Acceptability of meat must account for the following: abattoir hygiene, and the perfection of meat inspection in post- mortem and ante-mortem. Anti-mortem must consider the animal condition, animal handling, and other aspects of the slaughter animal welfare. While, post- mortem must consider the Islamic slaughter, the perfection of bleeding, meat preservation, meat transportation and meat packaging. In Elkadaro slaughter house animals were rested for more than twelve hours before slaughtering, animal transportation is carried in a proper way so no stress take place, perfect bleeding is eminent and Islamic slaughter is strictly practiced. The major bacterial contaminants previously found on the carcase surface were *Corynebacterium,*

Table 5. Bacterial counts of the third visit.

Carcase	Sample site	Bacterial count CFU/cm^2		
		Fresh caracase in slaughter-hall temperature 32°C	Chilled carcase in the slaughter house temperature 0.5°C	Chilled carcase at the air port temperature. -2°C
First	A	7×10^3	1×10^5	7×10^4
Second	B	1×10^4	1×10^5	1×10^5
Third	C	2×10^4	2×10^5	2×10^5
Fourth	D	3×10^3	8×10^4	2×10^5
Fifth	E	3×10^3	2×10^5	6×10^4

A (thigh muscles), B (external abdominal muscles), C (chest area), D (shoulder muscles) and E (vertebral area). Duration of time: in the chiller 13 h and refrigerated vehicle 16. Cut-off (critical) point: fresh meat (10^6 CFU / cm^2) and chilled meat (10^7 CFU/ cm^2) (ICMSF, 1986; Gracey et al., 1999).

Table 6. Bacterial count of the fourth visit.

Carcase	Sample site	Bacterial count CFU/cm^2		
		Fresh caracase in slaughter-hall temperature 32°C	Chilled carcase in the slaughter house temperature 0.5°C	Chilled carcase at the air-port temperature -2°C
First	A	2×10^4	1×10^4	3×10^4
Second	B	2×10^4	9×10^4	5×10^3
Third	C	5×10^3	3×10^3	2×10^4
Fourth	D	1×10^3	8×10^3	1×10^3
Fifth	E	2×10^4	8×10^3	1×10^4

A (thigh muscles), B (external abdominal muscles), C (chest area), D (shoulder muscles) and E (vertebral area). Duration of time: in the chiller 14 h and refrigerated vehicle 14 h. Cut-off (critical) point: fresh meat (10^6 CFU / cm^2) and chilled meat (10^7 CFU/ cm^2) (ICMSF, 1986;Gracey et al., 1999).

Table 7. Bacterial count of the fifth visit.

Carcase	Sample site	Bacterial count CFU/Cm^2		
		Fresh caracase in slaughter-hall temperature 36°C	Chilled carcase in the slaughter house temperature -1.4°C	Chilled meat at the air-port temperature -2°C
First	A	2×10^6	9×10^6	5×10^4
Second	B	8×10^5	6×10^5	6×10^5
Third	C	2×10^6	8×10^5	8×10^4
Fourth	D	2×10^6	1×10^6	5×10^4
Fifth	E	6×10^5	1×10^6	1×10^5

A (thigh muscles), B (external abdominal muscles), C (chest area), D (shoulder muscles) and E (vertebral area) Duration of time: in the chiller 12 and 24 h and refrigerated vehicle 3 and 6 h. Cut-off (critical) point: fresh meat (10^6 CFU/ cm^2) and chilled meat (10^7 CFU/ cm^2) (ICMSF, 1986; Gracey et al., 1999).

Lisleria, Staphylococcus spp.,*Micrococcus* spp., *Bacillus* spp., *Actinomycetes, Actinobacillus* spp., *Chromobacterium* and *Enterobacteria* spp., (Suliman, 2004). Elamin (2002) isolated Staphylococcal, Micrococcus, Corynebacteria, Kurthia, Entero-bacteria and Pseudomonia. (Sary, 1972) reported the contamination of meat with staphylococcus coagulase positive.

Gracy et al. (1999) considered that microbial count of 10^5 CFU/cm^2 was satisfactory for fresh meat, while count of 10^6 CFU/cm^2 was considered unsatisfactory. Bacterial count of 10^6 CFU/cm^2 for chilled meat was considered

satisfactory, but count of 10^7 CFU/cm^2 was considered unsatisfactory. Furthermore, ICMSF (1980) reported that if meat is prepared under unhygienic conditions, the initial count was higher (exceeding 10^6 CFU/cm^2). The results of our study are similar to Frank and Mallion (1980) who recognized that a recent slaughtered and dressed carcase will be contaminated with bacteria count of 10^2 - 10^6 CFU /cm^2. In contrast, the findings of this study is disagree with study by Elamin (2002) in slaughter house in Omdurman, where the bacterial counts exceeding 10^7 CFU/cm^2. This disagreement is attributed to the hygienic standard of slaughter house in Omdurman was far below that applied in Elkadaro slaughter house as well as there was no demarcation between the area of clean and dirty operations.

Attaining high standards of hygiene and providing high quality meat for export is a matter of a paramount importance, by so doing Sudanese meat and meat products can cope with the international standards of trade and can compete in the international market. Strict hygienic measures must be applied in all production stages with regard to hazard analysis critical control point (HACCP) system.

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