

Full Length Research Paper

Survey of hygiene in ovine slaughterhouses of Algiers region by bacteriological analysis of carcasses

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Ovine meat is a major protein source in Algeria. Hygiene of food stuffs is an important concern in food production since food poisoning is a danger for public health. Two slaughterhouses were investigated in this study. Ten carcasses were sampled in each slaughterhouse during 4 consecutive weeks. The amount of total aerobic mesophilic flora and of Enterobacteriaceae was calculated on the 80 carcasses. The results were evaluated regarding European regulation 2001/471/EC. For both slaughterhouses, the total aerobic mesophilic bacteria counts $4.84 \log_{10}$ CFUs/cm² were close to the upper limit ($5 \log_{10}$ CFUs/cm²). The Enterobacteriaceae counts for the two slaughterhouses were $4.38 \log_{10}$ CFUs/cm² and $3.30 \log_{10}$ CFUs/cm², respectively. These values were above the upper acceptable limit ($2.5 \log_{10}$ CFUs/cm²). In conclusion, the ovine carcasses, in Algeria, seem to be heavily contaminated by bacteria constituting a risk of food poisoning.

Key words: Ovine slaughterhouse, hygiene, carcass, contamination.

INTRODUCTION

Red meat is a favorable environment for the development of a large number of bacterial species that may be responsible for the alteration of the meat or at risk for the consumer. Several cases of food poisoning have been reported after consumption of meat products contaminated by bacterial agents such as *Salmonella* spp., *Listeria monocytogenes*, *Staphylococcus aureus*, *Campylobacter* spp., *Yersinia enterocolitica* or *Enterohemorrhagic Escherichia coli* (Arvieux, 1998).

At the distribution level, 80 to 90% of the microflora was found in meat coming from slaughterhouses (Jouve, 1990). The main sources of contamination of carcasses along the chain of slaughter are: the animal (leather and dung),

equipment (machines and cutting tools), the environment (building, air, dust, water and harmful), method of work (non-compliance with the rules of slaughter) and labor (lack of personal hygiene) (Sheridan, 1998).

The level of surface contamination of carcasses varies depending on the conditions of hygiene and the procedure of slaughter (Lastaj et al., 1992; Widders et al., 1995). In Europe, in modern slaughterhouses, slaughtering techniques are largely mechanized ensuring a reduction of the carcasses to atmospheric contaminant exposure and of manipulation. In addition, the implementation of the HACCP (Hazard Analysis Critical Control Point) system allows the regular control for the improvement of the general hygiene of the chains of production, in application to decision of European commission 2001/471/EC (EC, 2001).

In Algeria, ovine meat is a major source of protein with around 20 000 000 of ovines. The slaughtering

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procedure is mainly artisanal. A few studies highlighted the inadequacy or even lack of hygiene in slaughterhouses studied (El-Hadef El Okki et al., 2005; Chahed, 2008; Nouichi and Hamdi, 2009). The objective of our study is a quantitative evaluation of surface contamination of ovine carcasses slaughtered in two of the eleven slaughterhouses (Staoueli and Kolea) implanted in the area of Algiers. No study has focused on the level of hygiene in these two slaughterhouses which produce about 20 tons of ovine meat per year for the local population.

In absence of Algerian legislation, the bacteriological quality of carcasses was assessed following the technical indications of European decision (EC, 2001). The enumerated flora were the total aerobic mesophilic flora (TAMF) and Enterobacteriaceae. TAMF is an indicator of overall contamination of carcasses (Roberts, 1980). Enterobacteriaceae are an indicator of fecal contamination (Cartier, 1990). The bacteria were collected by the swab technique. It is a fast, simple technique and which preserves the integrity market carcass.

MATERIALS AND METHODS

Samples were conducted on ovine carcasses in two slaughterhouses: Staouelli (A) and Kolea (B) located respectively at 20 and 40 kilometers at west of Algiers (Algeria). These are two communal facilities of artisan type built, in 1933, and significantly working the same way. In each built, there are one stable for both cattles and ovines (50 m²), one slaughter room (150 m²) and one chiller room. The slaughter room is divided into two areas: an area of capacity daily slaughter for 4 heads of cattles and an area for 70 heads of ovines. The movement of carcasses by air rail system is not mechanized and the area is not arranged so as to prevent intersection between live animals and carcasses.

The bleeding, skinning and eviscerating are done in the same local. The animals are lying on the ground and shot, according to muslim ritual, with the same knife. The skinning begins when the animals have stopped moving. The animals are then hung by their hind legs. While an operator continues the skinning of the carcass, another begins evisceration with a knife and his hands. Very often, the rumen and intestines are accidentally perforated causing the release of digestive contents on the carcasses.

Sampling

The number of samples was estimated according to the literature (Dennai et al, 2001; El-Hadef El Okki et al., 2005). In each built, samples were conducted on 40 stamped ovine carcasses randomly chosen, at a rate of 10 carcasses per week on different days of the week, in the dry season (from May 14 to June 17, 2008). In the built (A), samples were made several hours after slaughter while in the built (B) immediately after. Sampling swab technique, validated by the standard ISO 17604 (ISO, 2003d), was chosen. It is a double

swab with a wet swab and then a dry one on a surface of 100 cm². For each carcass, we collected 4 anatomical sites likely to be the greatest prevalence of contamination, according to the recommendations of the European decision 2001/471/EC: site A (the neck), site B (end of the chest), site C (flank) and site D (thigh). On each half carcass, 4 sites, on a same carcass swabs were grouped in a same thus constituting stomacher bag a sample of a single carcass. Samples were transported to the laboratory of bacteriology in insulated bags at a nearby temperature of 4°C.

Microbiological analysis

8 of the same carcass swabs were collected in a stomacher bag containing 100 ml of sterile physiological water the stock solution. After stomaching for 1 min, decimal dilutions (10⁻¹, 10⁻² and 10⁻³) were prepared, from the stock, in 9 ml physiological water solution, according to the standard ISO 6887-1 (ISO, 1999).

For the TAMF, PCA (Plate Count Agar, Merck) were inoculated with 1 ml of each decimal dilution and incubated at 30°C for 72 h. For Enterobacteriaceae, 1 ml of decimal dilutions was inoculated on VRBG (Violet Red Bile Agar with Glucose) plates (Sanofi diagnostic Pasteur, France). The plates were incubated at 37°C for 24 h. The plates containing between 30 and 300 CFUs were counted and the Log₁₀ CFUs per cm² was calculated. The mean and standard deviation of the counts for the 10 carcasses of the same week of sampling were calculated.

Counting and statistical analysis

Since the swab method underestimates (20% or less), the number of present bacteria, the counted CFUs were multiplied by 5 according to the European regulation 2001/471/EC (EC, 2001). The results were expressed in Log₁₀ CFUs per cm² of carcass. The mean and the standard deviation of counts for 10 carcasses of the same week in each slaughterhouse were calculated. Statistical analysis is conducted from the logarithmic mean, by the application of Fischer Student t-test and analysis of variance ANOVA on the threshold of 5% for comparison averages.

RESULTS

The results were summarized in Table 1. For TAMF, in the slaughterhouse (A), the minimal bacterial load was 4.02 log₁₀ CFUs/cm² (week 1) and the maximum load was 5.55 log₁₀ CFUs/cm² (week 3). On 4 weeks, there has been a progressive increase of the bacterial load between week 1 and the other 3 weeks. The count of week 3 is significantly more contaminated than of week 2. In the slaughterhouse (B), the minimal bacterial load was 4.29 log₁₀ CFUs/cm² (week 1) and the maximum load was 5.43 log₁₀ CFUs/cm² (week 4). The count of week 4 was significantly (p<0.05) higher than counts of weeks 1 and 2. Since the lower acceptable level is 3.5 log₁₀ CFUs/cm² and the upper acceptable level is 5 log₁₀ CFUs/cm² (EC, 2001), in slaughterhouse (A) and

Table 1. Comparison of Total aerobic mesophilic flora and Enterobacteriaceae on ovine carcasses in slaughterhouses (A) and (B), in Algiers area.

Slaughterhouse	Total aerobic mesophilic flora		Enterobacteriaceae	
	(A)	(B)	(A)	(B)
Week 1	4.02±0.59 ^a	4.29±0.82 ^a	3.48±0.20 ^a	2.48±1.81 ^{ac}
Week 2	4.74±0.72 ^b	4.67±0.60 ^a	3.96±0.54 ^b	2.84±0.89 ^a
Week 3	5.55±0.02 ^{cd}	5.04±0.5 ^{ac}	5.09±0.4 ^c	4.12±0.48 ^{bd}
Week 4	5.31±0.46 ^{bd}	5.43±0.14 ^{bc}	5.14±0.4 ^c	3.81±0.6 ^{cd}
Mean value	4.84±0.8 ^A	4.84±0.72 ^A	4.38±0.82 ^B	3.30±1.28 ^C

Slaughter (A): slaughter of Staouelli. Slaughter (B): slaughter of Kolea. The results were expressed in CFUs (mean ± standard deviation \log_{10}/cm^2) on 10 ovine carcasses in each week. The numbers with the same letter show no significant difference after analysis of variance ANOVA on the threshold of the 5%. Lower case letters: comparison between the lines. Caps letters: comparison between columns. Range carcasses (European regulation 2001/471/EC): for Total aerobic mesophilic flora, intermediate range (3.5 \log_{10} – 5.0 \log_{10} CFUs/cm²); unacceptable range (> 5 \log_{10} CFUs /cm²). For enterobacteriaceae: intermediate range (1.5 \log_{10} – 2.5 \log_{10} CFUs /cm²); unacceptable range (> 2.5 \log_{10} CFUs/cm²).

(B), 2 counts (weeks 1 and 2) were considered as intermediate and 2 counts (weeks 3 and 4) were considered as unacceptable. For Enterobacteriaceae, in the slaughterhouse (A), the minimum load was of 3.48 \log_{10} CFUs/cm² (week 1) and the maximum load is of the order of 5.14 \log_{10} CFUs/cm² (week 4). The variation of the bacterial load between the 4 weeks is significant ($p < 0.05$), with the exception between weeks 3 and 4. In the slaughterhouse (B), the minimum load was 2.48 \log_{10} CFUs/cm² (Week 1) and the maximum load was 4.12 \log_{10} CFUs/cm² (week 3). The count in week 3 were significantly ($p < 0.05$) higher than the counts of the week 1 and 2 and the count of week 4 was significantly higher than the count of week 2. Since the lower acceptable limit is 1.5 \log_{10} CFUs/cm² and the upper acceptable limit is 2.5 \log_{10} CFUs/cm², all the counts and 3 counts out of 4 (weeks 2 to 4) were considered as unacceptable for slaughterhouse (A) and (B), respectively.

The comparison of the two slaughterhouses indicated that the global counts (40 carcasses) of the TAMF were the same with 4.84 ± 0.8 and 4.84 ± 0.72 for slaughterhouse (A) and (B), respectively. For Enterobacteriaceae, the slaughterhouse (A) was significantly more contaminated ($p < 0.05$) than slaughterhouse (B): the global counts (40 carcasses) were 4.38 ± 0.82 and 3.30 ± 1.28 CFUs/cm² for slaughterhouse (A) and (B), respectively.

DISCUSSION

The control of hygiene in slaughterhouses, first link in the chain for the development of food products of animal origin, are essential to ensure the safety of consumers. In Algeria, the quality of the carcass is classically appreciated by a visual judgment by the veterinary inspector. Carcasses with pathological

lesions are seized and banned from the consumption. However, there is no regulation governing the control of the hygiene conditions in slaughterhouses.

The aim of this study is to evaluate the level of the hygiene in two slaughterhouses of Algiers area (capital of Algeria) located in urban areas. We counted two types of flores: the TAMF and Enterobacteria, flores counted for control of the general hygiene of a slaughterhouse, according to the european decision (2001/471/EC). The presence of excessive amount of TAMF is a danger of alteration of meats (Roberts, 1980). Food born diseases often follow the consumption of contaminated meats with enterobacteriaceae such as *Escherichia coli* O157:H7 which produce shiga toxins. These strains are associated with both outbreaks and sporadic cases of human disease, ranging from uncomplicated diarrhea to hemorrhagic colitis and hemolytic-uremic syndrome (Paton and Paton, 1998). Since slaughtering is done by the same operators and at fixed position, the carcasses were randomly selected.

In the slaughterhouses (A) and (B), the surface of the TAMF counts, revealed a similar contamination rates or an average of 4.84 \log_{10} . This result is intermediate for the TAMF. The weekly average rates recorded on 4 lots of ovine carcasses; show that 50% belong to the underclass and 50% to the unacceptable class. This rate of contamination is higher than those recorded at the level of the slaughterhouses of Tunisia, Morocco or France. In France, Dachy (1993) are recorded for this flora between 3.06 \log_{10} and 3.77 \log_{10} . In Tunisia, Fliss et al. (1990) and in the Morocco, Karib et al. (1994) recorded global average counts on ovine carcasses between 2.82 \log_{10} and 3.8 \log_{10} . In Algeria, El-Hadef El Okki et al. (2005) are recorded 5.42 \log_{10} , Nouichi and Hamdi (2009) reported a rate of 3.81

\log_{10} on ovine carcasses.

The excessive presence of the TAMF on ovine carcasses in these two studied slaughterhouses surface is visibly related to the conditions and deficient felling techniques at the level of these institutions. Indeed, on a manipulated carcass, it is normal to find a small amount. Their presence, beyond the defined limits, can mean a lack of hygiene of manufacturing (Ghafir and Daube, 2007). In modern slaughterhouses, slaughtering techniques are mechanized (the principle of walking in front). However, in the two institutions investigated, all stages of transformation of the animal carcass (bleeding, counting,...) are at fixed positions. This increases the risk of contamination crossed between ovine carcasses and skins, blood, viscera and the gastric content of the same or other animals. Also, since butchering of animals is carried out manually; it can assume that the origin of this flora would mainly be the skin of animals manipulated during this operation (Dachy, 1993). In addition, multiple contacts of the hands and tools with soiled leather of the operations of counting animals would increase the proportion of the TAMF, on the surface of the carcasses. Indeed, the study of Whyte et al. (2002) showed a significant reduction in the rate of bacterial contamination of carcasses using procedures minimizing contact with carcasses with the hands of the operators. Another origin would be soiled by fecal matter soil. Indeed, counting is done in a horizontal position on the ground or on tables soiled by fecal matter. The soiled fleece on the studied sheep, prior to slaughter, could be another source of contamination. Biss and Hathaway (1996) recorded microbiological on ovine carcasses whose wool was dirty more higher than that of the carcasses from which the fleece sheep was clean. Statistical analysis of the average log weekly generally shows a significant increase in the bacterial load of the first week to the 4th week of levies. This result could be explained by the effect of the season. Dennai et al. (2001) noted that the lower levels of contamination of carcasses have been recorded during the winter. In our study, samples were conducted from May 14 to June 17, period of summer in Algiers.

For Enterobacteria, the results of our study, revealed a level of contamination exceeding 2.5 \log_{10} , unacceptable result for all weeks, with the exception of the week 1 which is intermediate (2.48 \log_{10}). In Algeria, an unacceptable result is obtained by the study of El-Hadef El Okki et al. (2005) with a value of 2.90 \log_{10} , to the slaughterhouse of Constantine. Entericbacteria are used as marker of the hygienic quality of a carcass seen as a marker of fecal contamination. This flora moved, essentially, counting and gutting operations. Multiple contacts of carcasses with the hands, the holding of the

manipulators and equipment are the main causes (Ghafir and Daube, 2007). Moreover, the degree of contamination of the skins of animals has a direct impact on the contamination of carcasses. Byrne et al. (2007) have obtained an average of 2.7 \log_{10} on the carcasses of ovine with a clean, dry fleece and an average of 4.4 \log_{10} on carcasses from animals with a dirty and dry fleece or visible fecal material. During evisceration, faulty manipulation of the "unconscious" workers and accidental perforation of gastric bags may be the source of this contamination. Comparing the two slaughterhouses, there is a significant difference in the level of contamination by enteric bacteria. This difference could be explained by the time of collection. Indeed, in the slaughter house (A), where the rate of infection is higher (4.38 \log_{10}), ovine carcasses were taken several hours after slaughter. In the slaughterhouse (B), levies have been made immediately after slaughter.

Referring to the European decision, an unacceptable or intermediate result must trigger an action for review of process controls to identify the cause if possible, and prevent repetition. In our study, these results are the consequence of the deficiencies identified in hygiene and operation of these institutions on the one hand and on the other hand the lack of facilities and equipment (System of handling mechanized, room bleed etc) and the lack of qualification of the staff. However, sampling should be expanded (in the number and done also on cattles) and repeated on a longer period to be representative of the production in order to decide the redevelopment or closure of these slaughterhouses. Comparison between the level of contamination of all slaughterhouses of Algiers area should allow to evaluate significantly the risk for public health of algerian people. The slaughterhouse constituting one of the major critical points on the hygienic quality of meat. It is imperative to minimize microbial contamination making improvements concerning sanitation, facilities, equipment, operation and staff at the level of the two slaughterhouses deplorable hygiene behaviour endangers the health of the consumer.

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