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Evaluation of hygiene practices and microbiological quality of raw and mildly heat-treated vegetable salads from restaurants within Ilemela municipality of Mwanza, Tanzania

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ABSTRACT

In Tanzania, the consumption of vegetable salads is increasing and becoming popular in food service establishments of urban areas creating market for vegetables cultivated in rural and peri-urban areas. However, the products are among the high risky ready-to-eat foods (RTEs), as they are often served raw without being heat-treated and with no preservatives. A survey was carried out from May to June 2024 to evaluate hygiene handling and microbiological quality of raw and mild heat-treated vegetable salads served in restaurants in Ilemela Municipality. Hygiene practices were assessed by interviewing operators in thirty randomly selected restaurants. In parallel, thirty vegetable salad samples were collected and analyzed for Total Plate Counts (TPC) and *Escherichia coli (E. coli*). The findings demonstrated that food handlers had high illiteracy level with no food hygiene training. Hygiene practices that are crucial for safe preparation of food; such as wearing gloves, protective clothing and use of safe water were not regularly observed. Regarding microbiological quality, none (0/30) of the mildly heat treated vegetable salads had TPC, while, all (30/30) raw salad samples demonstrated high TPC contamination levels ranging from 3.2 to 4.6 Log cfu/g, exceeding the set limits. While, all (30/30) mildly heat treated salads were free of *E. coli*, 14/30 of the raw salad samples were positive. Thus, the raw salads were unsatisfactory for consumption. Therefore, food hygiene training and control by relevant authorities alongside treating vegetable salads with mild heat and food grade antimicrobial agents are essential in ensuring food quality and safety.

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1. Introduction

Vegetables and vegetable salads are important components in the human diet with several nutritional and health benefits to consumers (1–4). These products are highly nutritious, relatively cheap, palatable and easy to prepare (5).

Thus, their consumption is increasing in most countries including Tanzania (6). These salads may be prepared in several ways; they can be consumed raw without any

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heat treatment or can be mildly heat-treated prior to consumption (7).

However, vegetable salads are regarded as a high-risk group of foods because they are often prepared without any heating or addition of preservatives. Globally, approximately 10% of people contract diseases after consuming contaminated foods such as vegetable and fruit salads (8). In Ilemela Municipality, the majority of food service facilities including local restaurants are inadequately designed and lack important food storage facilities such as freezers and refrigerators. Hence, in such units ready-to-eat foods (RTEs) like salads are often stored at ambient conditions. Moreover, most food handlers who work in these establishments had no formal food hygiene and safety training and were neither registered nor licensed; and have limited knowledge of best food handling practices (9,10). Thus, owing to the manner and conditions these facilities operate, there is a possibility that some of the food products including vegetable salads may be contaminated with human pathogens, which could result infoodborne illnesses among consumers. This is a serious public health threat that may severely affect food business and health of consumers.

Additionally, these salads are frequently contaminated with disease causing agents like *E.coli*, *Vibrio cholera*, *Listeria monocytogens*, *Salmonella* spp. and *Campylobacter jejuni* (11–13). Similarly, several scientific investigations in both developed and developing nations have associated the consumption of vegetable salads with food borne disease out breaks like cholera, typhoid fever, listeriosis, and campylobacteriosis (14,15).

Nevertheless, Good Hygienic Practices (GHP) provide necessary conditions for the control or elimination of contamination from foods including vegetable salads (5). Further, adequate food processing is critical in preventing hazards and improving the food safety and quality (16). GHP ensure that ingredients and products are processed in hygienic conditions and are safe for human consumption.

Moreover, to decrease microbiological content, food processors need to properly wash, peel, add preservatives, heat-treat and/or refrigerate the vegetable salads and their ingredients (17). Also, the handlers must sanitize all food processing equipment and tools including the knives used for peeling and chopping. Since peeling and chopping are among the critical points of the industrial process of RTEs production. These processes increase respiratory and metabolic activities of vegetables. Moreover, these operations lead to the release of nutrient-rich cellular fluids which support microbial growth (18).

Furthermore, microbiological proliferation after the slicing, relies chiefly on the time interval between slicing and washing as well as the processing temperature (19). Short time and high temperatures (heat-treatment) could inhibit bacterial multiplication. Previous studies found that heating foods at the temperatures higher than 60oC is effective in eliminating or significantly minimizing microbiological contamination (20). Thus, heat-treatment may be vital to limit microbial multiplication in high risk RTEs such as vegetable salads (21). Since vegetable salads are good substrates for the multiplication of microorganisms (22), especially after chopping, thus, heat-treatment is useful.

Therefore, this study aimed at assessing the effects of handling practices and heat treatment on

microbiological quality of vegetable salads in Ilemela Municipality of Mwanza City in Tanzania.

2. Materials and methods

2.1. Study area and research design

A cross-sectional research was performed to assess hygiene of personnel and environment as well as microbiological quality of raw and mild heat-treated vegetable salads served in restaurants at Ilemela, Tanzania; from May 15 to June 10, 2024. Random sampling procedure was adopted to select three streets, namely Mahakama, Kanisani and Sokoni.Furthermore, thirty restaurants were randomly selected for the study, ten from each street. The number of restaurants was maintained at thirty due to budget constraints and time limitations. However, the sample size is still sufficient as the study focused to establish the current status.

2.2. Evaluation of food hygiene practices in the restaurants

Face-to-face interviews using a questionnaire with both open-ended and closed-ended questions was used to assess food hygiene practices by salad handlers operating in restaurants within Ilemela Municipality, Tanzania. The questionnaire consisted of questions on demographic characteristics of the operators, source of water and salad handling practices. The interviews involved one operator from each restaurant.

2.3. Evaluation of microbiological quality of raw and mildly heated vegetable salads

Two hundred, fifty grams (250 g) of raw and mildly heat-treated samples were aseptically collected from each restaurant in Ilemela for microbiological analysis. The samples were inserted in polythene zip lock bags and placed in a cool box containing ice packs to maintained them at <5ºC. Then, the samples were immediately transported to the Victoria Perch Limited Microbiology Laboratory and analyzed on the same day. Twenty-five grams (25 g) of each vegetable salad sample was weighed and transferred to 225 mL of sterile buffered peptone water (BPW). After which, 10-fold serial dilutions of samples from 10^{-1} to 10^{-10} in sterile peptone buffer was aseptically performed. The diluents were then inoculated onto the appropriate culture media.

Further, the enumeration of TPC were carried out according to ISO 4833:2003 (ISO, 2003a) (23), whereas, the detection of *E. coli* was conducted using ISO 7251: 2005 (ISO, 2005) (24). One millimeter of diluents was inoculated on Plate Count Agar (PCA) for the enumeration of TPC. The same amount of diluent was inoculated onto MacConkey Agar (MCA) for detection of *E. coli*. The inoculated plates were then incubated at 30 ± 1°C for 24 ± 2 h for TPC and 37 ± 1°C for 24 + 2 h for *E. coli*. Then appropriate dilutions were enumerated for presence of TPC; while, the presence of *E. coli* was visually confirmed.

2.4. Interpretation of microbiological quality of vegetable salads

Tanzanian standards (TZS) and East African Standards (EAS) were utilized in interpreting the microbiological results. Table 1 shows the criteria employed to interpret those results.

2.5. Statistical analysis and interpretation

The data collected were analyzed by IBM SPSS Version 25. The microbiological results were compared against the East African Food Standards (EAS 1109:2022 for TPC) and Tanzanian Food Standards (TZS 730/ISO 16649-1 for *E. coli*) and scientific literature. ANOVA

was used to assess whether the mean values of TPC and *E. coli* varied significantly among study streets. A p-value less than 0.05 ($p < 0.05$) was selected and considered statistically significant.

3. Results

3.1. Characteristics of restaurants influencing microbiological quality of vegetable salads

Table 2, shows characteristics of the restaurants in Ilemela Municipality. The majority of food service workers attended primary (12/30) and secondary (18/30) school education. However, none of the food service operator (0/30) had been trained on the best food handling practices. Most (27/30) of the handlers had operated in the food establishments for several years, >3 years. On the other hand, the restaurants had food serving capacity ranging from <50 plates (14/30) to 50 – 99 plates (16/30). Nevertheless, the majority (23/30) of restaurants had neither freezers nor refrigerators.

3.2. Hygiene practices in the restaurants serving vegetable salads

In this study only (6/30) restaurants had tap water in their kitchens (Table 3). Also, the majority (27/30) of restaurants did not treat water for washing equipment and utensils as well as food workers' and customers' hands (Table 3). Likewise, most (25/30, Table) restaurants did not change water for washing utensils. The majority of handlers did not wear hairnets (28/30, Table 3) and gloves (30/30, Table 3). Moreover, a significant number (22/30, Table 3) of operators in the study restaurants did not put on aprons. On the other hand, (6/30, Table 3) of the food handlers did not remove jewelry when preparing food. Moreover, all (30/30, Table 3) restaurants did not have hot water and soap to clean their tables (Table 3). Also, only (5/30, Table 3) of the handlers underwent medical examinations during employment and before starting operating in the restaurants. Likewise, only 3/30 of the handlers reported that they go through medical screening at least every six months (Table 3).

3.3. Microbiological quality of raw and mildly heat-treated vegetable salads

Total Plate Counts (TPC) were recovered in all raw vegetable salads (30/30, Table 4), ranging from 3.2 to 4.6 Log cfu/g above the standard. Additionally, 14/30 of the raw salad samples (Table 4) had *E. coli* contamination levels beyond the stipulated limits in vegetables and vegetable salads.

3.4. Variations in TPC contamination of vegetables salads among Ilemela Streets

The results of oneway analysis of variance (Table 5) showed that there were no statistically significant ($p>0.05$) differences in the mean values of TPC among Mahakama (4.2 ± 0.55 Log cfu/g), Kanisani (3.7 ± 0.61 Log cfu/g) and Sokoni (4.0 ± 0.21 Log cfu/g) streets.

Table 1. Microbiological criteria of raw vegetables and their salads

Parameter	Maximum limit	Source
Total Plate Counts (TPC)	10^2 cfu/g	EAS 1109:2022
Escherichia coli	Absent/25 g	TZS 730/ISO 16649-1

Table 2. Characteristics of restaurants

Variable	Category	MKM (N = 10)	KSN (N = 10)	SKN (N = 10)	Total (N = 30)
Gender	Male	8	7	10	25
	Female	2	3	0	5
Age (yrs)	<18	0	0	0	0
	18-25	7	6	8	21
	25-40	2	4	2	8
	>40	1	0	0	1
Marital status	Married	2	0	1	3
	Not married	8	10	9	27
Educational level	No school	0	0	0	0
	Primary	4	3	5	12
	Secondary	6	7	5	18
Knowledge acquisition	Experience	10	10	10	30
	Training	0	0	0	0
Freezer/fridge available	Yes	2	1	4	7
	No	8	9	6	23
Work experience (yrs)	<1	0	0	0	0
	1-2	0	1	2	3
	3-5	8	6	6	20
	>5	2	3	2	7
Plates served per day	< 50 plates	8	2	4	14
	50 – 99 plates	2	8	6	16
	100 – 500 plates	0	0	0	0

TSh = Tanzanian Shillings, yrs = years, MKM = Mahakama, KSN= Kanisani, SKN = Sokoni

Table 3. Hygiene practices in the restaurants serving salads

Variable	Attribute	MKM (N=10)	KSN (N=10)	SKN (N=10)	Total (N=30)
Boil water for washing equipment and utensils	Yes	1	2	0	3
	No	9	8	10	27
Supply boiled water for washing hands	Yes	0	2	0	2
	No	10	8	10	28
Use treated water to prepare food	Yes	0	1	0	1
	No	10	9	10	29
Tap water is available in the kitchen	Yes	0	4	2	6
	No	10	6	8	24
Frequently change water for washing utensils	Yes	1	3	1	5
	No	9	7	9	25
Wear hairnet when handling food	Yes	0	2	0	2
	No	10	8	10	28
Wear food grade gloves when handling food	Yes	0	0	0	0
	No	10	10	10	30
Wear apron when handling food	Yes	2	4	2	8

	No	8	6	8	22
Remove jewellery when handling food	Yes	1	2	3	6
	No	9	8	7	24
Wash hands before handling food	Yes	5	6	8	19
	No	5	4	2	11
Clean tables with hot water and soap	Yes	0	0	0	0
	No	10	10	10	30
Clean cutting boards before and after use	Yes	10	8	9	27
	No	0	2	1	3
Food contamination can cause food poisoning	Yes	10	10	10	30
	No	0	0	0	0
Attended training on food hygiene	Yes	0	0	0	0
	No	10	10	10	30
Underwent medical screening when employed	Yes	0	3	2	5
	No	10	7	8	25
Undergo medical checkup every 6 months	Yes	0	2	1	3
	No	10	8	9	27
Clean raw materials for salad preparation	Yes	10	10	10	30
	No	0	0	0	0

MKM = Mahakama, KSN = Kanisani, SKN = Sokoni

Table 4. Microbiological status of raw and mild heat treated salads

Salad samples	Counts of microorganisms (Log cfu/g)											
	Mahakama				Kanisani				Sokoni			
	TPC	EC	TPC	EC	TPC	EC	TPC	EC	TPC	EC	TPC	EC
	Raw salads		Heated salads		Raw Salads		Heated salads		Raw salads		Heated salads	
S1	4.6	-	*	-	4.2	+	*	-	4.6	+	*	-
S2	4.6	+	*	-	3.2	-	*	-	4.5	-	*	-
S3	4.5	+	*	-	4.6	-	*	-	3.4	-	*	-
S4	4.5	-	*	-	4.2	-	*	-	4.6	-	*	-
S5	3.4	+	*	-	3.3	+	*	-	3.2	-	*	-
S6	4.6	+	*	-	3.2	-	*	-	3.2	+	*	-
S7	4.5	+	*	-	4.6	-	*	-	4.5	-	*	-
S8	3.6	-	*	-	3.3	+	*	-	3.2	-	*	-
S9	3.3	+	*	-	3.2	-	*	-	4.5	+	*	-
S10	4.6	+	*	-	3.3	+	*	-	4.5	+	*	-
Total positive samples	**10**	**7**	**0**	**0**	**10**	**4**	**0**	**0**	**10**	**3**	**0**	**0**

EC = *E. coli*, TPC = Total Plate Counts, KSN = Kanisani, MKM = Mahakama, SKN = Sokoni, + = present, - = absent, *Microbial count < 1.0 x 101 cfu/g

Table 5. Differences in TPC contamination of vegetable salads among selected streets

Street	Restaurants (N)	Mean ± SD (Log cfu/g)
Mahakama	10	4.2 ± 0.55
Kanisani	10	3.7 ± 0.61
Sokoni	10	4.0 ± 0.21

4. Discussion

Inadequate food preparation and handling could result in contamination of food with chemical, physical and microbiological agents. Furthermore, contamination of foods including vegetable salads with TPC and *E. coli* beyond recommended limits poses a severe health risk to consumers. In this context, this study assessed the hygiene practices alongside TPC and *E. coli* contamination status of raw and mild heat-treated vegetable salads served in selected restaurants in Ilemela Municipality.

The findings showed that most of the workers in these restaurants had low level of education, ranging from primary to secondary school level, indicating inadequate food handling knowledge. In line with this, several studies associated lower education levels to inadequate hygienic practices among the food service workers in food establishments including restaurants (9,25,26). Although, appropriate trainings on the best food handling practices are vital in instilling safety knowledge and skills to food handlers that are critical in enhancing food hygiene and safety among food service establishments (27); in this study none of the operators had received any formal food handling training. In consisted with our findings, Ali and Immanuel (28) at Allahabad in India observed that none of the handlers (0%) had received formal training on best food handling practices.

Moreover, in our study, most of the food handlers had been working in the food service facilities for several years. Similarly, Ali and Immanuel (28) found that over 80% of food service workers had the experience of many years in food facilities such as restaurants and cafeterias. Also, Al-Kandari *et al*. (29) reported that majority food service workers in food establishments had operated in the food industry for many years. Of note, Nyarugwe *et al*. (30), reported that food hygiene and safety practices improve with the level of working experience in the food business. Equally, Bou-Mitri *et al*. (31) found that food handlers with higher food service experience had a greater food safety knowledge than ones with less experience.

On the other hand, the study restaurants served 50 to 99 plates per day. With numerous customers to serve simultaneously, it suggests that in these facilities enormous amount of food is prepared well in advance. So, it is likely that some hygienic rules and principles were not observed when preparing, handling and serving food, as workers could focus more on serving as many customers as possible without concentrating

on hygiene and proper handling. This circumstance could expose customers to microbiological hazards. In conformity with this, frequently foodborne disease (FBD) outbreaks are linked to mass catering (32,33).

Furthermore, most restaurants lacked tap water in their kitchens. The absence of tap water in the kitchens of these restaurants, suggests that some restaurants could be using unsafe water from either rivers, well and/or rain. Although, tap water is supposed to be safe, most frequently it is dirt and not treated (9). Also, the majority of restaurants did not treat water for washing equipment, utensils as well as food workers' and customers' hands; this heightens the risk of contaminating food. Likewise, most restaurants did not use clean, fresh water for washing utensils. If dirty water is reused without being changed frequently, may act as a medium for growth of microorganisms including food borne pathogens. In conformity to our findings, Kussaga and Nziku (9) recorded that that shortage of water compelled food handlers to reuse water for cleaning utensils and equipment. Further, if not hands are not thoroughly washed, they could be potential routes of cross-contamination to foods (34).

Nevertheless, most of the handlers did not wear hairnets and none wore gloves to prevent contamination of food. If personnel handling food are not putting on hairnets there is likelihood hair falling and contaminating foods. Moreover, a significant number of operators in the study restaurants did not wear aprons. Likewise, a study in Dodoma City, Tanzania, observed that 87% of the 200 food service establishments visited did not wear aprons (35). Such improper practices as well as touching RTEs with bare hands could lead to cross-contamination (36).

Furthermore, some handlers did not remove jewelry when preparing food. Other than the risk of detachment from the operator's body causing injuries to consumers, jewelry is also a potential source of microbiological contamination as it carries microorganisms. It is stipulated that food service workers must remove their accessories like watches, rings, and jewelry should not be worn during preparation, processing, handling and serving food (34).

Additionally, the majority of restaurants did not have hot water and soap to clean their tables and lacked hand washing facilities. Likewise, another study in Dodoma City, Tanzania, found that only 25% of food establishments cleaned processing equipment and hands with soap when preparing and serving food (35). However, effective hands cleaning and sanitization with appropriate disinfectants and sanitizers significantly minimizes the risk of microbiological contamination of foodborne diseases (37). On the other hand, the majority of food handlers were not medically examined, thus, they a potential source of several communicable diseases like tuberculosis, typhoid, and diarrhea. Thus, deliberate effort is needed to ensure that all food service establishments including restaurants comply with national food hygiene laws, regulations and guidelines.

Moreover, TPC were recovered in all raw vegetable salads above the stipulate limits in vegetable and vegetable salads, revealing inadequate hygiene in the restaurants. Equally, a significant number of raw salad samples had *E. coli* contamination levels beyond the recommended standard indicating the possibility of crosscontamination from handlers' hands, utensils,

and/or water. TPC and *E. coli* contamination in the analyzed salads implies that these products were unsatisfactory for human consumption (3,38). However, the mildly heated salads had no both TPC and *E. coli*. Several studies observed that heat could completely eliminate or significantly reduce both spoilage and pathogenic microorganisms in foods (39,40). Heat treatment prolongs the shelf life and improves the safety and quality of foods including vegetable salads (8). This in turn safeguards consumers' health increasing their confidence in consuming these products, which promotes food trade locally and globally.

5. Conclusion

While food service establishments including restaurants play a critical role in providing affordable food options to the majority of the urban population, they are also potential sources of hazards including human pathogens such as *E. coli* and *Salmonella.* Further, raw and minimally heat treated vegetable salads are among the high risk products that frequently harbor pathogens. The analyzed salads had *E. coli* and TPC contamination, and thus are potential sources human diseases. TPC contamination levels beyond the set limits reflect the inadequacy of hygienic practices in the study restaurants. Further, these facilities are owned and operated by people with limited education and knowledge of proper food handling. Nevertheless, they use non-potable water to wash utensils, equipment and hands, this creates further prospects for cross-contamination. Thus, these restaurants should mildly heat their salads in order to completely eliminate or significantly reduce the amount of microbiological load. Additionally, food handlers should be properly trained on the best food handling practices; also responsible government authorities including health officers and officials from the Tanzania Bureau of Standards should ensure that all food facilities observe food hygiene and safety standards to protect health of consumers and improve the quality of offered foods including vegetable salads.

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Authorship Contribution

Each author contributed significantly in the development of this manuscript. Ms. Marysiana K. Raymond was responsible for collecting samples and conducting the microbiological analyses. Mr. Juma M.J Magambo was lead investigator, designed the study, performed statistical data analyses, interpreted results and drafted the manuscript.

Conflict of interest

The authors declare no conflict of interest.

Data availability

Data are available on demand.

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