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Investigation of Food Safety Status in Some Restaurants of Salalah State Municipality, Sultanate of Oman

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Abstract: *A cross-sectional study was conducted from June to December 2012 in Salalah state municipality, Sultanate of Oman, to investigate the degree of microbial contamination of foods prepared in some restaurants. A total of 142 samples were randomly collected from 21 restaurants from 7 different areas. These samples were 38 water, 41 ready-to-eat foods, and 63 swabs. The water samples were from drinking and underground water while the food samples were meat- and vegetable-based. Moreover, the swab samples were taken from surfaces of knives or cutting boards, kitchen worktables, and hands of workers. Coliform bacteria and E. coli were detected, with most probable numbers (MPN) ranging from 1 to <200.5 per 100 ml and <1 per 100 ml in drinking water, and from 1 to <200.5 per 100 ml and from 2 to 8.7 per 100 ml in underground water. E. coli and Staphylococcus aureus were detected in 5.0% (95% CI, 0.71 to 9.29) and 3.0% (95% CI, -1.08 to 7.08) of the investigated foods and swabs. However, no Salmonella species, Bacillus species, and Listeria species were detected. Furthermore, statistical significant differences were not observed at p-value ≤0.05 when the total plate count (TPC) and the Enterobacteriace enumeration (EE) were compared between foods and swabs. The TPCs ranged from 1.0×10^2 cfu/g or cm^2 to 3.3×10^5 cfu/g or cm^2 while the EE levels were from 0.0×10^3 cfu/g or cm^2 to 3.4×10^3 cfu/g or cm^2. It can be concluded that water treatment practices in Salalah state municipality are effective, thus the water was safe for use but exerting more effort is favorable. The microbial quality of foods were satisfactory or unsatisfactory based on the TPC and satisfactory based on the EE. Regulations that state the microbiological quality standards of ready-to-eat foods prepared at restaurants are needed to be set by Omani authorities.*

Keywords: *safety, food, water, restaurants, bacteria, Oman*

1. INTRODUCTION

Food and water are very important vehicles for transmission of various microbial diseases to many consumers. These diseases are continuously diagnosed and reported worldwide and the toll in terms of human life and suffering is massive [8, 20, 26, 31]. The World Health Organization (WHO) stated that contaminated food and water contribute to about 1.5 billion cases of diarrhea in children and cause more than 3 million premature deaths annually [20]. In South East Asia alone, nearly 1 million child under 5 years of age die each year due to diarrheal diseases caused by consuming and drinking contaminated food and water [21]. The same age category in African countries is vulnerable and the most affected by microbial diseases transmitted by water [25]. Moreover, microbial water-borne diseases also affect developed countries. In the USA, approximately 560,000 people suffer from severe water-borne diseases and 7.1 million suffer from a mild to moderate infections, resulting in, more or less, 12,000 deaths per year [26].

The different species of bacteria found in food usually originate from many sources but their presence in water would generally suggest fecal contamination [22]. Poor environmental sanitation is the main incriminated source of food contamination as well as poor personal hygiene of food handlers [20, 31]. Inappropriate storage often leads to the multiplication and propagation of pathogens in food and consequently their total viable counts increase to infective doses. Sometimes it also leads to profuse

bacterial toxins production and excretion [20]. In addition, most of the food workers and handlers have limited education and therefore lack necessary knowledge about proper handling of food, and the risks that might arise to consumers in case of improper handling [31]. Certain habits and specific food preparation techniques, which might vary by culture, enhance the opportunity of microbiological contamination of food. There is also a growing trend of eating outside and consuming ready-to-eat foods in restaurants and retails, particularly, among young people. This has increased the risks of food-borne disease outbreaks [20]. Many bacterial species can be found on food processing surfaces from where they can subsequently contaminate the food and might cause its spoilage [29].

Although implementation of hazard analysis critical control points (HACCP) in food service establishments has brought an increased consciousness about sanitation conditions that are necessary to avoid food-borne illness outbreaks and many changes in food industry. It requires application of effective control procedures at critical control points associated with realistic and adequate monitoring for remedial actions and corrections [23, 6]. However, improper sanitary conditions in many developing countries in the whole food production chain starting from primary production to the consumers, create vulnerability in food safety [29]. Besides, these countries cannot fulfill HACCP requirements as there are no sufficient and efficient surveillance and systems to recognize, report, and track food-borne illnesses. Consequently, data on food-borne diseases are extremely scarce and improvements are needed to better identify the causes of food-borne diseases [20]. In the Sultanate of Oman, food safety status needs to be investigated as there is a paucity of data concerning the prevalence of contamination with multiple food-borne pathogens in ready-to-eat foods prepared at restaurants. This study aimed at giving some insights on this matter.

2. MATERIALS AND METHODS

Study design and sampling

A cross-sectional study was conducted for a period of six months, from June to December 2012, in Salalah state municipality, Sultanate of Oman [32]. A total number of 142 samples were collected from 21 restaurants from 7 different areas (3 restaurants in each). The investigated areas were Al-Haafah, Al-Sinaat Al-Jadeedah, Al-Goof, Awgaad, Al-Saadah North and South and Salalah Al-Wustaa. Samples were randomly collected as follow: 38 water, 41 ready-to-eat foods, and 63 swabs. The water samples were unbottled drinking and underground water; 19 from each, and were collected in sterile 100-ml glass bottles as described by Rice *et al.* [24]. Unbottled drinking water, according to the Omani standards number 8/2006 (OS 8/2006), is the water that undergoes through filtration and desalination by reverse osmosis, decantation, and disinfection and therefore it is fit for human consumption while underground water is that collected from a vertical hole cut into the ground and it is not fit for human consumption but can be used for several purposes like washing and cleaning of kitchen wares. The food samples were collected in sterile bags and were cooked meat-based foods like chicken, fish and beef and vegetable-based foods like potatoes. Furthermore, the swab samples were taken from surfaces of knives or cutting boards, kitchen worktables, and hands of workers. All collected samples were marked, numbered and transported promptly on ice to the Food and Water Laboratory, Directorate General of Salalah State Municipality, where they were all examined.

Laboratory Procedures

Testing of water samples

The collected water samples were assayed by using the Colilert® 18 system according to the instructions of manufacturer (IDEXX Laboratories, Inc., Westbrook, ME, USA) by adding 1 pack of the Colilert's nutrient-indicator or the substrate, which contains ortho-nitrophenyl-β-D-galactopyranoside (ONPG) and 4-methylumbelliferyl- β -D-glucuronide (MUG), to each sample. The 100-ml bottle was shaken until the substrate was thoroughly dissolved in the test sample. The mixture was then poured into a 51-well QuantiTray and the tray was sealed and incubated for 18 to 22 hours at 37±1°C. After that, the tray was removed from the incubator and viewed for discoloration of the wells by necked eyes. Total coliform-positive wells displayed a yellow color indicating ONPG hydrolysis whereas *E. coli*-positive wells were yellowish and fluorescing under ultra-violet (UV) light (365 nm) indicating MUG cleavage. By means of a table provided with the system, counts of the number of positive wells were converted to a most probable number (MPN) of coliform and *E. coli* per 100 ml.

Testing of foods and swabs

Sample preparation

All of the collected food samples were prepared according to Baylis *et al.* [27]. A 10-g of each test sample was put into a sterile plastic bag and 90 ml of Maximum Recovery Diluent (MRD) were added to it. The mixture was homogenized with a Stomacher for 2 minutes and kept at room temperature for 15 minutes. After that, 1 ml of the macerate was transferred into 9 ml of the MRD and mixed well. Then 1 ml from this suspension was cultured onto a solidified 15 to 20 ml volume of agar medium of choice and kept at proper incubating conditions. Furthermore, for bacterial and *Enterobacteriace* count and enumeration additional dilutions were made.

A volume of 5 ml of nutrient broth was added to each swab sample and were all kept at proper incubating conditions for 24 hours. After that 1 ml was cultured onto a solidified 15 to 20 ml volume of agar medium of choice as done for the food samples and further serial dilutions were made as well.

Bacterial counts

For bacterial counts, the total plate count (TPC) and the *Enterobacteriace* Enumeration (EE) were carried out as described by and Barrow and Feltham [33].

The TPC was conducted by making of a 10-fold serial dilution of each sample. Five sterile test tubes were labelled from 1 to 5. From the test tube 1, a volume of 1 ml was added into the test tube 2 to make a total volume 10 ml. The process continued until a serial dilution form 10^{-1} to 10^{-5} was achieved. Each dilution was then cultured by the pouring plate method using the standard plate count agar medium and cultured plates were then incubated at 37°C for 24 hours. After that, the number of all colonies was counted for each dilution and the mean count was determined. Each colony represented a bacterium or colony forming unit (cfu) that was in the diluted sample, this is why, the number of viable bacteria per Millilitre (ml) in the sample was calculated and expressed in cfu /g or cm^2.

The EE was carried out by using the pouring plate method and violet red bile glucose agar (VRBGA). A volume of 1 ml of the diluted sample was transferred to a Petri dish. Then 15 ml of tempered VRBGA in a 45°C water bath was added. The inoculum was carefully mixed with the medium and the mixture was allowed to solidify. After complete solidification, an overlay with 10 to 15 ml was made. Plates containing completely solidified mixtures were incubated at 37°C for 24 - 48 hours. The count was expressed as *Enterobacteriace* per g or cm^2 as follows: the number of computed colonies was divided by the inoculated volume which is multiplied by the dilution factor.

Isolation and identification of bacterial

The standard procedures for isolation of *Escherichia coli*, *Salmonella* species, *Staphylococcus aureus*, *Bacillus* species, and *Listeria* species were conducted by using the surface plate method and the respective selective media as described by Barrow and Feltham [33]. The collected food and swab samples were cultured onto prepared, violet red bile agar (VRBA), Oxford Listeria agar, mannitol salt agar (MSA), tryptic soy agar (TSA) and Baird Parker agar. All plates were incubated at 37^{o}C for 24 hours. For confirmation of *E. coli*, any growth on the VRBA was subcultured onto Brilliant green agar and into trypton water and incubated at 44^{o}C for 24 hours. For isolation of *Salmonella* species, samples were first cultured into buffered peptone water and kept at 37^{o}C for 24 hours, then subcultured into Selenite cystine broth base for 24 hours at 37^{o}C, and finally subcultured onto xylose lysine deoxycholate agar (XLDA) for 24 hours at 37^{o}C.

Statistical analyses

The generated data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 20.0, IBM/SPSS. Descriptive statistics were performed and Analysis of Variance (ANOVA) with a *p-value* of ≤0.05 likewise.

3. RESULTS

Microbial quality of water

Coliform bacteria were detected in 36.8% (7/19) of the drinking water samples with an MPN ranging from 1 to <200.5 per 100 ml but *E. coli* was not detected in any sample (0.0%, 0/19) with an MPN of <1 per 100 ml. Furthermore, the MPN levels in drinking water of 57.1% (12/21) of the restaurants

were acceptable according to OS 8/2006, however, the MPN levels of 33.3% (7/21) of the restaurants were inacceptable, and the microbial quality of 9.6% (2/21) of the restaurants was not evaluated (Table 1).

Table 1. *The MPNs of coliform bacteria and E. coli in drinking water by area in restaurants of Salalah state municipality (From June to December 2012)*

Area	Site	A	MPN	95% CI		B	MPN	95% CI		Safety
				L	H			L	H	
Al-Haafah	a	13	15	8.8	25.7	0	<1	0	3.70	1
	b	0	<1	0	3.70	0	<1	0	3.70	0
	c	0	<1	0	3.70	0	<1	0	3.70	0
Al-Sinaat	d	50	<200.5	146	~	0	<1	0	3.70	1
	e	0	<1	0	3.7	0	<1	0	3.70	0
	f	-	-	-	-	-	-	-	-	-
Al-Goof	g	0	<1	0	3.70	0	<1	0	3.70	0
	h	14	16.4	9.8	27.5	0	<1	0	3.70	1
	i	0	<1	0	3.70	0	<1	0	3.70	0
Awgaad	j	50	<200.5	146	~	0	<1	0	3.70	1
	k	1	1	0	3.70	0	<1	0	3.70	1
	l	-	-	-	-	-	-	-	-	-
Al-Saadah North	m	0	<1	0	3.70	0	<1	0	3.70	0
	n	51	<200.5	146	~	0	<1	0	3.70	1
	o	50	<200.5	146	~	0	<1	0	3.70	1
Al-Saadah South	p	0	<1	0	3.70	0	<1	0	3.70	0
	q	0	<1	0	3.70	0	<1	0	3.70	0
	r	0	<1	0	3.70	0	<1	0	3.70	0
Salalal Al-Wustaa	s	0	<1	0	3.70	0	<1	0	3.70	0
	t	0	<1	0	3.70	0	<1	0	3.70	0
	u	0	<1	0	3.70	0	<1	0	3.70	0

Alphabets indicate sampled restaurants = 21, A = number of coliform positive wells, MPN = most probable number, CI = confidence interval, L = lower limit, H = higher limit, B = number of *E. coli* positive wells, - = not done, ~ = unlimited, and safety of water is 1 = not safe and 0 = safe

MPNs of coliform bacteria and *E. coli* in 73.7% (14/19) and 10.5% (2/19) of underground water were from 1 to <200.5 per 100 ml and from 2 to 8.7 per 100 ml, respectively. According to OS 8/2006, 57.1% (12/21) and 33.3% (7/21) of the restaurants were using water with acceptable and inacceptable MPN levels. Additionally, the microbial quality well water of 9.6% (2/21) restaurants was not measured (Table 2).

Table 2. *The MPNs of coliform bacteria and E. coli in underground water by area in restaurants of Salalah state municipality (From June to December 2012)*

Area	Site	A	MPN	95% CI		B	MPN	95% CI		Safety
				L	H			L	H	
Al-Haafah	a	1	1	0.30	5.6	0	<1	0	3.70	0
	b	45	109.1	78.6	185.7	0	<1	0	3.70	1
	c	10	11.1	6.1	20.5	2	2	0.6	7.3	1
Al-Sinaat	d	0	<1	0	3.70	0	<1	0	3.70	0
	e	0	<1	0	3.70	0	<1	0	3.70	0
	f	50	<200.5	146	~	8	8.7	4.5	17.1	1
Al-Goof	g	1	1.1	0	3.70	0	<1	0	3.70	0
	h	10	11.1	6.1	20.5	0	<1	0	3.70	1
	i	3	3.1	1.7	9	0	<1	0	3.70	0
Awgaad	j	-	-	-	-	-	-	-	-	-
	k	-	-	-	-	-	-	-	-	-
	l	1	1	0	3.70	0	<1	0	3.70	0
Al-Saadah North	m	3	3.1	1.1	9	0	<1	0	3.70	0
	n	5	5.3	2.3	12.3	0	<1	0	3.70	1
	o	51	<200.5	146	~	0	<1	0	3.70	1
Al-Saadah	p	51	<200.5	146	~	0	<1	0	3.70	1
	q	2	2	0.6	7.3	0	<1	0	3.70	0

South	r	3	3.1	1.1	9	0	<1	0	3.70	0
Salalal Al-Wustaa	s	0	<1	0	3.70	0	<1	0	3.70	0
	t	0	<1	0	3.70	0	<1	0	3.70	0
	u	0	<1	0	3.70	0	<1	0	3.70	0

Alphabets indicate sampled restaurants = 21, A = number of coliform positive wells, MPN = most probable number, CI = confidence interval, L = lower limit, H = higher limit, B = number of *E. coli* positive wells, - = not done, ~ = unlimited, and safety of water is 1 = not safe and 0 = safe

Microbial quality of food

Total plate and *Enterobacteriace* count and enumeration

Statistical significant differences at *p-value* of ≤0.05 were not observed when the TPC was compared between food samples and swabs, and the EE as well. On one hand, as shown in Table 3, the highest TPC level reported from meat-based food samples (3.3×10^5 cfu/g) was in Al-Sinaat, from vegetable-based foods (1.3×10^4 cfu/g) was in Al-Saadah South, on knives or cutting boards (1.0×10^5 cfu/cm^2) was in Al-Haafah and Al-Saadah North, on surfaces of kitchen worktables (2.0×10^5 cfu/cm^2) was in Al-Haafah and from hands of workers (1.6×10^5 cfu/cm^2) was in Al-Saadah South.

Table 3. *Comparison of the mean total plate counts (log_{10} cfu/g or cm^2) between the samples of foods and swabs collected from restaurants of Salalah state municipality (From June to December 2012)*

Area	Foods and swabs					Significance
	A	B	C	D	E	
Al-Haafah	1.4×10^5	3.7×10^3	1.0×10^5	2.0×10^5	1.0×10^5	NS
Al-Sinaat	3.3×10^5	1.0×10^4	2.7×10^4	4.2×10^4	1.0×10^5	NS
Al-Goof	1.0×10^3	1.4×10^2	3.8×10^3	1.0×10^5	1.4×10^5	NS
Awgaad	1.6×10^5	1.3×10^3	1.5×10^3	1.1×10^3	1.0×10^5	NS
Al-Saadah North	7.6×10^2	2.7×10^3	1.0×10^5	5.2×10^4	4.9×10^3	NS
Al-Saadah South	1.0×10^5	1.3×10^4	2.5×10^4	7.3×10^4	1.6×10^5	NS
Salalah Al-Wustaa	1.0×10^2	6.6×10^3	1.0×10^3	1.0×10^5	3.8×10^4	NS

A = meat-based foods, B = vegetable-based foods, C = knives or cutting boards, D = surface of kitchen worktable, E = hands of workers, * = significant at *p-value* ≤0.05, NS = not significant at *p-value* ≤0.05, and ND = not done

The following EE levels: 0.037×10^3 cfu/g, 1.000×10^3 cfu/g, 3.400×10^3 cfu/cm^2, 1.500×10^3 cfu/cm^2, and 0.267×10^3 cfu/cm^2 were the highest, correspondingly, recorded from samples of meat- and vegetable-based foods and swabs from knives or cutting boards, surfaces of kitchen worktables and hands of workers (Table 4).

Table 4. *Comparison of the mean Enterobacteriace enumeration total bacterial counts (log_{10} cfu/g or cm^2) between the samples of foods and swabs collected from restaurants of salalah municipality (From June to December/2012)*

Area	Foods and Swabs					Significance
	A	B	C	D	E	
Al-Haafah	0.037×10^3	0.033×10^3	0.033×10^3	0.067×10^3	0.033×10^3	NS
Al-Sinaat	0.037×10^3	0.067×10^3	0.029×10^3	0.037×10^3	0.000×10^3	NS
Al-Goof	0.000×10^3	0.000×10^3	0.000×10^3	0.133×10^3	0.033×10^3	NS
Awgaad	0.033×10^3	0.133×10^3	0.000×10^3	0.000×10^3	0.000×10^3	NS
Al-Saadah North	0.000×10^3	0.667×10^3	3.400×10^3	1.100×10^3	0.267×10^3	NS
Al-Saadah South	0.033×10^3	0.033×10^3	0.000×10^3	0.400×10^3	0.000×10^3	NS
Salalah Al-Wustaa	0.000×10^3	1.000×10^3	0.100×10^3	1.500×10^3	0.000×10^3	NS

A = meat-based foods, B = vegetable-based foods, C = knives or cutting boards, D = surface of kitchen worktable, E = hands of workers, * = significant at *p-value* ≤0.05, NS = not significant at *p-value* ≤0.05, and ND = not done

There are no available regulatory standards for microbiological safety criteria set by the Omani authorities for locally (non-industrial) prepared ready-to-eat foods. However, according to the Dutch, Canadian and Hong Kong food safety standards, that comply with the guidelines of the

microbiological quality of various ready-to-eat foods according to Gilbert *et al*. [28], food quality is classified to good or satisfactory, acceptable or marginal, unsatisfactory, and unacceptable or potentially hazardous (Table 5). In that view, the microbial quality of meat-based foods were either satisfactory in 42.9% (3/7) of the investigated areas or unsatisfactory in 57.1% (4/7) areas depending on the results of the TPC while depending on the results of the EE, all of the investigated areas (100%, n = 7) had satisfactory meat-based foods. Additionally, the microbial counts of vegetable-based foods were either satisfactory in 71.4% (5/7) of the investigated areas or acceptable in 28.6 (2/7) areas depending on the results of the TPC while depending on the results of the EE, all of the investigated areas (100%, n = 7) had satisfactory vegetable-based foods.

Table 5. *The categories and subsequent action to be taken according to the New South Wales (NSW) Food Authority*

	Category	**Interpretation**	**Action**
Pass	good	results are within expected microbiological levels for this type of product (lower range) and present no food safety concern	none
	acceptable	results are within expected microbiological levels for this type of product (upper range) and present no food safety concern	none
Fail	unsatisfactory	results are outside the expected microbiological levels for this type of product, present no food safety concern, and might indicate poor food handling practices	further samples are taken for testing. If these return good or acceptable results no action is taken but if return unacceptable the business is inspected to determine if food handling controls and hygiene practices are adequate. A product withdrawal may be considered while further testing occurs
	potentially hazardous	results are outside of the expected microbiological levels for this type of product and present a potential food safety concern.	inspection of suppliers to determine if food handling controls and hygiene practices are adequate; a product recall is considered

Bacterial species detected in restaurants

Two species of bacteria, namely: *E. coli* and *S. aureus* were isolated and identified from the 7 areas under investigation as shown in Table 6. *E. coli* was detected in 5.0% (95% CI, 0.71 to 9.29) and *S. aureus* was in 3.0% (95% CI, -1.08 to 7.08) of the investigated samples. However, no *Salmonella* species, *Bacillus* species, and *Listeria* species were detected in any of the studied restaurants with 0.0% (95% CI, 0.0 to 0.0) prevalence.

Table 6. *Detected bacteria in different investigated samples of foods and swabs from restaurants of Salalah state municipality (From June to December/2012)*

Bacteria	**Number of tested**	**Number of positive**	**Percentage of Positive**	**95% CI**	
				Lower	**Upper**
E. coli	99	5	5.0	0.71 - 9.29	
Salmonella species	50	0	0.0	0 - 0	
Staphylococcus aureus	67	2	3.0	-1.08 - 7.08	
Bacillus species	50	0	0.0	0 - 0	
Listeria species	50	0	0.0	0 - 0	

4. DISCUSSION

Level of bacterial count of water is an important factor in assessing the quality and safety of the water [31]. Results of this study have shown that the samples of drinking and underground water of more than half of the investigated restaurants were safe for use for the intended purpose and the samples of nearly one third of the restaurants were not safe to be used, according to the OS 8/2006. This finding was contrary to Al-Bahry *et al.* [30] who found no opportunistic and pathogenic bacteria in all the of water samples collected from reservoirs at pumping station. The counts of total heterotrophic plate (THP) below the desired levels also [30]. However, when water tanks at households were investigated, coliforms were detected in all, and the most frequent isolated bacteria were *Klebsiella pneumonia* and *Enterobacter cloacae*. Others like *Aeromonas* spp., *Legionella* spp., *Pasteurella* spp.,

Pseudomanads spp., *Salmonella* spp., and *Yersinia* spp. were also isolated [30]. Further inconsistency to the findings of this study, were the findings of Sudheesh *et al.* [29] who found very low relative light units (RLU) values that ranged from 0±0 to 138±18 RLU from tested water samples from some Omani fish markets and thus all the samples fulfilled safety standards. Additionally, Nawas *et al.* [10], Shahidul *et al*. [36], and Nkere *et al*. [31] observed diverse water safety levels. Nawas *et al*. [10] found colifrms in 33.33%, *Salmonella* species in 46.67% and *Vibrio* species in 53.33% of water samples collected from restaurants in Chittagong, Bangladesh. Another study from Dhaka, Bangladesh, by Shahidul *et al*. [36] reported *Vibrio* spp., *Salmonella* spp. and *Shigella* spp., in 50%, 35%, and 60% of the tap water samples collected from different restaurants. When Nkere *et al*. [31] evaluated the bacteriological quality of foods and water consumed in Nsukka, Nigeria, 100% of the water samples were contaminated. Schets *et al.* [15] investigated total coliform and *E. coli* counts in a set of samples (a total of 179) in three different laboratories in the Netherlands and recorded the following average results per 100 ml: total coliforms of 70.2, 50.1 and 30.3 and *E. coli* counts of 14.0, 14.5 and 4.1. Furthermore, the MPNs of coliform bacteria and *E. coli* in this study were lower than that of Nawas *et al*. [10] who found a total viable count that ranged from 1.60×10^4 cfu/ml to 4.38×10^5 cfu/ml and a total coliform count of >1100 cfu per 100 ml. Further higher reports than the findings of this study were the findings of Christensen *et al*. [4], Nkere *et al*. [31], and Shahidul *et al*. [36]. Christensen *et al*. [4] indicated that *E. coli* and other coliform bacteria were present in the investigated drinking water distribution systems in the Netherlands in relatively high concentrations (2 *E. coli* per ml^{-1} and 5 total coliforms per ml^{-1}) and Shahidul *et al*. [36] found a total count of heterotrophic bacteria ranging between 1.2×10^4 and 5.4×10^4 cfu/ml and a total coliforms ranging between 11 and 40 cfu per 100 ml. The means of lactose fermentative bacteria (LF) and *E. coli* counts in 80.0% (8/10) of the water samples were 5.32 $\log_{10}$ cfu/ml and 4.46 $\log_{10}$ cfu/ml, respectively, and the MPNs ranged from 0 to 10 in 20% (2/10) of the samples and from 51 to 180 in 80.0% (8/10) of the samples [31]. The amount and type of water treatment applied to each of the investigated water in each study can elaborate the observed differences. The most commonly used water treatment processes include filtration, flocculation and sedimentation, and disinfection. Ion exchange and adsorption are also included in some treatment processes. Combination of treatment processes might vary from country to country and from one place to another in one country. Also, water is often disinfected by chlorination or ozonation before it enters into the distribution system to ensure that potentially dangerous microbes are inactivated. Chlorine, chloramines, or chlorine dioxide are most often used, not only at the treatment plants but also in the pipes that distribute water to the public. Ozone and ultra violet radiation are effective disinfectants but neither of them is used in controlling biological contaminants in the distribution pipes and thus the water is prone to post-treatment contamination during distribution. The source type and quality of the water could result in differences too. For instance, underground water is used for certain purposes without applying any treatment, while surface water needs treatment as it is exposed to direct air run off and easily become contaminated. Prolonged water static time can lead to pathogens proliferation due to the accumulation of the essential trace nutrients they need and as result the microbial water quality change.

Evaluation of the bacterial quality of ready-to-eat foods is a useful indicator of the safety of the food. It is also one important criterion to predict the mean life of foods as well as identifying inadequate preparation or manufacturing and handling [14, 31, 38]. In this study, the bacterial quality of meat-based foods was either satisfactory or unsatisfactory depending on the results of the TPC, while for vegetable-based foods it was either satisfactory or acceptable, but depending on the results of the EE, the quality of all meat- and vegetable-based foods was satisfactory. This was opposing to the findings of Baluka *et al*. [39] who found that food safety standards were violated in 66.7% and 71.4% of the investigated different categories of food facilities in Uganda.

Regarding the TPC and EE levels, there were no statistical significant differences observed when they were compared between foods and swabs, confirming the results of Baluka *et al*. [39], who noted that the means of the aerobic plate counts (APC) were not significantly different between the investigated groups. But contrary Maori and De [37] did notice significant variation between the values of total bacterial counts (TBC) of spoons, forks, knives, cups, plates, washing pot in each restaurant. Additionally, the bacterial counts of vegetables, rice, potatoes, beef, chicken stew, and pies were statistically different and also between the estimates of foods from hygienic and unhygienic sources [38].

The contamination levels reported in this study were lower than that reported from foods and crockery and cutlery in Bangladesh, Nigeria, Uganda and South Africa [10, 14, 37, 38, 39]. Nawas *et al.* [10] found a TVC ranging from 1.86×10^4 to 7.28×10^5 cfu/g in salads from 15 restaurants located in Chittagong, Bangladesh. The total mesophilic aerobic counts from the 216 samples of fried ground beef in Nigeria, ranged between 6.70×10^8 and 9.30×10^9 cfu/g^{-1} with a mean count of 4.5×10^9 cfu/g^{-1} [14]. Baluka *et al*. [39] reported a total mesophilic aerobic count of 937,165 cfu/g. The mean total count in foods ranged from 7.64 to 9.21 $\log_{10}$ cfu/ml or g [31]. Moreover, the total values of bacterial counts (TBC) were between 1.0×10^4 and 2.5×10^6 cfu/ml for cups, forks, knives, plates, and washing pots and the mean value of aerobic bacterial count from vegetables, rice, potatoes, beef, chicken stew and pies were between 2.58±0.24 and 6.8±0.07 $\log_{10}$ cfu/g^{-1} [37, 38].

The recorded EE levels in ready-to-eat foods were lower than the findings of Salihu *et al*. [14] and Nkere *et al*. [31] in Nigeria. Salihu *et al*. [14] found counts of fecal coliforms that were between 1.0×10^3 and 1.0×10^5 cfu/g^{-1} and *E. coli* counts which were between 1.0×10^2 and 1.0×10^5 cfu/g^{-1} and Nkere *et al*. [31] found a mean *E. coli* count of 6.34 to 7.81 $\log_{10}$ cfu/ml or g. In South Africa, an *E. coli* count of 1.0×10^3 cfu/g from meat-based foods was recorded whilst in Australia, counts have gone beyond 1.0×10^6 cfu/g [17, 18]. In Uganda, the total coliform counts were 7,965.2 cfu/g, 5,271.1 cfu/g, and 13,117 cfu/g from the two categories (A and B) of food outlets and from foods that contained beef [39].

E. coli was found in 5.0% of the investigated samples and this percentage was low in contrast to the findings of Castro *et al.* [2], Stagnitta *et al.* [17] and Saeed *et al.* [13]. In Mexico, 99.0% (129/130) of the investigated restaurants were colonized by coliforms; 85.0% (110/129) of which were colonized by *E. coli* and 7.0% (8/110) by diarrheagenic *E. coli* pathotypes [2]. In San Luis, Argentina, different types of mead-based foods, mostly hamburgers and fresh sausages, were investigated and 58.3% of the samples were infected with coliforms and *E. coli* [17]. Moreover, 32.0% (18/55) of the inspected vegetable salads from restaurants and cafeteria in Iraq were *E. coli*-positive [13]. Other food contamination reports include the observations made by Rangel *et al.* [12] in the USA, where a total of 350 outbreaks were documented in the period from 1982 to 2002. Among these outbreaks, transmission routes for 183 (52.0%) and 10 (3.0%) were food and drinking water and were confirmed to occur in 28.0% restaurants and other food serving facilities. Ground beef, other beef, dairy products and other foods including poultry products were the most colonized by *E. coli*. In Bangladesh and Nigeria, Nawas *et al*. [10] and Salihu *et al*. [14] found *E. coli* in 73.33% of the processed salads sold for consumers at restaurants and in 36.6% of the samples of traditionally cooked meat. In addition, Salihu *et al*. [14] found aerobic bacteria in 100% of the tested samples of the fried ground beef (*Dambun nama*) as well as fecal coliforms in 49.5% (109/216) and *E. coli* in 36.6% (79/216). Sudheesh *et al.* [29] isolated *E. coli* from cutting boards, knives, and hands of workers with a degree of contamination that ranged from 1 (barely contaminated) to >100 (heavily contaminated). Nkere *et al*. [31] isolated a total of 98 coliform strains from food samples and *E. coli* strains were comprising 51.0%. *E. coli* was also detected in 18.5% (5/27) and in 33.3% (7/21) of the food facilities in Uganda and samples taken from the crockery and cutlery of restaurants [37, 39].

S. aureus was observed in 3.0% of the investigated samples herein and this did concur the observations of Kadariya *et al*. [9] who indicated that this bacteria has been detected in commercially-distributed meats from farms to restaurants and food serving centers in different parts of the world, and found *S. aureus* in 4.0% the retail beef meat in the US [9]. Methicillin-resistant *S. aureus* (MRSA) and other types of *S. aureus* were respectively isolated from 5.0% (6/120) and 39.2% (47/120) of retail meat samples in Louisiana [11]. Moreover, higher prevalences of *S. aureus* of 16.4% (27/165) in red meats were also observed in the US [7], besides, multidrug resistant (MDR) *S. aureus* from 52.0% (71/136) of meats and poultry [19], and any *S. aureus* from 22.5% (65/289) [1]. In Asian and European countries, *S. aureus* has been found in raw retail meat products with diverse prevalences that reached up to 11.9% [9], while in Africa, Salihu *et al*. [14] reported *S. aureus* in 69.9% (151/216) of the fried ground beef in Nigeria. Scanga *et al*. [34] reported that *S. aureus* count ranged between 10×10^5 and 10×10^7 cfu/g^{-1}. Sudheesh *et al.* [29] isolated *S. aureus* from cutting boards, knives, and hands of workers with a degree of contamination that ranged from 1 (barely contaminated) to >100 (heavily contaminated). *S. aureus*, was also isolated from 69.9% (151/216) of the samples with counts ranging between 10^5 and 10^7 cfu^{-1} [14]. Crockery and cutlery of restaurants were shown to be colonized by *S. aureus* [37, 38].

Salmonella species, *Bacillus* species, and *Listeria* species were not detected in any of the studied restaurants in the present study. This was contrary to the findings of some studies [3, 10, 37, 39]. *Salmonella* was detected in 13.33% of the ready-to-eat and raw foods [3], and Nawas *et al*. [10] found it as well as *Vibrio* species, *Proteus* species, *Enterobacter* species, *Hafnia* species, *Serrtia* species, and *Citrobacter* species from salads sold at restaurants. *Salmonella* was also detected in 4.2% (2/48) of the investigated food facilities in Uganda [39], further it was isolated from crockery and cutlery together with *Klebsiella* spp., *Shigella* spp., *Bacillus* spp., and *Proteus vulgaris* [37]. Furthermore, Rahimi and Shakerian [35] detected *Listeria* species in 8.5% of oloveyh salad, yogurt stew, vegetable salad, macaroni salad and meat salad in restaurants of Shahrekord, Iran. The highest isolated were from vegetable salad (17.3%) and the lowest were from macaroni salad (4.2%). *Listeria monocytogenes* (3.0%), *L. innocua* (4.7%) and *L. seeligeri* (0.9%) were the isolated and identified *Listeria* species. Inconsistent with the results of this study also, *Salmonella* (from 1 to >100) and *B. cereus* were detected in samples collected from cutting boards, knives, and hands of workers [29]. Strains of *Klebsiella pneumoniae* and *Enterobacter* species were detected too [31]. Certain organisms including *Listeria* spp. (22%), *Enterobacter* spp. (18%), *Aeromonas hydrophila* (12%), *Klebsiella oxytoca* (8%), *Proteus mirabilis* (6.3%), and *Pseudomonas luteola* (2.4%) were recovered from ready-to-eat foods in South Africa, but, interestingly, neither *Salmonella* spp. nor *E. coli* were not isolated from any of the samples [38].

Food quality might vary from good to potentially hazardous due to certain factors and undesired practices. These factors and practices affect the number of bacteria in the food and could promote the growth of certain bacterial species as well, and include 1) storage of the ready-to-eat foods at a temperature above 8ºC, 2) infrequent and improper cleaning of slicing tools and other food processing and serving utensils including worktables, cutting boards, and crockery and cutlery or keeping them in open baskets or trays in the open air and 3) lack or insufficient control and monitoring of food serving facilities by authorities, and 4) poverty and low standard of personal and environmental hygiene [5, 16, 31, 37]. Other factors that might influence food safety involve different food preparation methods and cooking, the water that is used for cleaning of the utensils and plates, the water that is used for washing vegetables or their irrigation, and supervision and surveillance of the workers during food processing to avoid practices that lead to cross contamination. All these factors and undesired practices could create an insurmountable risk of acquiring food-borne illnesses by consumers.

5. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, although bacteria were detected in water, treatment practices in Salalah state municipality are effective, thus the water was safe for use but exerting more effort is favorable. Bacterial levels of meat-based foods were either satisfactory or unsatisfactory depending on the results of the TPC while depending on the results of the EE levels were all satisfactory. Equally, for vegetable-based foods, the quality was satisfactory or acceptable depending on the results of the TPC while depending on the results of the EE levels were all satisfactory. This study provided useful information about the microbiological quality of foods prepared in some restaurants in Oman. Good Hygienic Practices (GHP) are essential to ensure food safety, hence they should be observed in all food serving facilities. Regulations that state the microbiological quality of ready-to-eat foods prepared at restaurants, ensure regular monitoring, and application of corrective actions and the corrective actions themselves are needed to be set by the Omani authorities.

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