The bacterial quality of red meat and offal in Casablanca (Morocco)

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The present study aimed to evaluate the bacteriological quality of beef ($n = 52$), lamb ($n = 52$) and beef offal ($n = 52$) marketed in Casablanca, Morocco. Meat and offal samples ($n = 156$), were collected randomly from butcheries, supermarkets, and slaughterhouses. Two sampling periods were considered, one during the hot season and the second one during the cold season. The samples were analyzed for the presence of the following bacteria: *Escherichia coli*, coagulase-positive *Staphylococcus, Clostridium perfringens, Salmonella,* and *Listeria monocytogenes*. Results indicated that counts of the aerobic plate count, and fecal coliforms were particularly high in all the samples analyzed. *E. coli*, coagulase-positive *Staphylococcus* and *C. perfringens* were detected in 37.8, 16, and 4.5% of the meat samples, respectively. Neither *Salmonella* nor *L. monocytogenes* were isolated from meat samples. Approximately 26.9% of beef, 34.6% of lamb and 28.8% of beef offal samples contained bacteria above the maximum limits established by the Moroccan regulatory standards for meat and meat products. Seasonality and the distribution location significantly ($p < 0.05$) affected bacterial populations: the hot season and butcheries appeared to be cases where the highest populations of bacteria in meat were observed. These high levels of microbiological contamination attest the poor hygienic quality of meat and offal, possibly due to uncontrolled processing, storage, and handling of these products.

1 Introduction

Recent data from either developing or developed countries indicate that, at least 10% of the population may experience a food borne disease. The situation is equally serious in developing countries [1], with obvious economic consequences [2]. In 2002, the Centers for Disease Control in the United States reported 76 000 cases of food borne diseases, the majority being of bacterial origin [3]. In Europe, monitoring the impact of food borne disease mortality is not a major priority; however, 50 000 cases of acute gastro-enteritis per million inhabitants annually are reported. In France, 559 cases of food borne diseases were reported in 2001, of which 64% were due to salmonellosis [4].

In Morocco, although several efforts have been made to improve food safety and quality, food borne diseases still represent one of the main causes of morbidity [5]. During the last 5 years (2000 to 2004), 7118 cases of food borne diseases have been reported among which 86% were of bacterial origin (Morocco foodborne disease outbreaks, searchable data 2000–2005. Yearly Reports 2000–2004). According to the same report, 21.3% of the bacterial food borne diseases was caused by red meat and meat products and 14.7% occurred in the city of Casablanca. Many factors have contributed to increased food borne diseases. Mass production, environmental factors, and inadequate knowledge on food handling have contributed to increased contamination of foodstuffs [1]. Other factors were also reported including increased consumption of fresh-chilled, minimally processed foods rather than highly processed foods, and dine-out and take-away meals as well as alternative cooking methods (Red meat safety and clean livestock. Food stand. agency, 2002). With highly perishable foodstuffs such as fresh red meat, the threat of food poisoning is particularly important [2]. Because of the nature of meat and the means by which it has to be obtained from the animal, some level of microbial contamination is inevitable, and may include pathogenic bacteria. With regard to micro-

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Abbreviations: **SAS**, Statistical Analysis Systems; **APC**, aerobic plate counts; **cfu**, colony forming units; **GLM**, general linear model

bial hazards, meat is generally a safe product when cooked and handled appropriately prior to consumption, but problems may arise when hygienic practices are not observed and any present food borne pathogens are allowed to survive and multiply. For this reason, any kind of raw meat is regarded as a high-risk category food and should be handled accordingly [6].

Red meat is an important part of the human diet. Moroccan official data reported that between 2000 and 2004, an average of 152 000 tons of beef, 116 000 tons of lamb, 51 000 tons of beef offal, and 47 000 tons of other red meats (goat, camel, and horse) are presumably produced yearly in Morocco, with more than 12% of red meat production in Casablanca (National Statistics Rapport for department of animal producing. Ministry of Farming, Morocco 2005).

The main studies performed on red meat and beef offal, focused on the evaluation of the hygienic quality [7–10]. None of these studies assessed the hygienic quality of raw red meat produced during various seasons and at different distribution locations. In order to provide such information, objectives of the present work were (i) to determine incidence and/or levels of pathogenic and nonpathogenic microorganisms present in red meat and beef offal produced in Casablanca, and (ii) to analyze the effect of seasonality and distribution location on the incidence of such microorganisms.

2 Materials and methods

2.1 Sample collection

Samples were collected between April 2002 and March 2004. A total of 156 raw meat and beef offal samples were randomly collected from butcheries ($n = 18$), supermarkets (n = 18), and slaughterhouses ($n = 6$) in Casablanca, Morocco. Samples of beef ($n = 52$), lamb (n = 52), and beef offal ($n = 52$) were collected. Two sampling periods were considered: a hot season (April to September) with temperatures varying between 25 and 39°C, and relative-moisture between 32 and 72%, and a cold season (November to March) with temperatures varying between 5 and 20°C and relative-moisture between 56 and 84%. At 2–week intervals, approximately 200 g of raw meat and beef offal were aseptically collected. All samples were sent to the laboratory in sterile bags at 4°C for ≤ 2 h. A portion (25 g) of each sample was placed into a separate sterile stomacher bag with 225 mL 0.1% sterile peptone water, and then pummeled with a MIX I mixer (AES Laboratory, Combourg, France). Samples were subsequently diluted serially in 0.1% sterile peptone water for bacterial analyses.

2.2 Bacteriological analysis

Viable cell counts were performed by the spread-plate method after tenfold serial dilutions in 0.1% w/v peptone solution as follows: (i) Aerobic total count (ATC) was carried out on plate count agar (PCA; Bio-Rad, Marnes la Coquette, France) and incubated at 30°C for 72 h. (ii) Fecal coliforms (FC) counts were carried out on Violet Red Bile Lactose Agar (Bio-Rad) incubated at 44°C for 24 h, typical colonies were considered as round, red-to-pink, 0.5–2 mm in diameter, surrounded with a red-to-pink halo. (iii) *E. coli* counts, on RAPID'*E. coli* Agar (Bio-Rad) incubated at 37°C for 18 to 24 h, typical *E. coli* colonies were considered as violet-to-pink. (iv) *S. aureus* on Baird-Parker agar with egg yolk-potassium tellurite emulsion plates (Bio-Rad) incubated at 35 ± 1°C for 24 to 48 h. Typical colonies (black surrounded by clear zones) were tested for coagulase activity using rabbit plasma after activation by overnight incubation in brain heart broth (Bio-Rad) at 35°C. (v) *C. perfringens* and other sulfite-reducing clostridia on tryptone-sulfite agar with Cyclocerine (Bio-Rad) incubated anaerobically at 44 ± 1°C for 24 to 48 h, followed by a confirmation on lactose-sulfite broth and thioglycholate with resazurine broth (Bio-Rad).

In addition to the above-mentioned enumerations, 25-g samples were analyzed for the presence or the absence of *Salmonella* spp, and *L. monocytogenes* using enrichment procedures. For confirmation of *Salmonella,* 25 g of each samples was homogenized with 225 mL of 0.1% peptone water and was incubated at 37°C for 24 h. Portions of 1 and 0.1 mL of this pre-enrichment culture were transferred, for enrichment, to 9 mL of Muller Kauffman with added Tetrathionate broth, and to Rappaport Vassiliadis Soy enrichment broth (Bio-Rad), respectively. Inoculated enrichment media were incubated at 37 and 42°C, respectively. After 24 h of incubation, a loopful of each enrichment medium was streaked onto Xylose-Lysine-Desoxycholate agar (Bio-Rad), Edel and Kampelmarcher agar and Hektoen agar (Bio-Rad) and incubated at 35°C for further 24 h. Presumptive colonies of *Salmonella* were picked from each plate and subjected individually to Kligler test (Double Sugar Iron agar). Typical colonies (Glucose+, Lactose-, Gas-, H2S+) were then picked and confirmed using the Enterobacteriaceae API 20E, commercial kit (Biomerieux, Marcy l'Etoile, France). Presumptive *Salmonella* isolates were serotyped using commercial antiserum according to the Kaufman and Whit protocol [11].

For confirmation of *L. monocytogenes*, a 25-g sample was homogenized in a sterile bag with 225 mL of Half Fraser broth (Bio-Rad) and incubated at 30°C for 24 h. A 1-mL portion from this pre-enrichment culture was transferred to 9 mL of enrichment broth (Complete Fraser broth) (Bio-Rad) and incubated at 35°C for 24 h. A loopful of the

enrichment culture was streaked onto Palcam (Bio-Rad) and Oxford agars (AES Laboratory), and incubated at 35°C for 24 to 48 h. Typical colonies were characterized biochemically by the *Listeria* API commercial test-kit (Biomerieux) [12].

2.3 Data analysis

For each organism, duplicate plates were enumerated and the means calculated. All bacterial counts were expressed as $\log_{10}$ colony forming units (cfu) per g ($\log_{10}$ cfu g^{-1}). The mean $\log_{10} (X)$ value and SD were calculated on the assumption of a log normal distribution. Data for counts from beef, lamb, and beef offal were analyzed separately. Preliminary analysis of fixed effects for data from beef, lamb, and beef offal using the general linear model (GLM) procedure of Statistical Analysis Systems (SAS®) v 8.2 (SAS, 2002) indicated that populations were dependent on season and distribution location. Data for beef and lamb were separated by organism and evaluated using a 2×2 (distribution location × season, respectively) factorial design. Data for beef offal were separated by organism and evaluated using a $2 \times 2 \times 2$ (distribution location × season × type, respectively) factorial design. For beef and lamb, individual fixed effects and up to two-way interactions were evaluated with ANOVA using the model $y = a + x_1 + x_2 + x_1x_2$ in the GLM procedures of SAS®, where x_1 represents distribution locations, x_2 represents season. For beef offal, individual fixed effects and up to three-way interactions were evaluated with ANOVA using the model $y = a + x_1 + x_2 + x_3 + x_1x_2x_3$ in the GLM procedures of SAS®, where x_1 represents distribution locations, x_2 represents season, and x_3 represents type of beef offal. Least-squares means were separated using a protected pair wise *t*-test of SAS®. All differences were reported at a significance level of alpha = 0. 5.

3 Results and discussion

3.1 General remarks

Microbiological profiles of beef, lamb and beef offal are reported in Tables 1, 2, and 3, respectively. Morocco has legislative microbiological safety criteria for foods, including raw meats [13]. For fresh red meat, acceptable upper limits are 2.5 $\log_{10}$ cfu g^{-1} for fecal coliforms, 2 $\log_{10}$ cfu g^{-1} for *S. aureus*, and 1.3 $\log_{10}$ cfu g^{-1} for *C. perfringens*. In addition, according to regulations, *Salmonella* and *L. monocytogenes* should be undetectable in a 25-g

Table 1. Microbiological profile of beef (mean $\log_{10}$ cfu g^{-1} ± SD)

	Distribution location					
	Slaughterhouse Season		Butchery Season		Supermarket Season	
	Hot ($n = 26$)	Cold ($n = 26$)	Hot ($n = 26$)	Cold ($n = 26$)	Hot ($n = 26$)	Cold ($n = 26$)
Aerobic plate counts	5.2 ± 0.8[a]	5.1 ± 1.5[a]	7.3 ± 1.1[b]	6.5 ± 1.4[a]	7.3 ± 0.7[b]	7.1 ± 1.0[b]
Fecal coliforms	1.6 ± 0.6[a]	1.6 ± 0.9[a]	3.7 ± 1.6[a]	2.8 ± 1.6[a]	3.2 ± 0.9[b]	1.4 ± 0.6[a]
Escherichia coli	1.0 ± 0.0[a]	1.2 ± 0.5[a]	3.2 ± 1.3[b]	2.4 ± 1.5[b]	2.5 ± 0.9[b]	1.0 ± 0.1[a]
Staphylococcus aureus	2.1 ± 0.3[a]	2.1 ± 0.3[a]	2.3 ± 0.4[a]	2.1 ± 0.5[a]	2.2 ± 0.4[a]	2.0 ± 0.0[a]
Clostridium perfringens	1.0 ± 0.0[a]	1.0 ± 0.0[a]	1.3 ± 0.5[a]	1.0 ± 0.0[a]	1.1 ± 0.3[a]	1.0 ± 0.1[a]

a, b) Means in the same row with different superscript letters are different ($p < 0.05$).

Table 2. Microbiological profile of lamb (mean $\log_{10}$ cfu g^{-1} ± SD)

	Distribution location					
	Slaughterhouse Season		Butchery Season		Supermarket Season	
	Hot ($n = 26$)	Cold ($n = 26$)	Hot ($n = 26$)	Cold ($n = 26$)	Hot ($n = 26$)	Cold ($n = 26$)
Aerobic plate counts	5.7 ± 1.0[a]	5.2 ± 1.3[a]	6.7 ± 0.9[a]	7.2 ± 0.9[a]	6.6 ± 1.2[a]	5.5 ± 1.6[a]
Fecal coliforms	2.0 ± 0.9[a]	2.1 ± 0.8[a]	3.7 ± 1.2[b]	3.3 ± 1.2[a]	3.4 ± 0.6[a]	1.9 ± 1.1[a]
Escherichia coli	1.2 ± 0.6[a]	1.3 ± 0.6[a]	3.2 ± 1.4[b]	2.6 ± 1.3[a]	2.2 ± 0.8[a]	1.6 ± 0.9[a]
Staphylococcus[a)]ureus	2.1 ± 0.2[a]	2.0 ± 0.0[a]	2.8 ± 1.2[a]	2.2 ± 0.6[a]	2.3 ± 0.5[a]	2.2 ± 0.6[a]
Clostridium perfringens	1.0 ± 0.0[a]	1.3 ± 0.5[a]	1.2 ± 0.6[a]	1.1 ± 0.3[a]	1.0 ± 0.0[a]	1.2 ± 0.5[a]

a, b) Means in the same row with different superscript letters are different ($p < 0.05$).

Table 3. Microbiological profile of beef offal (mean $\log_{10}$ cfu g^{-1} ± SD)

		Distribution location					
		Slaughterhouse		Butchery		Supermarket	
		Season		Season		Season	
		Hot ($n = 8$)	Cold ($n = 8$)	Hot ($n = 10$)	Cold ($n = 10$)	Hot ($n = 8$)	Cold ($n = 8$)
Aerobic plate counts	Heart	$3.2 \pm 0.5^{a, x}$	$2.7 \pm 0.5^{a, x}$	$6.4 \pm 1.1^{b, x}$	$3.9 \pm 1.5^{a, x}$	$3.9 \pm 1.4^{a, x}$	$4.4 \pm 1.8^{a, x}$
	Liver	$4.9 \pm 0.7^{a, y}$	$4.4 \pm 1.6^{a, y}$	$7.5 \pm 0.5^{b, x}$	$5.6 \pm 1.8^{a, x}$	$7.7 \pm 0.5^{b, y}$	$5.3 \pm 1.4^{a, x}$
Fecal coliforms	Heart	$1.0 \pm 0.0^{a, x}$	$1.0 \pm 0.0^{a, x}$	$3.3 \pm 1.4^{b, x}$	$1.4 \pm 1.0^{a, x}$	$1.9 \pm 0.8^{b, x}$	$1.5 \pm 1.0^{a, x}$
	Liver	$1.8 \pm 0.6^{a, y}$	$1.6 \pm 0.5^{a, y}$	$3.8 \pm 0.9^{b, x}$	2.8 ± 1.3^{ax}	$4.0 \pm 1.1^{b, x}$	$3.1 \pm 1.5^{b, x}$
Escherichia coli	Heart	$1.0 \pm 0.0^{a, x}$	$1.0 \pm 0.0^{a, x}$	$1.8 \pm 1.1^{a, x}$	$1.4 \pm 0.9^{a, x}$	$1.8 \pm 0.7^{b, x}$	$1.4 \pm 0.8^{a, x}$
	Liver	$2.0 \pm 0.8^{a, x}$	$1.2 \pm 0.5^{a, x}$	$3.4 \pm 1.0^{b, x}$	$2.8 \pm 1.3^{a, x}$	$3.8 \pm 1.3^{b, y}$	$3.0 \pm 1.4^{a, x}$
Staphylococcus aureus	Heart	$2.0 \pm 0.0^{a, x}$	$2.0 \pm 0.0^{a, x}$	$2.0 \pm 0.0^{a, x}$	$2.0 \pm 0.0^{a, x}$	$2.0 \pm 0.0^{a, x}$	$2.0 \pm 0.0^{a, x}$
	Liver	$2.1 \pm 0.6^{a, x}$	$2.0 \pm 0.0^{a, x}$	$3.3 \pm 0.8^{b, y}$	$2.0 \pm 0.0^{a, x}$	$2.2 \pm 0.6^{a, x}$	$2.1 \pm 0.2^{a, x}$
Clostridium perfringens	Heart	$1.0 \pm 0.0^{a, x}$	$1.0 \pm 0.0^{a, x}$	$1.2 \pm 0.3^{a, x}$	$1.0 \pm 0.1^{a, x}$	$1.0 \pm 0.0^{a, x}$	$1.0 \pm 0.0^{a, x}$
	Liver	$1.0 \pm 0.0^{a, x}$	$1.0 \pm 0.0^{a, x}$	$1.8 \pm 0.9^{a, x}$	$1.2 \pm 0.5^{a, x}$	$1.1 \pm 0.3^{a, x}$	$1.0 \pm 0.0^{a, x}$

a, b) Means in the same row with different superscript letters are different ($p < 0.05$).

x, y) Means in the same column for each offal type with different superscript letters are different ($p < 0.05$).

meat sample. There are no safety criteria concerning beef offal in the Moroccan standard regulations, however, for purposes of comparison reference is made to fresh red meat upper limits.

3.2 Aerobic plate counts

Microbiological quality may be considered a factor in determining meat quality. Aerobic plate counts (APC) are a widely accepted measure of the general degree of microbial contamination [14]. Meat is generally considered of poor hygienic quality or unfit for consumption when the APC on its surface exceeds 7 or 8 $\log_{10}$ cfu g^{-1}, respectively [15]. In this study, mean APC values were 6.5 ± 1.1, 6.2 ± 1.2, and 5.0 ± 1.4 $\log_{10}$ cfu g^{-1} for beef, lamb and beef offal, respectively. The mean APC in beef collected in slaughterhouses (5.2 ± 1.2 $\log_{10}$ cfu g^{-1}) is higher than that reported by Karib *et al*. [8] that ranged from 3.7 ± 0.5 to 4.4 ± 0.6 $\log_{10}$ cfu g^{-1}. The mean APC of beef collected in butcheries (7.3 ± 1.1 $\log_{10}$ cfu g^{-1} in hot season and 6.5 ± 1.4 $\log_{10}$ cfu g^{-1} in cold season) is similar to that reported by Oumokhtar *et al.* [9]. In the present study, beef liver collected in butcheries had mean APC values of 6.5 ± 0.8 $\log_{10}$ cfu g^{-1} in cold season to 7.5 ± 0.5 $\log_{10}$ cfu g^{-1} in hot season. These results are in agreement with those reported by Oumokhtar *et al.* [9], who found APC values of 6.50 ± 0.72 $\log_{10}$ cfu g^{-1}. Distribution location affected ($p < 0.05$) the levels of APC on meat samples. The levels of APC increased during the various stages of selling meat by >2 logs from slaughterhouses to retail. This may have been due to poor hygienic conditions and inadequate temperature during transport and storage of meat after the distribution process.

3.3 Fecal coliforms

The average numbers of fecal coliforms were 2.5 ± 1.2 $\log_{10}$ cfu g^{-1}, 2.8 ± 1.0 $\log_{10}$ cfu g^{-1} and 2.3 ± 1.1 $\log_{10}$ cfu g^{-1}

in beef, lamb and beef offal, respectively. In this study, mean of fecal coliform counts in beef collected in slaughterhouses (*i. e.* 1.6 ± 0.7 $\log_{10}$ cfu g^{-1}) was in accordance with that reported by Karib *et al.* [8] for beef collected in the slaughterhouse of Rabat. On the other hand, the results obtained for fecal coliforms in beef samples collected from butcheries (3.2 ± 0.6 $\log_{10}$ cfu g^{-1}) were consistent with those reported by Oumokhtar *et al.* [9] for samples beef collected from butcheries in Rabat. The statistical analysis of the data obtained revealed that the effect of the sampling location on the numbers of fecal coliforms was highly significant ($p < 0.05$) whereas there appeared to be no seasonal effect. The average numbers of fecal coliforms in meat samples taken from butcheries or supermarkets were significantly ($p < 0.05$) higher than those recorded for meat samples taken from the slaughterhouses suggesting that the hygienic conditions and temperature in which the product was handled and stored after the slaughtering process may have been inadequate.

3.4 *Escherichia coli*

Of all samples analyzed, 59 (37.8%) tested positive for *E. coli* including 13 (25%) samples of beef, 23 (44.2%) of lamb and 23 (44.2%) of beef offal. The average counts for *E. coli* were 2.0 ± 1.0 $\log_{10}$ cfu g^{-1}, 2.1 ± 1.0 $\log_{10}$ cfu g^{-1}, and 2.1 ± 1.0 $\log_{10}$ cfu g^{-1} in beef, lamb and beef offal, respectively. Similar *E. coli* contamination levels in these products were reported by other authors [16, 17]. Both season and distribution location affected ($p < 0.05$) the incidence and the level of contamination beef and lamb with *E. coli*. The average numbers of *E. coli* in meat samples collected from butcheries and supermarkets were 1 log higher than the average numbers of the same species in meat samples collected from slaughterhouses. According to Gill *et al.* [16], the counts of *E. coli* increase steadily (more than

Mol. Nutr. Food Res. 2006, *50*, 557–562

Bacterial quality of red meat and offal

561

3 log unit) during the various stages of carcass handling and deboning process. Such increases in contamination become further aggravated with poor hygienic conditions during handling and processing. High counts of *E. coli* in foods are not always alarming because most strains are harmless and opportunistic in nature [6]. Nevertheless, the bacterium is well recognized as a fecal indicator that provides a fair estimate of the level of fecal contamination and the hygienic conditions during handling and processing [18]. Furthermore, some *E. coli* strains are pathogenic and have been associated with severe gastroenteritis through internalization, toxin production and interference with physiological functions [19]. Benkerroum *et al*. [20] have isolated shigatoxin producing *E. coli* O157 at a frequency of 11.1% from meat products marketed in the city of Rabat.

3.5 *Staphylococcus aureus*

S. aureus has long been recognized as a food poisoning bacterium of concern to human health worldwide [21]. In the present study, the pathogen was isolated from 25 samples (16%) of the 156 meat and beef offal samples with a prevalence of 11.5, and 20.5% in the cold and the hot season, respectively. The average counts of *S. aureus* recorded in beef, lamb and beef offal were 2.1 ± 0.4, 2.3 ± 0.7, and 2.1 ± 0.5 $\log_{10}$ cfu g^{-1}, respectively. The counts of the pathogen in beef samples collected from slaughterhouses (2.1 ± 0.3 $\log_{10}$ cfu g^{-1}) were in agreement with those reported by Karib *et al*. [8] (*i. e.* 2.4 ± 0.4 $\log_{10}$ cfu g^{-1}). Enumeration of *S. aureus* revealed that the count of the pathogen exceeded 5 $\log_{10}$ cfu g^{-1} in 3 out of the 156 analyzed samples (0.02%). Such high level contamination with *S. aureus* has been associated with increased risk for staphylococcal food poisoning [22]. High contamination of food with *S. aureus* has been related to improper personal hygiene of employees [23] during handling and processing.

Neither season nor sampling location significantly ($p > 0.05$) affected the levels of contamination of red meat and beef offal samples with *S. aureus*.

3.6 *Clostridium perfringens*

The overall mean count of *C. perfringens* in meat and beef offal was 1.1 ± 0.3 $\log_{10}$ cfu g^{-1}. However, individually, the count of *C. perfringens* exceeded the tolerable limit set by the Moroccan food safety regulations (*i. e.* 1.3 $\log_{10}$ cfu g^{-1}) in 7 (4.5%) of the 156 samples analyzed, all of which were taken at point-of-sale. Such counts were significantly ($p < 0.05$) affected by the season of sampling.

C. perfringens is one of the most widespread of all pathogenic bacteria in the environment, and is commonly found (although in low numbers) in the gastrointestinal tract of healthy animals, where from it generally contaminates animal carcasses during slaughtering [6]. Nonetheless, the most frequently involved anaerobic microorganisms involved in food spoilage and/or poisoning are sulfite-reducing clostridia. These microorganisms can grow inside the carcasses, thereby producing off-flavors and/or producing toxins [24].

Correlation analysis between the five group of microorganisms, namely APC, fecal coliforms, *E. coli*, *S. aureus* and *C. perfringens* indicated a high correlation between fecal coliforms and *E. coli* (r = 0.92, $p < 0.05$), and between APC and fecal coliforms (r = 0.77, $p < 0.05$).

3.7 *Salmonella*

Salmonella was not detected in any of the 25-g meat and beef offal samples. These results are in agreement with those reported previously [8, 9, 25]. In studies done by Madden *et al*. [26], and Bacon *et al*. [27], the prevalence of presumptive *Salmonella* spp. was reported to be 1.3 to 1.5%, respectively.

3.8 *Listeria monocytogenes*

L. monocytogenes was not detected in any of the 25-g meat or beef offal samples. Results from this study contrast with those of, Kriem *et al*. [28] who reported a 14.4% overall incidence of *L. monocytogenes* in red meat and meat products marketed in Rabat. Although, it is well established that refrigeration reduces or eliminates the risk of food borne diseases and is therefore required for the storage of many foods including meats [29, 30], *L. monocytogenes* is a typical cold-tolerant pathogen in meat [2]. It may result in serious and sometimes fatal diseases in humans, especially in immuno-compromised individuals. The incidence of human listeriosis in Morocco is low and there is no evidence implicating red meat as a vehicle of the pathogen in the reported cases (Morocco food borne disease outbreaks, searchable data 2000–2005. Yearly Reports 2000–2004). Despite the ubiquity of *L. monocytogenes*, its occurrence at high levels in fresh red meat is uncommon.

4 Concluding remarks

Results of this study indicated that bacterial counts in 30% of all tested samples were beyond the Moroccan safety limits. These cases were observed in samples taken from butcheries and supermarkets while all of those collected from slaughterhouses were below the regulatory standards. These results suggest that there may be a lack of adequate control

strategies during post-slaughter operations. Such inadequate controls may include: lack of good hygienic practices, inadequate sanitation during manufacturing, transport, storage, and post-production handling, as well as inadequate maintenance of adequate cold chain management during distribution. Consistent with other countries, Morocco is experiencing newer consumer trends in the culinary traditions with an obvious tendency to adopt international and further processed foods, some of which are uncooked or undercooked. Such a tendency combined with poor hygienic practices may contribute to increase the prevalence of pathogens in foods, thereby increasing the risk of food borne disease for consumers. Results obtained in this study provide evidence, which may be used by the Moroccan government to adopt regulations enforcing the application of the hazard analysis critical control points (HACCP) system as a means to identify and control the hazards in foods and especially in meat products. Furthermore, these results may promote the acceptance of programs such as HACCP by the meat industry in an attempt to provide safer and more wholesome products.

5 References

[1] Käferstein, F., Motarjemi, K., Bettcher, D. W., *Emer. Infect. Dis*. 1997, *3*, 603–610.

[2] Nel, S., Lues, J. F. R., Buyus, E. M., Venter, P., *Meat Sci.* 2004, *66*, 667674.

[3] CDC Preliminary food net Data on the incidence of food borne illness-selected CDC or the US Department of Health and Human Service. Washington DC, US Food and Drug Administration, *Cent. Food Safety App. Nutr. 2003*.

[4] Haeghebaert, S., Le Querrec, F., Bouvet, P., Gallay, A., *et al*., *B.E.H.* 2002, *50*, 249–254.

[5] Karib, H., *Animalis* 2001, *2*, 44–51.

[6] Mead, G. C., *British Food J.* 1994, *96*, 33–36.

[7] Stiles, E. M. E., Lai-King, N., *App. Env. Microbiol.* 1980, *40*, 346–351.

[8] Karib, H., Bazri, L., Yanguela, J., Blanco, D., *et al.*, *Viandes prod. carnés* 1994, *15*, 79–82.

[9] Oumoukhtar, B., Karib, H., Bouchriti, N., Araba, A., *Actes Inst. Agron. Vet.* 1998, *18*, 169–176.

[10] Houandji, M. A., Thèse de Doctorat vétérinaire, Institut Agronomique et vétérinaire Hassan II, Rabat 2002.

[11] Kauffman, F., Da Kauffman-White-Scheme, in: Van Oye, E. (Eds.), The World Problem of Salmonellosis, W. Junk, The Hague 1964, pp. 21–66.

[12] Capita, R., Calleja, C. A., Pietro, M., Fernandez, M., *et al.*, *Food Microbiol.* 2001, *18*, 555–563.

[13] Department Order N 624-04, Relative of animal and animal origin foods. *Official Bulletin Morocco* 2004, *5214*, 727–745.

[14] Alberle, E. D., Forrest, J. C., Gerrard, D. E., Mills, E. W., *Principles of meat science* (4th ed.), Kendall/Hunt Publishing Company, USA 2001.

[15] Report on mechanically recovered meat of Scientific Veterinary Committee, *Food Safety* 1997.

[16] Gill, C. O., Badoni, M., McGinnis, J. C., *Int. J. Food Microbiol.* 1999, *46*, 1–8.

[17] Gill, C. O., McGinnis, J. C., *Food Res. Int.* 2000, *33*, 123130.

[18] Eisel, W. G., Lintion, R. H., Muriana, P. M., *Food Microbiol.* 1997, *14*, 273–282.

[19] Sachey, B. A., Mensah, P., Collison, E., Dawson, E. S., *Int. J. Food Microbiol.* 2001, *71*, 21–28.

[20] Benkerroum, N., Bouhlal, Y., El Attar, A., Marhaben, A., *J. Food Prot.* 2004, *67*, 1234–1237.

[21] Acco, M., Ferreira, F. S., Henriques, J. A. P., Tondo, E. C., *Food Microbiol.* 2003, *20*, 489–493.

[22] Peiffer, B., Toxi-infections alimentaires à staphylocoques. *Actualité TIAC*, France 1999.

[23] Hatakka, M., Björkrth, K. J., Asplud, K., Mäki-Petäys, N., Korkeala, H., *J. Food Prot.* 2000, *11*, 1487–1491.

[24] Tholozan, J.-L., Carlin, F., Fach, P., Poumeyrol, M., *Bull. Soc. Fr. Microbiol.* 1997, *12*, 48–55.

[25] Rolthenberg, C. A., Berry, B. W., Oblinger, J. L., *J. Food Prot.* 1982, *45*, 527–532.

[26] Madden, R. H., Espie, W. E., Moran, L., McBride, J., *et al.*, *Meat Sci.* 2001, *58*, 343–346.

[27] Bacon, R. T., Sofos, J. N., Belk, K. E., Hayatt, D. R., *et al.*, *J. Food Protec.* 2002, *65*, 287–290.

[28] Kriem, M. R., EL Marrakchi, A., Hamama, A., *Microbiol. Alim. Nutr.* 1998, *16*, 179–187.

[29] Russel, S. M., *Poul. Sci.* 1995, *75*, 2057–2061.

[30] Rodrigo, S., Adesiyun, A., Asgarali, Z., Swanston, W., *Food Microbiol.* 2005, *22*, 125–131.