Sokoine University of Agriculture

MSc Dissertation

Handling Practices and Bacteriological Quality of Fresh Vegetable Salads Served in Food Service Establishments in Mwanza City

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HANDLING PRACTICES AND BACTERIOLOGICAL QUALITY OF FRESH VEGETABLE SALADS SERVED IN FOOD SERVICE ESTABLISHMENTS IN MWANZA CITY

Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Food Safety and Quality Assurance

By

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EXTENDED ABSTRACT

Food service establishments (FSE) offer a wide variety of foods, including the ready-to-eat (RTE) cold foods like fresh vegetable salads; also known as *Kachumbari* in Tanzania. *Kachumbari,* is often consumed raw without any further preparation or processing that could completely eliminate or substantially reduce pathogens to acceptable levels. Therefore, this salad is potentially risky if not well handled. The objective of this study was to assess handling practices and bacteriological quality of *Kachumbari* prepared and served in FSE in Mwanza City, Tanzania. A cross-sectional study involving thirty food handlers from 10 restaurants and 20 street food vending sites was conducted from March to April 2023. A semi-structured questionnaire and observation checklist were used to collect data on handling practices. In parallel, thirty samples of *Kachumbari*, along with 30 swabs from hands and chopping boards were collected and analyzed. The assessment of handling practices indicated that 93.3% of the food service establishments lacked formal food handling training, and 66.7% did not prioritize clean-as-you-go practices for food safety. Moreover, only 26.6% underwent annual medical checkups at work places. The majority of the handlers (66.7%) demonstrated a poor understanding of food safety principles and procedures. On the other hand, the bacteriological quality analysis revealed high contamination levels of total bacterial counts (ranging from 4.8 to 6.7 log CFU/g), *Staphylococcus aureus* (<1 to 6.7 log CFU/g), and *Escherichia coli* (<1 to 6.7 log CFU/g). All *Kachumbari* samples (100%) were unsatisfactory, and 17 (56.7%) had unsatisfactory *E. coli* levels. Moreover, 22 samples (73.3%) had unsatisfactory *S. aureus* levels, and 10 samples (33.3%) showed unsatisfactory *Salmonella* ssp. contamination. Also, chopping boards and hands had higher total counts ranging from 3.5 – 4.7 log CFU.cm^{-2}. The comparison of microbiological contamination levels between plastic and chopping boards, demonstrated that *Kachumbari* chopped on wooden chopping boards had statistically significantly higher *S. aureus* contamination levels ($p < 0.05$), than the one sliced on plastic cutting boards. Based on these findings, we recommend regular training in hygiene and safe handling of food among handlers to enhance handling practices. Furthermore, relevant government authorities should conduct frequent inspections and supervision in food service establishments to promote

personal hygiene and overall safety throughout the food value chain, thus, ensuring the quality and safety of vegetable salads in food service establishments in Mwanza City and Tanzania as a whole.

Keywords: Vegetable Salads, *Kachumbari*, Handling Practices, Bacteriological Quality, Safety, Mwanza City, Tanzania.

IKISIRI KUU

Migahawa na wauzaji wadogo wa vyakula mitaani (maarufu kama mama lishe) hutayarisha na kukuuza aina mbalimbali za vyakula baridi vilivyo tayari kuliwa, kama vile saladi za mboga; ambazo hujulikana kama kachumbari nchini Tanzania. Kachumbari, mara nyingi huliwa mbichi bila ya kupikwa wala kupashwa joto au kufanyiwa maandalizi mengine zaidi yanayoweza kuondoa kabisa au kupunguza vimelea wakiwemo bacteria wa magonjwa ya binadamu ili kukidhi viwango vinavyo kubarika. Kwa hiyo, kachumbari inaweza kuwa hatari kwa afya ya walaji ikiwa haijatayarishwa vizuri kwa kuzingatia usafi, taratibu za afya na kanuni za usalama wa chakula. Madhumuni ya utafiti huu yalikuwa kutathmini namna kachumbari inavyoandaliwa na kuhifadhiwa kwenye migahawa na mama lishe Jijini Mwanza, Tanzania, pia kuchunguza ubora wake kwa kuangalia viwango vya bakteria vilivyomo. Utafiti uliohusisha waandaaji wa vyakula kutoka migahawa 10 na mama lishe 20 ulifanyika kuanzia Machi hadi Aprili 2023. Dodoso na ufuatiliaji wa ana kwa ana vilitumika kukusanya taarifa (takwimu/data) za namna ya kuandaa na kuhifadhi kachumbari. Pia, sampuli thelathini za kachumbari, pamoja na sampuli 30 za mikono na vibao vya kukatia saladi zilikusanywa na kufanyiwa vipimo vya maabara. Uchunguzi wa namana ya kuandaa na kuhifadhi kachumbari ulionyesha kuwa 93.3% ya waandaaji wa chakula hawana mafunzo rasmi ya uandaaji bora wa vyakula, na 66.7% walikuwa hawasafishi sehemu zao za kutayarishia na kuuzia chakula wakati wa kufunga biashara. Pia idadi kubwa ya waandaji wa chakula (73.4%) hawakupima afya zao kila baada ya miezi sita kama sheria inavyotaka. Wengi wa waandaaji wa chakula (66.7%) walionyesha uelewa duni wa kanuni na taratibu za usalama wa chakula. Kwa upande mwingine, vipimo vya ubora wa chakula vilionesha viwango vya juu vya bakteria kwenye kachumbari (4.8 - 6.7 log CFU/g), *Staphylococcus aureus* (<1 - 6.7 log CFU/g), na *Escherichia coli* (<1 - 6.7) log CFU/g). Sampuli zote za kachumbari (100%) zilionyesha kuwa kachumbari haikuwa na ubora unaoridhisha. Asilimia 17 (56.7%) ya sampuli zilikuwa na viwango vya *E. coli* visivyoridhisha. Aidha, sampuli 22 (73.3%) zilikuwa na viwango vya *S. aureus* visivyoridhisha, kadharika sampuli 10 (33.3%) zilionyesha viwango vya *Salmonella* visivyo ridhisha. Pia mikono na vibao vya kukatia kachumbari vilikuwa na viwango vya juu vya bakteria, kuanzia 3.5 hadi 4.7 log $CFU.cm^{-2}$. Aina ya kibao cha kukatia kachumbari ilihusiana kwa kiasi kikubwa na viwango vya *S. aureus* kwenye kachumbari ($p<0.05$). Kulingana na matokeo haya, tunapendekeza mafunzo ya mara kwa mara kuhusu usafi na utunzaji salama wa

chakula kwa waandaaji na wahudumu wa chakula, pamoja na ukaguzi na usimamizi wa mamlaka husika za serikali, ili kuimarisha na kuhakikisha uhifadhi bora, usafi na usalama katika mnyororo mzima wa thamani ya vyakula katika sehemu za huduma za vyakula katika Jiji la Mwanza na Tanzania kwa ujumla.

Maneno muhimu: Saladi za Mboga, Kachumbari, Utayarishaji Chakula, Ubora na Usalama wa Chakula, Mwanza, Tanzania.

DECLARATION

I, **JUMA MORIGO JOHN MAGAMBO**, do hereby declare to the senate of the Sokoine University of Agriculture that this dissertation is my original work, done within the period of registration and that it has neither been submitted nor been concurrently submitted for a degree award in another institution.

_____ _____

Juma Morigo John Magambo Date
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The above declaration is confirmed by;

_____ _____

Dr. Jamal B. Kussaga Date
(Supervisor)

_____ _____

Dr. Nuria K. Majaliwa Date
(Supervisor)

LIST OF PAPER AND PUBLISHED MANUSCRIPTS

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DEDICATION

This work is dedicated to my beloved Mother Theresia Magambo, my wife Avelina Wilfred and our children Gerald, Gian and Gracious; without forgetting my friend and brother Mr. Nyamhanga Masese Mataragio for their love, prayers and encouragements throughout my engagement in this MSc work.

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LIST OF ABBREVIATIONS AND ACRONYMS

BPA	Baird Parker Agar
BPW	Buffered Peptone Water
CB	Chopping Board
CFU	Colony Forming Unit
df	Degrees of Freedom
DIT	Dar es Salaam Institute of Technology
EAS	East African Standards
EASTRIP	East Africa Skills for Transformation and Regional Integration Project
FBD	Food Borne Disease
FSE	Food Service Establishments
GDP	Gross Domestic Product
ISO	International Organization for Standardization
MCA	MacConkey Agar
MFQ	Master of Science in Food Safety and Quality Assurance
MSA	Mannitol Salt Agar
MSc	Master of Science
p	Probability value
PCA	Plate Count Agar
PCB	Plastic Chopping Board
pH	Hydrogen Potential
r	Pearson Correlation Coefficient
RES	Restaurants
RTE	Ready to Eat Food
SFV	Street Food Vending Site
SPSS	Statistical Product and Service Solution
SS	Salmonella Shigella
SUA	Sokoine University of Agriculture
TBC	Total Bacterial Counts
TBS	Tanzania Bureau of Standards
TSh	Tanzanian Shillings
TVLA	Tanzania Veterinary Laboratory Agency
TZS	Tanzanian Standards
US	United States of America
US-FDA	United States of America Food and Drug Administration
WCB	Wooden Chopping Board
WHO	World Health Organization
XLD	Xylose Lysine Deoxycholate
yrs	Years

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 Background Information

The consumption of fresh vegetable salads among consumers in developing countries including Tanzania has increased, as people prefer fresh, natural and/or mild treated foods (Kariuki *et al*., 2017; Mir *et al*., 2018). Fresh and mild heat-treated foods like salads are mostly prepared without addition of preservatives (Aggarwal *et al*., 2020; Kariuki *et al*., 2017).

Vegetable salads commonly known as *Kachumbari* in Tanzania is mainly prepared from one or more types of vegetables, such as bell peppers, cabbages, cucumbers, carrots, tomatoes and onions (Mbae *et al*., 2018). *Kachumbari* could be mildly heat treated or prepared without any heat treatment. Vegetable salads are often eaten in their raw forms therefore for public safety, *Kachumbari* should be prepared and handled under hygienic conditions.

Kachumbari is among the foods which are categorized as ready to eat (RTE) cold foods. Cold foods are an extremely diverse group of foods which are served and eaten cold (Kapeleka *et al*., 2020). Cold does not strictly mean that the foods are not heat treated, they could be heat treated but served cold or at ambient conditions. They include fruits, juices, vegetable salads (*Kachumbari*) and bans (Sabharwal *et al*., 2020). Vegetable salads are important components in the human diet with several health and nutritional benefits to consumers (Charles-Aworh, 2015; Pereira *et al*., 2022).

Kachumbari is usually served with street vended foods such as fried potato, bananas and cassava chips. However, the product is known for harboring foodborne pathogens, which is highlighted by several severe national and international food related disease outbreaks including diarrhoea, typhoid fever, campylobacteriosis and listeriosis (Fung *et al.*, 2018; Kintz *et al*., 2019). However, in Tanzania, vending of RTE foods is predominated by individuals who are neither licensed nor trained in food sanitation (Ndunguru and Ndossi, 2020). Therefore, ready to eat foods especially vegetable salads have high risk of contamination because most of them are prepared in inadequate environment and handled by people with limited knowledge of food handling practices (Adeleke *et al*., 2020; Kariuki

et al., 2017; Lopes Nonato and Almeida- Minussi, 2016; Ndunguru and Ndossi, 2020).

Furthermore, vegetable salads may be subjected to various sources of contamination before and after harvesting, during transport and at places of sale (Ndunguru and Ndossi, 2019). In developing countries like Tanzania, vegetables and other raw materials for preparation of salads are normally sold in open markets where products are often placed on or near the ground and not sufficiently covered (Adeyemi *et al*., 2019; Marras, 2018; Mbae *et al*., 2018). Also, inadequate facilities such as unclean carts and vehicles are used to transport vegetables (Adeyemi *et al*., 2019; Mbae *et al*., 2018), sometimes handlers carry vegetables in gunny sacks on bicycles or their backs. On the other hand, food preparation surfaces are mostly made of wooden or plastic boards and not well cleaned (Kariuki *et al.,* 2017; Marras, 2018; Mohammad & Al-Taee, 2018).

Moreover, RTE salads are normally kept in open plates without covers (Adeleke *et al*., 2020; Adeyemi *et al*., 2019), which increases risk of contamination from dust and other foreign bodies including insects. On the other hand, Toe *et al*.(2017) reported that street food establishments lack effective decontamination of vegetables to eliminate or significantly reduce the initial contaminants. Mostly, washing remains the major method of cleaning vegetables, but the sources of water are often contaminated (Kussaga and Nziku, 2023). Additionally, majority of food handlers lack knowledge of best food handling practices (Adeleke *et al*., 2020; Odonkor and Odonkor, 2020). A study in Tanzania, observed unhygienic preparation and serving of vegetables where there was contact of vegetables with raw foods of animal origin like chicken, fish and beef (Marras, 2018). Furthermore, ready to eat salads are often handled with bare hands and held at ambient temperatures for long periods before being served (Namukwambi *et al*., 2022; Rakha *et al*., 2022; Toe *et al*., 2017).

Of note, some farmers use wastewater for irrigation which affects the quality and safety of raw vegetables and their salads. This water could be the possible source of pathogenic microorganisms on vegetables and vegetable salads, including *Salmonella* spp., *Shigella* spp., *Campylobacter* spp., *Listeria monocytogenes* and *Escherichia coli* (Adeleke *et al*., 2020; Obinda *et al*., 2021). Contaminations may also take place after harvest through unsafe wash water or by cross-contamination from an infected food-handler (Abdullahi *et al*., 2020; City *et al*., 2016). Additionally, studies conducted in developing

countries have reported the presence of animals, insects and liquid wastes in the food service establishments such as restaurants and street food vending sites (Abdullahi *et al*., 2020; Adeleke *et al*., 2020), which could be another source of contamination. The consumption of vegetable salads raises serious public health concerns. Thus, this study assessed the handling practices and bacteriological quality of fresh vegetable salads in food service establishments in Mwanza City, Tanzania.

1.2 Problem Statement and Justification

1.2.1 Problem statement

Food business contributes significantly to the economies of developing countries, especially through informal sector. In Tanzania, 76.2% of the adult population is absorbed in informal sector including street food vendors and restaurants., which accounts for 48% of Gross Domestic Product (GDP) (Kraemer-Mbula and Wunsch-Vicent, 2016). Majority of consumers in urban and peri-urban areas prefer taking their main meals such as roasted meat, fried potatoes, cassava, bananas, ugali or rice accompanied with vegetable salads (*Kachumbari*). In Tanzania the RTE food business is high in big cities including Mwanza, where a food vendor can serve over 168 people per day (Marras, 2018). Thus, in Mwanza City, restaurants and street vendors play a big role in supplying foods to its urban inhabitants. However, similar to other RTEs, vegetable salads have no additional processing steps that could completely destroy or reduce pathogens to acceptable levels (Adeleke *et al*., 2020; Namukwambi *et al*., 2022) and yet are often prepared under unhygienic conditions and handled by people with limited knowledge on proper food handling (Ndunguru and Ndossi, 2020; Odonkor and Odonkor, 2020).

Furthermore, *Kachumbari* is often prepared in advance and stored for a long time at ambient conditions before is served to consumers. Although several studies across the world have observed that vegetable salads are often contaminated with *Escherichia coli*, *Salmonella* spp., *Shigella* spp., and *Staphylococcus aureus* (Namukwambi *et al*., 2022; Obinda *et al*., 2021), very few studies have been conducted in Tanzania (Kayombo and Mayo, 2018; Ndunguru and Ndossi, 2020). Consequently, there was limited information on hygienic food handling practices and bacteriological quality of vegetable salads in Tanzania. Therefore, the current study aimed at assessing the bacteriological quality and associated hygienic and safety practices of the food handlers in food service establishments (FSE) serving *Kachumbari* in Mwanza City, Tanzania.

1.2.2 Study justification

Previous studies have documented that consumption of contaminated vegetables and their salads may result in foodborne diseases (FBD) such as diarrheal illnesses in humans (Amor *et al*., 2018; Bennett *et al*., 2018; Kharel *et al*., 2016). Worldwide, each year, 1 out of 10 people get ill from food contaminated with microbial agents culminating in more than 600 million illnesses and 420 000 deaths per annum (WHO, 2015) and Africa accounts for more than 91 million of foodborne illnesses and over 137 000 deaths. Furthermore, each year US$110 billion is spent in medical expenses in developing countries (WHO, 2015). Hence, economic consequences of FBD in such countries including Tanzania are correspondingly severe (Hoffmann *et al*., 2019). The assessment of handling practices and bacteriological quality of RTE cold foods including vegetable salads provides an up-to-date and useful information on bacteriological quality and risk factors practiced by the food handlers, which may be helpful in the control of FBD and consequently boost the economy. Thus, this study aimed at assessing the handling practices and bacteriological quality of vegetable salads (*Kachumbari*) in FSE in Mwanza City. The findings of this study may be of paramount importance in safeguarding the health of consumers of RTE street foods including *Kachumbari* salads. They may also be utilized by the government to enhance food safety rules, regulations and principles.

1.3 Objectives

1.3.1 General objective

The general objective of this study was to assess the handling practices and bacteriological quality of fresh vegetable salads (*Kachumbari*) from selected FSE in Nyamagana and Ilemela municipalities in Mwanza.

1.3.2 Specific objectives

i. To evaluate handling practices of *Kachumbari* in the selected FSE that prepare and serve *Kachumbari* in Mwanza City.
ii. To analyse bacteriological quality of *Kachumbari*, cutting boards, and handlers' hands.

1.4 Research Questions

i. What are the handling practices of *Kachumbari* in the selected FSE that prepare and serve *Kachumbari* in Mwanza City?
ii. What is the bacteriological quality of *Kachumbari,* chopping boards and handlers' hands from selected FSE?

CHAPTER TWO
PAPER I

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Assessment of Handling Practices of Fresh Vegetable Salads in Restaurants and Street Vendors: A Case of Mwanza City, Tanzania

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Food safety is crucial for promoting public health and economic development. Food service establishments (FSE) provide a wide range of foods, including raw, mild and well-heat treated. Raw or mild-heat treated foods like fresh vegetable salads, *Kachumbari*, are potentially risky if not well handled. The objective of this study was to assess handling practices of operators involved in the preparation and serving of *Kachumbari* in various FSE in Mwanza City, Tanzania. A cross sectional study involving thirty food handlers from 10 restaurants and 20 street food vending sites was conducted in April 2023. A semi-structured questionnaire and observation checklist were used to collect data. Results indicated that 93.3% lacked formal food handling training, and 66.7% did

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not prioritize clean-as-you-go practices for food safety. Moreover, 53.3% felt that wearing clean clothes when handling food was not important, and only 26.6% underwent annual medical checkups. Moreover, the majority of the handlers (66.7%) demonstrated a poor understanding of food safety principles and procedures. Based on these findings, we recommend regular trainings on best handling practices among food handlers, coupled with inspections and supervision by relevant government authorities, to ensure that food prepared in FSE in Mwanza City and Tanzania as a whole is safe for human consumption.

Keywords: Fresh vegetable salads; handling practices; Kachumbari; Mwanza City; Tanzania.

1. INTRODUCTION

The consumption of fresh vegetables and mild-heat treated products like salads is increasing in developing countries including Tanzania [1]. Fresh and mildly heat-treated foods are often prepared without addition of any preservatives [2,3]. Fresh vegetable salads offer a healthy and balanced diet option; and are claimed to prevent several micronutrient deficiencies and chronic diseases such as heart diseases, cancer and obesity [4].

Fresh vegetable salads commonly known as *Kachumbari* in Tanzania is mainly prepared from one or more types of vegetables, such as bell peppers, cabbages, cucumbers, carrots, tomatoes, and onions [5]. *Kachumbari* could be mildly heat treated or prepared without any heat treatment. Vegetable salads are often consumed in their raw forms; therefore, for public safety, *Kachumbari* should be prepared and handled under hygienic conditions.

Kachumbari is among the foods which are categorized as ready to eat (RTE) cold foods. Cold foods are an extremely diverse group of foods which are served and consumed while cold [6]. These fresh vegetable salads are normally served with rice, roasted meat, fried potato and/or cassava.

Nevertheless, all types of food, including *Kachumbari*, are subject of contamination during the processes of preparation, serving, or storage. The contamination of food by handlers may result in food borne outbreaks posing a great threat to the consumers' health and economies of nations [7,8,9]. Approximately seventy percent (70%) of cases of diarrheal disease in developing countries are caused by the consumption of contaminated food [10,11]. Food prepared and served in large quantities is prone to contamination if strict hygiene and safety principles are not observed [12,13]. Inadequate knowledge of food hygiene and/or negligence in safe food handling have been associated with contamination and transmission of human pathogens worldwide [12].

Like in many developing countries, the majority of food service providers in Tanzania are neither licensed nor trained in proper food handling [14]. Yet, they operate in inadequately designed facilities. Ready-to-eat foods, especially vegetable salads, have high risk of contamination because most of them are prepared in inadequate environment and handled by people with limited knowledge on best handling practices [15,14]. Studies to assess the handling practices of vegetable salads in the Tanzanian food service industry are limited. Therefore, the objective of this study was to assess handling practices of vegetable salads (*Kachumbari*) in food service establishments in Mwanza City, Tanzania. The findings of our study could aid in enhancing the proper food handling and sanitation practices among FSE, which may result in a decrease in food-borne illnesses associated with the consumption of RTE foods including vegetable salads and thereby lower treatment costs and promote economic growth.

2. MATERIALS AND METHODS

2.1 Study Area and Period

The current study was conducted in Ilemela and Nyamagana Municipalities in Mwanza City, in April 2023. This city is positioned in the northern part of Tanzania. It is located between 1°30' and 3° south of the Equator. Longitudinally, Mwanza is situated between 31°45' and 34°10' east of Green wich. The population of this city is estimate at 1,310,754 [16]. In Tanzania, the urban settlement of Mwanza ranks second after the city of Dar es salaam. It is the largest business center for all the regions around Lake Victoria. Mwanza is bordered by three regions; Geita Region, borders it to the west, Shinyanga to the south and Simiyu to the east. While to the north it is bordered by the Lake Victoria.

2.2 Study Design

The study employed a descriptive cross-sectional research design to assess the food handling and sanitation practices associated with contamination of *Kachumbari* in food service establishments (FSE) in Nyamagana and Ilemela Municipalities, Mwanza City. The two municipalities were selected because of their high number of street food vendors and restaurants.

2.3 Sampling Procedure

This study recruited thirty (n = 30) *Kachumbari* handlers from thirty food service establishments, of which 10 were restaurants and 20 were street food vending sites (SFVS), using a multi-stage sampling technique. All the participants had direct contact with food as they prepared and handled it themselves. The number FSEs were restricted to 30 due to financial and time limitations but also the objective of the study was to establish the current status.

First, simple random sampling technique was used to select four wards with a high population of street food vendors in Mwanza City, two wards from each municipality. Igoma and Mirongo wards in Nyamagana, as well as Kirumba and Nyakato wards in Ilemela, were randomly picked from a list of wards with a high population of street vendors in Mwanza.

Thereafter, convenience sampling was used to select the thirty (30) FSE, proportionally between SFVS and restaurants, from the four randomly chosen wards; where 20 street vending sites and 10 restaurants were selected for the study. Convenience sampling is appropriate for studies on urban vending because of the difficulties in accessing urban vendors and their unwillingness to complete surveys [17]. However, only FSE that prepared and served *Kachumbari* were included into the study.

2.4 Assessment of Handling Practices

Face-to-face interviews using semi-structured questionnaires (containing closed-and open-ended questions) were used to collect socio-demographic information on food handlers alongside information on food handlers' knowledge of food safety and hygiene, attitudes, and practices [18,13]. Participation by food handlers was voluntary.

2.5 Interpretation of Results

The questionnaire had mainly "yes" or "no" questions, whereas the observation checklist had only "yes" or "no" questions. A one-point score was attributed to the correct answer on every question, and a zero score was assigned to the incorrect answer. Then the overall performance was converted to a percentage (%) by dividing the total score by the total number of questions in a particular section. Total scores ≥ 64% of the maximum score of "knowledge", "attitude", or "practices" were considered good, while lower scores were regarded as poor [13].

The questionnaire's questions concerning the handlers' food safety knowledge were 14 (Table 2), while questions regarding attitudes were 7 (Table 3). On the other hand, the questions dealing with the handlers' food safety practices were 18 (Table 4).

2.6 Statistical Analysis

The collected data were analyzed using SPSS (Version 25 for Windows, SPSS Inc., Chicago, IL, USA). Descriptive statistics were employed to compute frequencies, means, and standard deviations. A hierarchical cluster analysis with the furthest neighbor method and squared Euclidean distance was employed to analyze the handling performance data. A non-parametric test (the Mann-Whitney U test) was performed to determine the differences between the clusters in the handling practices. The statistical significance level was set at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Socio-Demographic Characteristics

The study included 30 *Kachumbari* handlers, of whom 10 were from restaurants and 20 from street food vending sites. The hierarchical cluster analysis (average linkage) generated a dendrogram (Fig. 1) displaying two clusters. Cluster I had 10 *Kachumbari* handlers from restaurants, while cluster II had 20 handlers from street food vending sites. This indicated that food handling practices were more similar within individual clusters than between clusters. Moreover, these findings suggested that the handling of food was different between restaurants and street food vending sites. However, based on Mann-Whitney U test results, no statistically significant ($p > 0.05$) difference in handling practices was observed between the two clusters (restaurants and street food vending sites).

Table 1. Socio-demographic characteristics

Variable	Category	Frequency (%)		Total (%)
		Cluster I	Cluster II	
Age (yrs)	<18	0 (0)	0 (0)	0 (0)
	18 – 25	0 (0)	15 (75.0)	15 (50.0)
	25 – 45	10 (100)	5 (25.5)	15 (50.0)
	>45	0 (0)	0 (0)	0 (0)
Gender	Male	9 (90.0)	19 (95.0)	28 (93.3)
	Female	1 (10.0)	1 (5.0)	2 (6.7)
Marital status	Married	7 (70.0)	4 (20.0)	11 (36.7)
	Not married	3 (30.0)	16 (80.0)	19 (63.3)
Educational level	Informal	0 (0)	0 (0)	0 (0)
	Primary	3 (30.0)	11 (55.0)	14 (46.7)
	Secondary	7 (70.0)	9 (45.0)	16 (53.3)
Food preparation knowledge	Experience	8 (80.0)	20 (75.0)	28 (93.3)
	Training	2 (20.0)	0 (25.0)	2 (6.7)
Experience in RTE food industry (yrs)	<1	0 (0)	4 (20.0)	4 (13.3)
	1 – 2	0 (0)	5 (25.0)	5 (16.7)
	>2	10 (100)	11 (55.0)	21 (70.0)
Business capital (TSh.)	1 00,000 - 500,000	0 (0)	20 (100)	20 (66.7)
	> 500,000	10 (100)	0 (0)	10 (33.3)
Registration by relevant authorities	Yes	10 (100)	0 (0)	10 (33.3)
	No	0 (0)	20 (100)	20 (66.7)

Key: RTE = ready to eat, yrs = years, TSh = Tanzanian shillings

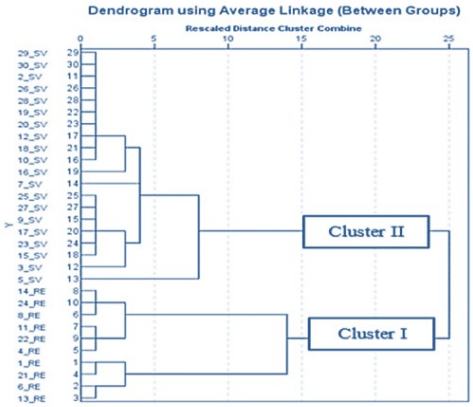

Fig. 1. A dendrogram showing clusters by hierarchical cluster analysis on the relationship of *Kachumbari* handlers with respect to their handling practices

On the other hand, this study was predominated by male food handlers (93.3%) while only two (6.7%) participants were females, one from each cluster (Table 1). The gender distribution in our study was in contrast with earlier studies conducted in Tanzania, which observed that more than 80% of handlers in FSE were women [19,20]. Nevertheless, the results were in line with other studies conducted in different countries that found higher proportions of male handlers in FSE like restaurants and street food vending sites [21,22,23]. This indicates that the ratio of males to females in the food business depends on several factors, such as the type of food business and the geographical area in question. On the other hand, the age of all

handlers (100%) in cluster I FSE (restaurants) ranged from 25 - 45 years old, while the majority (75.0%) of cluster II FSE (SFVS) were between 18 and 25 years old (Table 1). This demonstrated that *Kachumbari* handlers who operated in restaurants were relatively older compared to the workers at street food vending sites. However, none of the handlers was below 18 years old. Similarly, Nizame et al. [24] in Bangladesh and Karondo [19] in Tanzania observed that the majority of food service workers in street food businesses and restaurants are often adults aged 18 years and older.

Further, all food handlers (100%) had attended primary school, 53.3% of whom furthered their education to secondary school level (Table 1). The high proportions of participants with primary and secondary education in the study could be attributed to the Tanzanian government's initiatives to guarantee universal access to primary education through the provision of free education in public schools from primary to secondary level, as well as to ensure that every child goes to school [25,26]. However, in the current study, none of the participants had a qualification higher than a secondary school certificate. In conformity with our findings, several studies established that the vast majority of street food handlers in various parts of the world, including Tanzania, were adults above 18 years old and had completed primary school [19,27]. Mramba [28] observed that 61% of the food handlers working in FSE in Mwanza City had primary school education. According to a study by Bou-Mitri et al. [21], 60% of handlers in Lebanese restaurants had primary level education. This suggests that street food vending is an economic activity often dominated by people with low educational level and limited training in food hygiene and safety. Nevertheless, education is vital to improving food safety practices in food service establishments [29].

Although, appropriate training on food safety and hygiene is key in imparting food handling knowledge and skills to food service workers, so as to enhance their safe food handling practices [30], in our study only 6.7% of the participants reported to have received formal training in food handling (Table 1). These findings are comparable with previous studies done in other countries. Ali and Immanuel [13] at Allahabad in India found that none of the food handlers (0%) had attended formal training for food handling. Similarly, Al-Kandari et al. [31] in Kuwait reported that 58.0% of the food service workers had not participated in any food safety training program. Odonkor and Odonkor [23] in Ghana identified lack of training to handlers (i.e., 63%) as the main barrier to food safety in the food establishments. Likewise, most handlers who worked in the visited FSE (both restaurants and street food vending sites) in Mwanza City were inadequately trained on proper food handling, which could compromise quality and safety of food.

Additionally, in this study 70.0% of the participants had been working in the RTE food industry for >2 years (Table 1). Likewise, Ali and Immanuel [13] reported that 80% of food handlers had the experience of >2 years in this industry. Karondo [19] and Al-Kandari et al. [31] also revealed that most food handlers had been operating in the RTE food business for several years. Food safety and handling practices improve with experience [32]. Bou-Mitri et al. [21] observed that workers with greater food handling experience had higher knowledge scores compared to those with lower experience. Similarly, Faour-Klingbeil et al. [33] recorded a positive impact of working experience on the food safety awareness among participants operating in food establishments.

Furthermore, the current study observed that all (100%) cluster I establishments (restaurants) had business capital of Tanzanian Shillings (TSh) 1,000,000 to 2,500,000, while 100% of the cluster II FSE (street food vending site) had invested between TSh. 100,000 and 500,000 (Table 1). Equally, Mramba [28], documented that most of the street food vendors in Mwanza invested capital ranging between 100,000 and 500,000 Tanzanian shillings. According to the Tanzanian classification of businesses, businesses with a capital of not more than 5 million Tanzanian Shillings (TSh) are categorized as microenterprise [34]. Thus, all FSE in our study fell within the microenterprise group, indicating that they could not afford to improve the infrastructure, secure cooling facilities, or employee trained personnel. A previous study in Dodoma reported that lack of capital hindered enforcement of food hygiene regulations such as wearing aprons and boiling water for washing hands [35].

Moreover, none of the cluster II FSE (street food vending sites) was licensed or registered, while all cluster I (restaurants) (100%, Table 1) were registered by both, Tanzania Revenue

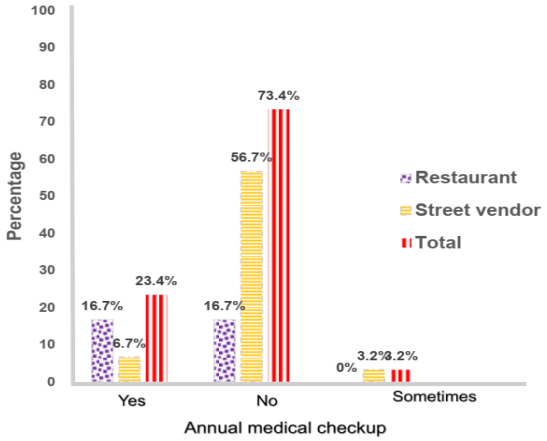

Fig. 2. Annual food handler medical checkup

Authority (TRA) and Healthy Municipal Council (HMC). These findings were in agreement with a previous study in Tanzania Marras [20] and Mfinanga [35] which observed that street food vendors operate in non-licensed premises. Lack of registration among the FSE indicates that they operated in poorly designed facilities which could not comply with food premise registration regulations. Handling of food in such premises may cause cross contamination with various food safety risks.

3.2 Food Safety Knowledge of Food Handlers

The findings of food handlers' food safety knowledge showed that all participants (100%) expressed a unanimous belief in the necessity of inspecting raw materials used in salads to ensure the quality and safety of the final product. Similarly, all participants (100%) concurred that proper cleaning of raw materials significantly contributes to minimizing contaminants, underscoring its importance for the safety of food (Table 2).

However, certain questions revealed areas of inadequate understanding. For example, none of the participants (0%, Table 2) recognized the role of wearing gloves when serving salads in reducing the risk of cross-contamination. Likewise, none of the participants (0%, Table 2) acknowledged the necessity of wearing masks during the distribution of unwrapped food. Furthermore, slightly more participants (53.3%, Table 2) considered that wearing clean clothing while handling food was not necessary. Additionally, more participants (66.7%, Table 2) regarded cleaning the food processing environment after services as not important. Overall, the food handlers had poor food safety knowledge. Most of the participants (66.7%, Fig. 2) had a food safety knowledge score lower than 64%. However, the handlers in our study were more knowledgeable than those operating in other places in the world [13,36].

3.3 Food Safety Attitudes of Food Handlers

Table 3 shows the food handlers' attitudes toward food safety. All participants (100%, Table 3) agreed that quality specifications play an important role in ensuring the safety and quality of raw materials used in food products. However, only 36.7% of participants expressed that cutting boards should be properly sanitized between salad preparation and handling other raw food items. This suggests the potential for improved understanding of this crucial practice. Further, majority (70.0%, Table 3) of participants found it unacceptable to use one cutting board for chopping both vegetables and raw meat due to awareness of the associated cross-

contamination risks. Most handlers (73.3%, Table 3) recognized the importance of using different chopping boards for different types of foods to prevent cross-contamination. This awareness underscores the significance of employing proper practices to maintain food safety.

All participants (100%, Table 3) understood that proper hand washing is a crucial practice for reducing the risk of food contamination. A majority (70.0%, Table 3) of participants believed that touching other things while handling food could increase the risk of contamination. On the other hand, about (30.0%) of the handlers did not understand that keeping food at fridge temperature (0 - 4°C) can help reduce the risk of contamination. In conformity with this, Teffo and Tabit [36] documented that a significant segment of participants in their study stored food at incorrect temperature. Moreover, some previous studies observed that sufficient knowledge and positive attitudes do not necessarily lead to good practices [37,38,21].

3.4 Medical Checkup of Personnel

Majority of the food handlers (73.4%, Fig. 2) did not perform any medical checkup before being employed and after every six months. According to Tanzanian food legislation, food handlers shall undergo medical screening at least twice every year [39]. This implies that food was sometimes handled by sick handlers in some of the food service establishments in Mwanza city. Health checkup is a component of food safety in ensuring that food is not handled by sick people [40,23].

3.5 Food Safety Practices of Food Handlers

According to the results about food handlers' safety and hygiene practices, a relatively modest percentage (36.7%, Table 4) of the handlers indicated that they wash their hands before touching raw foods. This observation underscores the need for enhanced attention to proper hand hygiene practices among a

Table 2. Food safety knowledge of food handlers

Variable	Yes N (%)	No N (%)
Is covering raw materials crucial for food safety?	15 (50.0)	15 (50.0)
Does inspecting raw materials enhance product safety?	30 (100)	0 (0)
Is proper raw material cleaning essential for food safety?	30 (100)	0 (0)
Can covering vegetable salads lower contamination risk?	16 (53.3)	14 (46.7)
Does wearing gloves when serving salads prevent cross-contamination?	0 (0)	30 (100)
Must one wear clean clothing when handling food?	14 (46.7)	16 (53.3)
Should one wear a mask when distributing unwrapped food?	0 (0)	30 (100)
Is proper handwashing vital for food safety?	30 (100)	0 (0)
Can eating/drinking while chopping salad raise contamination risk?	25 (83.3)	5 (16.7)
Can nail polish impact safety of food?	30 (100)	0 (0)
Can accessories (like rings and bracelets) carry food-borne pathogens?	17 (56.7)	13 (43.3)
Is daily pre-service establishment cleaning crucial for food safety?	30 (100)	0 (0)
Is post-service establishment cleaning key to food safety?	10 (33.3)	20 (66.7)
Does cleaning the food storage area reduce cross-contamination?	27 (90.0)	3 (10.0)

Table 3. Food safety attitudes of food handlers

Variable	Yes N (%)	No N (%)
Raw material quality specs not useful for quality and safety.	0 (0)	30 (100)
No need to sanitize cutting boards between salad prep and other raw foods.	19 (63.3)	11 (36.7)
Vegetables and raw meat can share the same chopping board.	9 (30.0%)	21 (70.0%)
Distinguishing between chopping boards is crucial.	22 (73.3)	8 (26.7)
Hand washing minimizes food contamination risk.	30 (100)	0 (0)
Handling food along with other items increases contamination risk.	21 (70.0)	9 (30.0)
Keeping food at fridge temperature (0 - 4°C) lowers contamination risk.	21 (70.0)	9 (30.0)

Table 4. Food safety practices of food handlers

Variable	Yes N (%)	No N (%)
Do you properly wash your hands before touching raw foods?	11 (36.7)	19 (63.3)
Do you properly wash your hands after touching raw food?	25 (83.3)	5 (16.7)
Do you properly wash utensils by soap and potable water?	5 (16.7)	25 (83.3)
Do you wear nail polish while handling *Kachumbari?*	0 (0)	30 (100)
Do you thoroughly wash the chopping board with soap and potable water?	6(20.0)	24 (80.0)
Do you eat while preparing *Kachumbari*?	1 (3.3)	29 (96.7)
Do you separate raw materials from ready-to-eat *Kachumbari?*	30 (100)	0 (0)
Do you keep *Kachumbari* at fridge temperature (0 - 4^{o}C)?	0 (0)	30 (100)
Do you keep *Kachumbari* at ambient temperature?	30 (100)	0 (0)
Do you cover the *Kachumbari container or plate* after preparation?	10 (33.3)	20 (66.7)
Do you properly clean your tables after each meal?	21 (70.0)	9 (30.0)
Do you wear clean, sterile gloves when serving *Kachumbari?*	0 (0)	30 (100)
Do you wear clean protective clothing?	12 (40.0)	18 (60.0)
Do you use chopping boards of different colors?	3 (10.0)	27 (90.0)
Do you sanitize chopping boards when switching to another product?	13 (43.3)	17 (56.7)
Do you have a special storage room for raw materials?	6 (20.0)	24 (80.0)
Do you chop vegetables on the same board used to chop raw meat?	5 (16.7)	25 (83.3)
Do you mix leftovers *Kachumbari* with fresh *Kachumbari?*	0 (0)	30 (100)

significant portion of food handlers. Conversely, a substantial majority (83.3%, Table 4) of food handlers demonstrated that they wash their hands after handling raw foods. This finding signifies a strong awareness of the importance of post-contact hand washing in maintaining food safety standards.

Alarmingly, only 16.7% (Table 4) of the handlers reported that they adequately washed utensils using soap and potable water. In line with this, Halim-lim *et al*. (2023) [29] in the Maldives noted that some food establishments did not properly wash utensils, and others left the dirty utensils inside the sink for a long time. This result suggests the potential existence of gaps in proper utensil cleaning practices that warrant further attention and education. Furthermore, a relatively small proportion (20.0%, Table 4) of participants indicated that they thoroughly washed chopping boards with soap and potable water. This finding proposes consideration of more robust practices to ensure proper board sanitation.

The mixed storage of raw foods with ready-to-eat products results in cross-contamination [41]. Encouragingly, in our study, all participants (100%) exhibited a strong understanding of cross-contamination prevention by confirming their commitment to separating raw materials from ready-to-eat *Kachumbari*. Likewise, previous studies reported that it was vital to separate the raw foods from the ready-to-eat foods [29]. However, notable gaps were identified in temperature control practices. None of the participants reported maintaining *Kachumbari* at fridge temperature, suggesting room for improvement in this critical aspect of food safety.

Notably, none of the participants reported the use of clean, sterile gloves during the serving of *Kachumbari*, and a minority (40.0%, Table 4) reported wearing clean food processing clothing while handling food. These findings indicate potential areas for improvement in personal protective equipment (PPE) usage. In terms of chopping board practices, only a small percentage (10.0%) of participants reported using boards of different colors, commonly employed to prevent cross-contamination. A moderate proportion (43.3%, Table 4) of participants reported sanitizing chopping boards when transitioning between cutting different products, signifying a partial awareness of this practice.

The scores for washing utensils using soap and potable water as well as properly washing hands before touching food were lower than in the previous works [42,43]. Poor hygiene, unsafe practices, and improper handling of food are the main causes of foodborne illnesses. Hence, food handling needs proper hand washing at every step of preparing food, especially before handling the food, after touching raw food material and any other contaminated surfaces or materials, as well as after using toilets [44].

Overall, in this study, the food safety practice level of the food handlers was poor, with 86.7% of the participants not practicing recommended hygienic and safety standards (Fig. 3). Conversely, some previous studies documented high levels of good food safety practices in FSE, such as restaurants, cafeterias, and stationary street food vendors [38,21,44]. However, in conformity with our findings, a number of earlier studies showed comparable degrees of poor hygiene practices among food handlers [45]. This inconsistency in food safety practice level might be due to differences in the study tools used, geographical area, and sociodemographic characteristics.

3.6 Hygiene and Safety of Food Processing Environment

The surveyed FSE had no access to potable water (96.7%, Table 5). Although thermal or chemical treatment of water is an important step towards ensuring food safety [46,47], very few FSE (13.3%, Table 5) used boiled or treated water for salad preparation. This practice creates opportunities of contamination with various food safety hazards.

According to Tanzanian food law, all FSE should have clean and well-furnished toilets [48]. However, a significant proportion (43.3%) of the FSE had no toilets (Table 5) as several were street vendors. Further, 30% of the FSE lacked the handwashing facilities. Legesse et al. [49] recorded similar findings that indicated lack of basic sanitation facilities like toilets, hand washing facilities, potable water, and waste disposal facilities in several food establishments in Arba Minch Town, Ethiopia. Nevertheless, the availability of sanitary facilities is a pre-requisite intended to minimize, control, and/or prevent food contamination and disease spread [50]. Equally, hand hygiene is crucial in preventing the transmission of pathogens during food handling, and having a dedicated hand washing facility is a positive food safety indicator [44].

Additionally, in this study, the majority of FSE (66.7%, Table 5), used the same chopping board for all products, which raises concerns as it can lead to cross-contamination between different food items, compromising food safety. Likewise, Ncube et al. [51] observed high levels of food contamination and poisoning in food establishments, which were associated with the use of unhygienic food chopping boards.

Furthermore, proper waste management is essential to maintain cleanliness and prevent the growth of harmful microorganisms [52]. However, only 20.0% of the FSE (Table 5) had sufficient waste disposal facilities such as waste bins with a lid. A secure lid helps prevent pests and insects from accessing the waste, reducing the risk of contamination. Thus, the use of inadequate waste disposal facilities in most FSE suggests high risk contamination and cross-contamination in their foods.

About 26.7% (Table 5) of the establishments were reported to be dusty. The presence of unwanted materials such as dust and particles during the processing and preparation of food

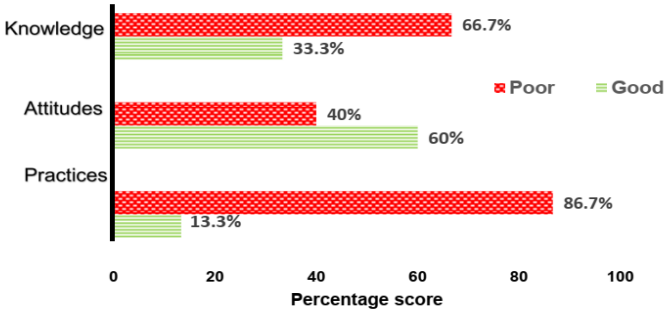

Fig. 3. Food handlers' level of food hygiene and safety knowledge, attitudes and practices

Table 5. Hygiene and safety of food processing environment

Variable	Yes (%)	No (%)
Potable water available	1 (3.3)	29 (96.7)
Boil water for salad preparation	4 (13.3)	26 (86.7)
Toilets available	17 (56.7)	13 (43.3)
The toilets are clean	16 (53.3)	14 (46.7)
A hand washing facility available	21 (70.0)	9 (30.0)
A clean knife used to chop salads	26 (86.7)	4 (13.3)
Use the same knife to chop other products	18 (60.0)	12 (40.0)
Thoroughly clean the knife before and after chopping products	22 (73.3)	8 (26.7)
The knife is made of stainless steel	30 (100)	0 (0)
The knife has rust	30 (100)	0 (0)
A functioning refrigerator is available for storing Kachumbari	0 (0)	30 (100)
A cool box is available and used to store Kachumbari	0 (0)	30 (100)
A waste disposal facility is available	29 (96.7)	1 (3.3)
The waste disposal facility is lid type and sufficient	6 (20)	24 (80)
The establishment is located near the damping site	2 (6.7)	28 (93.3)
The establishment is located near sewerage system	3 (10.0)	27 (90.0)
The establishment is located near the water logging place	4 (13.3)	26 (86.7)
The place is dusty	8 (26.7)	22 (73.3)
The place has bad smell	1 (3.3)	29 (96.7)
Pets (such as cats or dogs) are present in the establishment	8 (26.7)	22 (73.3)

food can be a source of pathogenic organisms [53]. Therefore, the presence of dust in some of the establishments is an indication of poor food safety and quality.

Furthermore, a small percentage of establishments were located near damping sites (6.7%), sewerage systems (10.0%), or waterlogging places (13.3%) (Table 5). Additionally, a few establishments had a bad smell (3.3%) and/or pets (26.7%, Table 5). Some previous studies also reported that pets and pests like rodents were present in FSE (Alimi, 2016) [54]. Of note, all domestic, wild, and pet animals are reservoirs of some pathogenic organisms, such as *Salmonella* spp. [46,55]. Thus, the presence of pests in a handful of the FSE in the current study rises food safety concerns. This suggests that there is a significant need for improvement in hygiene practices in the majority of the establishments studied.

4. CONCLUSION

The current handling practices of players in food service business in Mwanza City do not guarantee quality and safety of *Kachumbari*, a mild heat-treated product. Lack of trained handlers on best food handling practices indicate that the product is most likely contaminated. Moreover, preparation in advance accompanied with a long duration before serving increase risk of pathogen growth. In addition, inadequate facilities and equipment to ensure hygiene raise even more concerns on the safety of products handled in such environment. If the quality and safety of vegetable salads especially in tropical settings are to be guaranteed, the players should observe hygienic handling and adopt refrigeration storage. As compared to well-treated products, mild heat products are risky to contamination and growth of pathogens if best handling practices are not observed. Regardless, the potential risk to contamination, such product is preferred by consumers. Therefore, strategies to ensure safety of the product are essential at all levels. The food control authorities should monitor such establishment to ensure that they observe food hygiene regulations. The players need also to be trained on handling practices to maintain quality and safety across the chain.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mir SA, Shah MA, Mir MM, Dar BN, Greiner R, Roohinejad S. Microbiological contamination of ready-to-eat vegetable salads in developing countries and potential solutions in the supply chain to

control microbial pathogens. Food Control. 2018;85:235–244.
Available:https://doi.org/10.1016/j.foodcont.2017.10.006

2. Akoachere JFTK, Tatsinkou BF, Nkengfack JM. Bacterial and parasitic contaminants of salad vegetables sold in markets in Fako Division, Cameroon and evaluation of hygiene and handling practices of vendors. BMC Research Notes. 2018;11(1):1–7. Available:https://doi.org/10.1186/s13104-018-3175-2
3. Kibitok SK, Ndoku JM. Journal of Food Safety and Hygiene Evaluation of microbial contamination of consumed fruits and vegetables salad (Kachumbari) around Egerton University , Kenya. Journal of Food Safety and Hygiene. 2016;2(1):3–6.
4. Septembre-Malaterre A, Remize F, Poucheret P. Fruits and vegetables, as a source of nutritional compounds and phytochemicals: Changes in bioactive compounds during lactic fermentation. Food Research International. 2018;104, 86–99.
Available:https://doi.org/10.1016/j.foodres.2017.09.031
5. Mbae KM, Ndwiga MK, Kiruki FG. Microbiological quality of Kachumbari, a raw vegetable salad popularly served alongside roast meat in Kenya. Journal of Food Quality; 2018. Available:https://doi.org/10.1155/2018/8539029
6. Kapeleka JA, Sauli E, Sadik O, Ndakidemi PA. Co-exposure risks of pesticides residues and bacterial contamination in fresh fruits and vegetables under smallholder horticultural production systems in Tanzania. PLoS ONE. 2020;15(7July):1–23.
Available:https://doi.org/10.1371/journal.pone.0235345
7. Adams M, Motarjemi Y. Basic food safety for health workers world health organization Basic food safety for health workers. Geneva. 1999;24–27. Available:https://apps.who.int/iris/bitstream/handle/10665/65992/WHO_SDE_PHE_FOS_99.1?sequence=1
8. Annor GA, Baiden EA. Evaluation of Food Hygiene Knowledge Attitudes and Practices of Food Handlers in Food Businesses in Accra, Ghana. Food and Nutrition Sciences. 2011;02(08):830–836.
Available:https://doi.org/10.4236/fns.2011.28114
9. Omaye ST. Food and nutritional toxicology. Food and Nutritional Toxicology; 2004. Available:https://doi.org/10.1201/9780203485309
10. Fung F, Wang HS, Menon S. Food safety in the 21st century. Biomedical Journal. 2018;41(2):88–95.
Available:https://doi.org/10.1016/j.bj.2018.03.003
11. World Health Organization. Food-borne disease burden epidemiology reference group. who estimates of the global burden of foodborne diseases. 2015;1068–1069. Available:https://doi.org/10.1007/978-3-662-43978-4_3884
12. The World Health Organization (WHO). Five Keys to Safer Food Manual. Five Keys to Safer Food Manual. 2006;1–30. Available:http://www.who.int/foodsafety/publications/consumer/manual_keys.pdf
13. Idris Ali A, Immanuel G. Assessment of hygienic practices and microbiological quality of food in an institutional food service establishment. Journal of Food Processing & Technology. 2017;08(08). Available:https://doi.org/10.4172/2157-7110.1000685
14. Ndunguru JN, Ndossi DG. Bacteriological analysis of ready-to-eat foods from Morogoro municipal market. Tanzania Veterinary Journal. 2020;37(November):17–24.
Available:https://doi.org/10.4314/tvj.v37i1.4s
15. Lopes Nonato I., Almeida Minussi LO. De. Nutritional Issues Concerning Street Foods. Journal of Clinical Nutrition & Dietetics. 2016;02(01):1–9. Available:https://doi.org/10.4172/2472-1921.100014
16. Review WP. World Population Review. In World Population Review; 2022.. Available:https://worldpopulationreview.com/world-cities/mwanza
17. Mramba NR. The Conception of street vending business (SVB) in income poverty reduction in Tanzania. International Business Research. 2015;8(5):120–129. Available:https://doi.org/10.5539/ibr.v8n5p120
18. Ansari-Lari M, Soodbakhsh S, Lakzadeh L. Knowledge, attitudes and practices of workers on food hygienic practices in meat processing plants in Fars, Iran. Food Control. 2010;21(3):260–263.

Available:https://doi.org/10.1016/j.foodcont.2009.06.003

19. Karondo JV. The role of street food vending to the vendor's household welfare In Ilala municipality in Dar Es Salaam, Tanzania.pdf. 2021;9. Available:http://www.cbe.ac.tz/bej%0ATHE
20. Marras S. Street_food_In_Tanzania_A_literature_rev. 2018;1. Available:www.fao.org/publications
21. Bou-Mitri C, Mahmoud D, El Gerges N, Jaoude MA. Food safety knowledge, attitudes and practices of food handlers in lebanese hospitals: A cross-sectional study. Food Control. 2018;94 (June):78–84. Available:https://doi.org/10.1016/j.foodcont.2018.06.032
22. Loukieh M, Mouannes E, Abou C, Hanna L, Francesco W, Marc F, Zeidan B. Street foods in Beirut city: An assessment of the food safety practices and of the microbiological quality. January. 2018;1–11. Available:https://doi.org/10.1111/jfs.12455
23. Odonkor ST, Odonkor CJA. An Assessment of Food Safety Knowledge and Practices in the Ghanaian Hospitality Industry. Journal of Food Quality; 2020. Available:https://doi.org/10.1155/2020/5618492
24. Nizame FA, Alam MU, Masud AA, Shoab AK, Opel A, Islam K, Luby SP. Hygiene in Restaurants and among Street Food Vendors in Bangladesh. 2019;101(October 2013):566–575. Available:https://doi.org/10.4269/ajtmh.18-0896
25. Ndibalema P. Making sense of basic education statistics in Tanzania: Emerging issues and implications for future practice. International Journal of Elementary Education. 2019;8(1):26. Available:https://doi.org/10.11648/j.ijeedu.20190801.14
26. Right-to-Education-Initiative. 28 january 2016. January 2016; 2018. Available:www.right-to-education.org
27. Raphael G, Mrema GI. Assessing the Role of Microfinance on Women Empowerment: A case of PRIDE (T) -Shinyanga. Business and Economic Research. 2017;7(2):35. Available:https://doi.org/10.5296/ber.v7i2.10238
28. Mramba N. Exploring street vendors characteristics and social-economic significance in Mwanza Tanzania. Journal of Business and Management Review. 2022;3(3):208–228. Available:https://doi.org/10.47153/jbmr33.3382022
29. Halim-lim SA, Mohamed K, Sukki FM, David W, Fatimah U, Zainal U, Jamaludin AA. Food Safety Knowledge, Attitude, and Practices of Food Handlers in Restaurants in Mal é, Maldives. 2023;1–15.
30. Ledo J, Hettinga KA, Bijman J, Kussaga J, Luning PA. A tailored food safety and hygiene training approach for dairy farmers in an emerging dairy chain. Food Control. 2021;124(January):107918. Available:https://doi.org/10.1016/j.foodcont.2021.107918
31. Al-Kandari D, Al-abdeen J, Sidhu J. Food safety knowledge, attitudes and practices of food handlers in restaurants in Kuwait. Food Control. 2019;103:103–110. Available:https://doi.org/10.1016/j.foodcont.2019.03.040
32. Nyarugwe SP, Linnemann AR, Ren Y, Bakker EJ, Kussaga JB, Watson D, Fogliano V, Luning PA. An intercontinental analysis of food safety culture in view of food safety governance and national values. Food Control. 2020;111(September 2019):107075. Available:https://doi.org/10.1016/j.foodcont.2019.107075
33. Faour-Klingbeil D, Kuri V, Todd E. Investigating a link of two different types of food business management to the food safety knowledge, attitudes and practices of food handlers in Beirut, Lebanon. Food Control. 2015;55:166–175. Available:https://doi.org/10.1016/j.foodcont.2015.02.045
34. Survey N. Tanzania national baseline survey report. Jurnal Penelitian Pendidikan Guru Sekolah Dasar. 2012;6(August):128. Available:https://www.fsdt.or.tz/wp-content/uploads/2016/05/MSME-National-Baseline-Survey-Report.pdf
35. Mfinanga FA. Compliance of food vendors to food vending regulations in Tanzania-a case of Dodoma municipality; 2018. Available:http://www.ijmra.us
36. Teffo LA, Tabit FT. An assessment of the food safety knowledge and attitudes of food handlers in hospitals. BMC Public Health. 2020;20(1). Available:https://doi.org/10.1186/s12889-020-8430-5
37. Akabanda F, Hlortsi EH, Owusu-Kwarteng J. Food safety knowledge, attitudes and

practices of institutional food-handlers in Ghana. BMC Public Health. 2017;17(1):1–9. Available:https://doi.org/10.1186/s12889-016-3986-9

38. Asmawi UMM, Norehan AA, Salikin K, Rosdi NAS, Munir NATA, Basri NBM, Selamat MI, Nor NM. An assessment of knowledge, attitudes and practices in food safety among food handlers engaged in food courts. Current Research in Nutrition and Food Science. 2018;6(2): 346–353. Available:https://doi.org/10.12944/CRNFSJ.6.2.09
39. TBS. Guidelines for a client who wish to apply for registration of non-manufacturing premises for food and cosmetics; 2022a. Available:https://www.tbs.go.tz
40. Hassan JK, Fweja LWT. Assessment of food safety knowledge and compliance to hygienic practices among street food vendors in Zanzibar Urban District. Current Journal of Applied Science and Technology. 2020;39(7):59–72. Available:https://doi.org/10.9734/cjast/2020/v39i730577
41. Montville R, Chen Y, Schaffner DW. Glove barriers to bacterial cross-contamination between hands to food. Journal of Food Protection. 2001;64(6):845–849. Available:https://doi.org/10.4315/0362-028X-64.6.845
42. Abdul-Mutalib NA, Abdul-Rashid MF, Mustafa S, Amin-Nordin S, Hamat RA, Osman M. Knowledge, attitude and practices regarding food hygiene and sanitation of food handlers in Kuala Pilah, Malaysia. Food Control. 2012;27(2):289–293. Available:https://doi.org/10.1016/j.foodcont.2012.04.001
43. Al-Shabib NA, Mosilhey SH, Husain FM. Cross-sectional study on food safety knowledge, attitude and practices of male food handlers employed in restaurants of King Saud University, Saudi Arabia. Food Control. 2016;59:212–217. Available:https://doi.org/10.1016/j.foodcont.2015.05.002
44. Souza CVS de, Azevedo PR M de, Seabra LMAJ. Food safety in Brazilian popular public restaurants: Food handlers' knowledge and practices. Journal of Food Safety. 2018;38(5):1–9. Available:https://doi.org/10.1111/jfs.12512
45. Salhadi NA, Ab Hamid MR, Osman NS, Md Nor N. A Qualitative Study on the Determination of Healthy Cafeteria Practice in Selangor, Malaysia. Environment-Behaviour Proceedings Journal. 2017;2(5):141. Available:https://doi.org/10.21834/e-bpj.v2i5.691
46. Ehuwa O, Jaiswal AK, Jaiswal S. Salmonella, food safety and food handling practices. Foods. 2021;10(5):1–16. Available:https://doi.org/10.3390/foods10050907
47. Jarvis NA, O'Bryan CA, Dawoud TM, Park SH, Kwon YM, Crandall PG, Ricke SC. An overview of Salmonella thermal destruction during food processing and preparation. Food Control. 2016;68:280–290. Available:https://doi.org/10.1016/j.foodcont.2016.04.006
48. TBS. Tanzania standard food hygiene – Code of hygienic practice for street-vended food. 2022b;1(1121):1–7.
49. Legesse D, Tilahun M, Agedew E, Haftu D. Food handling practices and associated factors among food handlers in Arba Minch Town Public food establishments in Gamo Gofa Zone, Southern Ethiopia. Epidemiology: Open Access. 2017;07(02). Available:https://doi.org/10.4172/2161-1165.1000302
50. Garcia SN, Osburn BI, Cullor JS. A one health perspective on dairy production and dairy food safety. One Health. 7(March). 2019; 7:100086. Available:https://doi.org/10.1016/j.onehlt.2019.100086
51. Ncube F, Kanda A, Muzeketwa D, Chiripamberi V. Risk factors for food poisoning among self- catering university students. International Journal of Environmental Health Research. 2020; 1–11. Available:https://doi.org/10.1080/09603123.2020.1723498
52. Kumwenda S. Challenges to Hygiene Improvement in Developing Countries. The Relevance of Hygiene to Health in Developing Countries. 2019;1–18. Available:https://doi.org/10.5772/intechopen.80355
53. Kamboj S, Gupta N, Bandral JD, Gandotra G, Anjum N. Food safety and hygiene: A review. International Journal of Chemical Studies. 2020;8(2):358–368. Available:https://doi.org/10.22271/chemi.2020.v8.i2f.8794

54. Alimi BA. Risk factors in street food practices in developing countries: A review. Food Science and Human Wellness. 2016;5(3):141–148. Available:https://doi.org/10.1016/j.fshw.2016.05.001

55. Simpson KMJ, Hill-Cawthorne GA, Ward MP, Mor SM. Diversity of Salmonella serotypes from humans, food, domestic animals and wildlife in New South Wales, Australia 05 Environmental Sciences 0502 Environmental Science and Management 07 Agricultural and Veterinary Sciences 0707 Veterinary Sciences. BMC Infectious Diseases. 2018;18(1):1–11. Available:https://doi.org/10.1186/s12879-018-3563-1

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CHAPTER THREE

PAPER II

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A Cross-sectional Study to Assess Bacteriological Quality of Fresh Vegetable Salads and Associated Risk Factors in Food Service Establishments in Mwanza City

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study examined the bacteriological quality of fresh vegetable salads and associated risk factors in restaurants and street food vendors in Nyamagana and Ilemela municipalities, Mwanza City, Tanzania. Thirty samples of vegetable salads (i.e., *Kachumbari*), along with 30 swabs from hands and chopping boards, were collected and analyzed. High contamination levels exceeding acceptable limits were observed with total bacterial counts, *S. aureus*, and *E. coli* ranging from 3.6

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to 6.7 log CFU/g. All *Kachumbari* samples (100%) were unsatisfactory, and 17 (56.7%) had unsatisfactory *E. coli* levels. Moreover, 22 samples (73.3%) had unsatisfactory *S. aureus* levels, and 10 samples (33.3%) showed unsatisfactory *Salmonella* spp. contamination. Further, *Kachumbari* from street food vending sites had a significantly ($p < 0.05$) higher TBC mean value (6.5 ± 0.3 log CFU/g) than the one from restaurants (5.2 ± 0.6 log CFU/g). On the other hand, chopping boards and hands had high total counts ranging from 3.5 to 4.7 log CFU.cm^{-2}. Also, the type of chopping board was significantly related to the *S. aureus* contamination levels in the *Kachumbari* salads ($p < 0.05$). The presence of both hygiene indicator microorganisms and pathogens indicates a potential public health risk associated with the consumption of *Kachumbari*. Urgent intervention measures are required to enhance handling practices, personal hygiene, and overall safety throughout the food value chain, thus ensuring the quality and safety of vegetable salads in food service establishments.

Keywords: Vegetable salads; kachumbari; bacteriological quality; safety.

1. INTRODUCTION

The consumption of fresh vegetable salads as well as mild heat-treated products has increased across the world, including in developing countries [1], due to their relatively low cost, high nutritious values, and easy preparation. Vegetable salad may be prepared in several ways, either taken as raw without any kill-step or mild heat treated and carry different names depending on the location [2–4]. In Tanzania, vegetable salad is commonly known as *Kachumbari*. Globally, over 2.5 billion people eat ready-to-eat (RTE) street foods such as vegetable salads every day [5].

Kachumbari is widely prepared and consumed in various food service establishments (FSE) in Tanzania. This salad is prepared from different types of vegetables, like bell peppers, cabbages, cucumbers, carrots, tomatoes and onions [2]. Although salads may be mildly heat-treated, they are normally taken when they are cold. They are regarded as among the ready-to-eat (RTE) cold foods [6]. Cooling can be done in a refrigerator, but in most FSE, such facilities are lacking; hence, cooling is done under ambient conditions. For public safety, salads should be prepared and handled under hygienic conditions.

Vegetable salads are rich sources of micronutrients such as vitamins (like vitamins A, B, C and K) and minerals (including iron, calcium, zinc, magnesium and phosphorus) with several health and nutritional benefits to consumers [7,8]. Consumers prefer taking vegetable salads along with their main dish, particularly, fried potatoes, plantain, rice or ugali. However, if not well-handled vegetable salads are frequently associated with microbiological contamination [1,9,10]. Consumption of vegetable salads has been implicated with foodborne disease (FBD) outbreaks [11,12]. The outbreaks vary in magnitude from a small number of individuals affected to several thousands [13]. Previous studies have identified the presence of pathogens like *Escherichia coli* and *Salmonella* spp. in fruit juices and vegetable salads [2,9,14].

Moreover, vegetables present multiple avenues for attachment and invasion of pathogenic microorganisms at different stages along the food chain, including cultivation, harvesting, processing and marketing [15]. The utilization of contaminated water during vegetable washing constitutes an additional source of contamination [16]. Other potential sources of contamination are soil, unclean processing equipment, feces (of human or animal origin), and inadequate product handling [14].

Furthermore, Mwanza City has numerous street food vendors and restaurants that serve vegetable salads. Although the local food markets in this city are not well organized, they are the major sources of vegetables for *Kachumbari* preparation in the city's food service establishments. Therefore, from the sanitary practices, it is rational to presume the presence of bacterial contamination in vegetables purchased from these markets. Similarly, previous studies in developing countries like Tanzania, have observed inadequate sanitary conditions, unhygienic food handling practices during preparation, and insufficient storage facilities for food in food establishments including, street food vending sites, restaurants, and hotels [3,4,9]. Moreover, vegetable salads, like other RTE foods, are commonly consumed without heat treatment or other processing effective to eliminate or significantly reduce

harmful microorganisms [17]. These factors collectively intensify the risk of contracting food-borne diseases among consumers of fresh vegetables and salads, which raises public health concerns.

Although several studies across the world have assessed the microbiological quality of fresh fruits and vegetable salads [14,18], very few studies have been conducted in Tanzania [9,19]. Consequently, in Tanzania, there is limited information on the bacteriological quality of the cold RTE foods including *Kachumbari*. Considering the increase in the consumption of vegetable salads in Tanzania and its neighboring countries [2], the information on bacteriological quality of these salads may be useful in enhancing proper food hygiene practices and management for safeguarding public health and strengthening consumer confidence; which could in turn reduce FBD treatment costs and promote sales in FSE like restaurants and street vendors. Therefore, the current study aimed at assessing the bacteriological quality of *Kachumbari* (fresh vegetable salads) and associated risk factors in the food service establishments that prepare and serve this salad in Mwanza City, Tanzania.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in Nyamagana and Ilemela Municipalities in Mwanza City. This city is situated in the northern part of Tanzania. It is positioned between 1°30' and 3° south of the Equator and longitudinally located between 31°45' and 34°10' east of Greenwich. The population of Mwanza city is around 1,310,754 inhabitants [20].

2.2 Study Design

The study utilized a descriptive cross-sectional research design to assess the risk factors of contamination and evaluate the bacteriological quality of *Kachumbari* in FSE. The survey was conducted from March to April 2023.

2.3 Assessment of Microbiological Contamination

2.3.1 Selection of bacteriological parameters

The four bacteriological parameters comprising indicators of fecal hygiene (*E. coli*), personnel hygiene (*S. aureus*), food safety (*Salmonella* spp.), and general process hygiene (total bacterial counts, TBC) were selected and analyzed [2,21]. Total bacterial counts were selected to evaluate the general quality of raw materials, the efficiency of handling methods and hygienic conditions during processing, the hygienic state of the tools and utensils, and the time/temperature profile during storage. *E. coli* naturally grows only in the intestines of human and vertebrate animals [22]. It is the species of coliform that is considered as the indicator of fecal contamination and the potential presence of human pathogens [23]. Therefore, the presence of *E. coli* in food suggests that human pathogens may have accessed the food. The natural habitats of *S. aureus* are human skin, hair and superficial mucous membranes (nose). Thus, the presence of huge populations of *S. aureus* may imply enterotoxin production or a problem with sanitation or manufacturing procedures [24]. *Salmonella* spp. is the most common pathogenic bacteria in both humans and animals, and they are abundantly present in nature. *Salmonella* spp. has been observed to be the important cause of food-borne diseases that pose a severe public health problem across the world [25]. Therefore, the detection of *Salmonella* spp. in food implies that the food is unsafe and unsuitable for human consumption.

2.3.2 Sample collection

A total of 90 samples were collected for microbiological analysis from 30 FSE. The number of FSE involved were restricted to 30 due to budgetary and time constraints but also the study aimed to establish the current status. A multistage technique and convenience sampling were used to select the 30 FSE. First, two wards with a high population of street food vendors were randomly selected from each municipality from a list of wards with a high population of street vendors. Then, convenience sampling was employed to select the thirty FSE, proportionally between street food vending sites (SFV) and restaurants, from the four randomly chosen wards; in which 20 SFV and 10 restaurants were drawn for the study. Thereafter, three samples (*Kachumbari*, hand and chopping board swabs) were obtained from each FSE. Overall, 30 *Kachumbari* samples, 30 food handler's hand swabs and 30 chopping board (CB) swabs were collected for microbiological analysis. The collected samples were aseptically transferred into sterile zip-lock bags to minimize the risk of cross-contamination. The bags were kept in a

cool box with ice packs to keep the temperature between 4 and 7℃. Then samples were transported to the Tanzania Veterinary Laboratory Agency (TVLA) microbiology laboratory and analyzed within 2 hours after sampling using methods adapted from the US-FDA Bacteriological Analytical Manual [26,27]. Analytical reagents (diluents) and medium were prepared in accordance with the relevant test method specifications and the manufacturer's instructions.

2.3.3 Analysis of samples

Laboratory analysis samples were prepared aseptically. From each salad 25 g was weighed on analytical balance (Adventurer TM PRO OHAUS) made in China; and transferred into sterile polythene zip-lock bags. Thereafter, *Kachumbari* in each sterile bag was mixed well with 225 mL of buffered peptone water (BPW). The mixture was then homogenized thoroughly by using a stomacher (Seward STOMACHER R 3500 Lab System). Also, the collected swab samples of food handlers' hands and chopping boards were first placed into 5 mL of buffered peptone water for 2 minutes. Then, 10-fold serial dilutions of samples from 10^{-1} to 10^{-10} in the sterile buffer were aseptically performed. After which 0.1 mL from each dilution was inoculated onto Plate Count Agar (PCA, for TBC), MacConkey Agar (MCA for *E. coli*), Baird Parker Agar and Mannitol Salt Agar (BPA and MSA, for *S. aureus*) and Xylose Lysine Deoxycholate (XLD) Agar and *Salmonella* Shigella (SS) Agar (XLD and SS for *Salmonella* spp.) and incubated at 30 ± 1°C for 24 ± 2 h for TBC, 37 ± 1°C for 24 + 2 h for *E. coli*, 37 ± 1°C for 48 ± 2 h for *S. aureus* and 37 ± 1°C for 24 ± 2 h for *Salmonella* spp. Then appropriate dilutions were enumerated for presence of TBC, *E. coli* and *S. aureus*, and the presence of *Salmonella* spp. was visually confirmed. After which total number of microbes per gram of salad and per cm^2 of contact surface (hands and chopping boards) were calculated accordingly.

2.3.4 Interpretation of microbiological results

Tanzanian standards (TZS) and East African Standards (EAS) were employed to interpret the results. The criteria used to interpret microbiological results are presented in Table 1.

2.4 Assessment of pH

The pH was measured in the salad exudate after aseptically taking samples for microbiological analysis and allowing them to stabilize at room temperature. A pH and Conductivity Meter (Benchtop pH Meter, Bioevopeak) was used after being calibrated using standard buffer solutions of pH 7.0 and pH 4.0. The 5 mL of salad exudate was placed into a test tube, the pH tip was submerged approximately 3 cm into the liquid and was permitted to stabilize, then the reading was taken. Distilled water was used to rinse the probe between the measurements.

2.5 Statistical Analysis

The data collected were analyzed using IBM SPSS Version 25. Descriptive statistics were employed to compute means, standard deviations, median and range. Whereas, an independent t-test was performed to determine the difference in the mean bacterial counts of TBC, *S. aureus* and *E. coli* between wooden and plastic chopping boards, as well as, between *Kachumbari* from restaurants and street food vendors. On the other hand, a one-way Analysis of Variance was carried out to assess the differences among mean values of TBC, *S. aureus* and *E. coli* in *Kachumbari,* and means were separated by Duncan's Multiple Range Test (DMRT). Correlation analysis was conducted to determine the relationship between microbiological counts (TBC, *E. coli* and *S. aureus*) of *Kachumbari* and that of hands. A chi-square test was performed to establish the relationship between independent variables (type of FSE and CB) and *Kachumbari* contamination with *E. coli* and *S. aureus*. The significance level, $P < 0.05$ was used.

Table 1. Microbiological criteria of vegetables and vegetable salads

S/N	Parameter	Criteria (Maximum Limit)	Source
1	TBC	10^2 CFU/g	EAS 1109:2022
2	*E. coli*	Absent	TZS 730/ISO 16649-1
3	*S. aureus*	10^2 CFU/g	TZS 125/ISO 6888-1
4.	*Salmonella spp*	Absent/25g	TZS 122/ISO 6579-1

3. RESULTS AND DISCUSSION

3.1 Raw Materials Used to Prepare the Salad

In this study, raw materials for *Kachumbari* preparation in food service establishments in Mwanza city were investigated. The findings showed that all FSE prepared their *Kachumbari* salads from onions, tomatoes, cucumbers, bell peppers, and carrots; without adding lemon or vinegar (Fig. 1). The FSE bought the raw materials (vegetables) only from the local food markets within Mwanza city and no other sources like farms or hawkers were utilized.

3.2 pH of *Kachumbari*

pH values of *Kachumbari* are presented in Table 2. The pH of the salad samples ranged from 3.0 to 5.7. The majority (24, 80%) of the samples had slightly low pH values, which ranged from 3.0 to 4.5 and only six (20%) samples had pH values between 4.8 and 5.7.

3.3 Microbiological Quality of *Kachumbari*

The microbiological quality was assessed in all (30) *Kachumbari* samples, 10 from restaurants and 20 from SFV. High total bacterial counts (ranging from 4.8 to 6.7 log CFU/g, Table 3) were found in vegetable salads. The TBC counts in all salads exceeded the set limit in vegetables and vegetable salads (2 log CFU/g, ure 2). However, *S. aureus* counts were between <1 and 6.7 log CFU/g (Table 3). Most (22) salads had excessive *S. aureus* contamination levels above the established legal limit (2 log CFU/g) in vegetable and vegetable salads, of which 6 were from restaurants and 16 were from SFV (Fig. 2). On the other hand, *Kachumbari* had *E. coli* contamination levels ranging from <1 to 6.7 log CFU/g (Table 3). Of these, 17 samples had high counts (4.7 – 6.7 CFU/g) beyond the set standard (i.e., *E. coli* absent); 7 were from restaurants and 10 from SFV (Fig. 3). *Salmonella* spp. contamination was detected in vegetable salads from 2 restaurants and 8 SFV (Fig. 3).

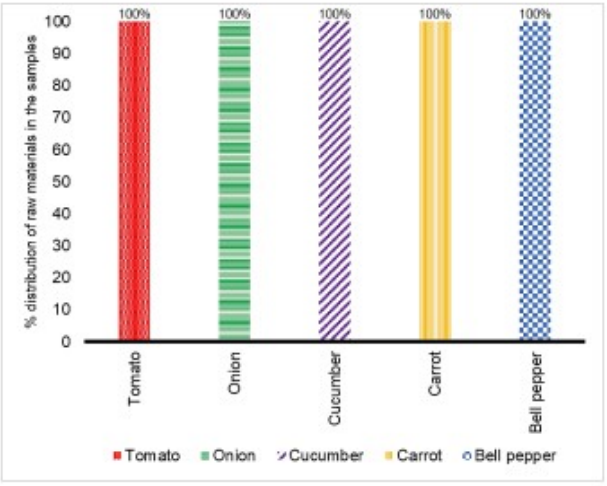

Fig. 1. Raw materials for *Kachumbari* preparation

Table 2. pH of *Kachumbari*

pH range	Number of samples (%)
0 – 2.9	0 (0)
3 – 4.5	24 (80)
4.8 – 5.7	6 (20)

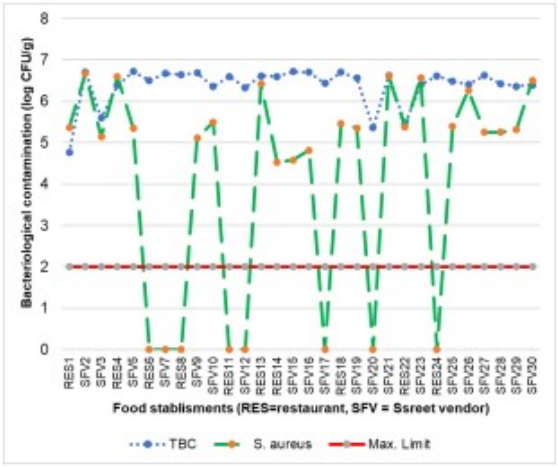

Fig. 2. TBC and *S. aureus* contamination levels in *Kachumbari*

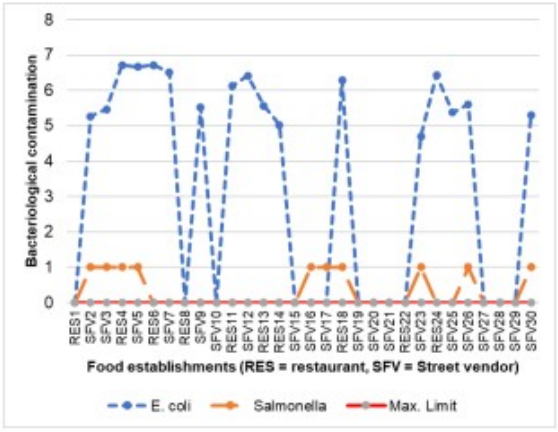

Fig. 3. *E. coli* and *Salmonella* contamination levels in *Kachumbari*

An independent t-test was conducted to assess the differences between microbiological contamination levels in vegetable salads from street food vending sites and those from restaurants. The findings revealed that the mean value for TBC (6.5 ± 0.3 log CFU/g) in *Kachumbari* from SFV was statistically significantly ($p < 0.05$, Table 3) higher than that of salads from restaurants (log CFU/g 5.2 ± 0.6). However, no significant differences ($p > 0.05$, Table 3) were observed in microbiological contamination with *S. aureus* and *E. coli* between vegetable salads from restaurants and street food vendors (Table 3). On the other hand, a one-way analysis of variance was performed to determine the differences among TBC, *S. aureus* and *E. coli* in *Kachumbari* salads. The ANOVA results showed that TBC contamination levels (6.4 ± 0.5 log CFU/g) were significantly ($p < 0.05$, Table 4) higher than *S. aureus* (4.5 ± 1.9 log CFU/g) and *E. coli* (4.0 ± 2.2 log CFU/g). Nonetheless, there were no statistically significant ($p > 0.05$, Table 4) differences between the microbiological mean counts of *S. aureus* and *E. coli*.

Table 3. Differences in microbiological contamination levels of *Kachumbari* salads between restaurants and street food vending sites

Microorganisms	Mean ± SD (log CFU/g)		Range (log CFU/g)
	SFV (N=20)	RES (N=10)	
Total bacterial counts	6.5 ± 0.3[a]	5.2 ± 0.6[b]	4.8 - 6.7
S. aureus	4.4 ± 2.4[a]	3.4 ± 2.9[a]	<1 - 6.7
E. coli	2.8 ± 2.9[a]	4.3 ± 2.9[a]	<1- 6.7

RES = restaurant, SFV = street food vending site. Mean values with different superscript letters in the same row are significantly different at P < 0.05.

Table 4. Prevalence of TBC, *S. aureus*, and *E. coli* in *Kachumbari*

Microorganism	N	Mean ± SD (log CFU/g)
Total bacterial counts	30	6.4 ± 0.5[a]
S. aureus	30	4.5 ± 1.9[b]
E. coli	30	4.0 ± 2.2[b]

Mean values with different superscript letters in the same column are significantly different at P < 0.05.

Table 5. Microbiological quality of salad chopping boards

FSE	Board type	Counts of microorganisms (Log cfu.cm^{-2})			Presence [+/-]
		TBC	*S. aureus*	*E. coli*	*Salmonella* spp.
RES11	PCB	4.7	2.7	*	-
RES13	PCB	4.4	*	*	-
RES18	*PCB*	4.7	*	*	-
RES24	PCB	4.1	*	*	-
RES8	PCB	4.7	*	*	-
SFV10	PCB	4.5	3.1	*	-
SFV12	PCB	4.7	3.4	*	-
SFV19	PCB	4.7	1.8	*	-
SFV2	PCB	4.7	4.8	*	-
SFV20	PCB	4.4	*	*	-
SFV25	PCB	4.7	3.4	4.7	-
SFV26	PCB	4.3	*	*	-
SFV28	PCB	4.6	*	*	-
SFV5	PCB	4.1	*	3.5	-
SFV9	PCB	4.4	2.1	*	+
RES1	WCB	4.7	2.5	4.7	-
RES14	WCB	3.6	2.7	*	-
RES22	WCB	4.7	4.1	*	-
RES4	WCB	4.6	*	*	-
RES6	WCB	3.5	*	*	-
SFV15	WCB	4.3	5.6	*	-
SFV16	WCB	4.5	3	*	-
SFV17	WCB	4.6	4.1	3.1	-
SFV21	WCB	4.7	5.3	*	-
SFV23	WCB	4.1	3.4	*	-
SFV27	WCB	4.7	4.8	*	-
SFV29	WCB	4.6	4.8	*	-
SFV3	WCB	4.7	3.4	*	-
SFV30	WCB	4.4	4.6	*	-
SFV7	WCB	3.9	3.4	*	-

*FSE = food service establishment, RES = restaurant, SFV = street food vending site, PCB = plastic chopping board, WCB = wooden chopping board, + = present, - = absent, *Microbial count < 1.0 x 101 Log CFU.cm^{-2}.*

3.4 Microbiological Quality of Salad Chopping Boards

In our study, 15 FSE used wooden chopping boards (WCB) to prepare *Kachumbari*, while the other 15 opted for plastic chopping boards (PCB). High contamination levels of TBC ranging from 3.5 to 4.7 and 4.1 to 4.7 log CFU.cm^{-2} were recovered on WCB and PCB, respectively (Table 5). *S. aureus* contamination levels on WCB and PCB ranged from <1 to 5.6 and <1 to 4.8 log CFU.cm^{-2}, respectively (Table 5). On the other hand, the mean value (3.4 log CFU.cm^{-2}) of *S. aureus* recovered on WCB was significantly ($p < 0.05$, Table 6) higher than on PCB (1.4 log CFU.cm^{-2}). The majority (26) of salad chopping boards had *E. coli* counts less than 1 log CFU.cm^{-2}, and the remaining four had counts ranging from 3.1 to 4.7 log CFU.cm^{-2} (Table 5). *Salmonella* contamination was recorded only on one salad chopping board (Table 5).

3.5 Association Between Type of Chopping Board and *Kachumbari* Contamination

An independent t-test was performed to determine the difference in the mean bacterial counts of TBC, *S. aureus* and *E. coli* between WCB and PCB. *Kachumbari* sliced on WCB had significantly ($p < 0.05$) higher *S. aureus* contamination levels (5.8 log CFU/g) than in the salads prepared on PCB (3.4 log CFU/g) (Table 6). No significant differences ($p > 0.05$, Table 6) were observed in microbiological contamination with TBC and *E. coli* between *Kachumbari* chopped on WCB and the one sliced on PCB (Table 6).

3.6 Correlations Between Micro-biological Contamination Levels of *Kachumbari* and Food Handlers' Hands

Correlation analysis was conducted to determine the relationship between microbiological counts (TBC, *E. coli* and *S. aureus*) of *Kachumbari* and hands of food handlers. Significant ($p < 0.05$) correlations between different types of indicator organisms on handlers' hands and in *Kachumbari* were observed during the analysis. The correlation between TBC in the salad and *E. coli* on hands was ($r = -0.398$, $p < 0.05$, Table 7) and between *E. coli* in the salad and *S. aureus* on hands was ($r = -.451$, $p < 0.05$, Table 7). However, all the observed positive correlations were not statistically significant ($p > 0.05$, Table 7).

3.7 Relationships Between Independent Variables and *Kachumbari* Contamination with *E. coli* and *S. aureus*

The outcomes of the chi-square test revealed a statistically significant relationship between chopping board type and contamination of *Kachumbari* with *S. aureus* ($p < 0.05$, Table 8). *S. aureus* was recovered in all 15 (100%) of the salads that were sliced on WCB and only in 10 (66.7%) of the *Kachumbari* prepared on PCB (Table 8). No significant differences in the frequency of the *Kachumbari* contamination with *E. coli* were noted based on both type of FSE and material of the salad chopping board ($p > 0.05$, Table 8).

This study assessed the bacteriological quality of fresh vegetable salads prepared and served in restaurants and street vendors in Mwanza City, Tanzania alongside associated risk factors for contamination and quality deterioration. Our findings revealed that *Kachumbari* from all study FSE, both restaurants and street food vendors showed high bacteriological contamination levels beyond the maximum limits in vegetable salads intended for human consumption as per Tanzania Bureau of Standards and East African Standards, thus questioning its safety to the consumers. The bacteriological load may indicate the safety (microbiological contamination level) of a product or its quality including the degree of spoilage [29]. However, the bacteriological quality and the extent of deterioration of RTE products like vegetable salads may be influenced by several factors such as source and nature of raw materials (vegetables), pH, FSE type, hygiene of food handlers' hands and type of chopping board used [2,30,31].

Regarding raw materials for *Kachumbari* preparation, in this study, all food service establishments prepared their vegetable salads from onions, tomatoes, cucumbers, bell peppers, and carrots; and added neither lemon nor vinegar. In line with our findings, Mbae et al. [2] in Kenya found that most (97.4%) of the food establishments prepared their *Kachumbari* from onions, tomatoes, and bell peppers, while only a small proportion of them included chili pepper. This signifies that tomatoes, onions, and bell

peppers are the major raw materials for *Kachumbari* preparation in Tanzania and its neighboring countries. Nonetheless, these vegetables can be contaminated with harmful microorganisms, including *E. coli* and *Salmonella* spp. [2,32]. In our study, all FSE obtained the vegetables (raw materials) from local food markets in Mwanza City. However, in these markets, the vegetables are not hygienically handled, and are often placed on unclean mats or tables and sprinkled with non-potable water. Although hygienic preparation of salads could completely or significantly reduce microorganisms of concern, recontamination may occur. Whyte [33] reported that food recontamination through air and dust is a critical issue when products stay for a long time in areas with the possibility of airborne contamination. Therefore, observing hygienic handling practices will prevent food safety hazards in the salads.

pH is another factor that may influence microbiological growth and quality of foods including vegetables and vegetable salads [34]. Most vegetables have pH values near the neutral region, 4.8 – 6.5 [35], which favors the growth of most spoilage bacteria and fungi. Thus, vegetables are easily spoiled by both bacteria and fungi. Luckily, in our study, the majority of the samples had low pH values ranging from 3.0 – 4.5, which could inhibit the growth of some bacteria, thereby slowing or hindering spoilage. Nevertheless, it is important to note that pH normally interacts with other parameters like temperature and water activity in foods to cause or prevent spoilage [36–38].

On the other hand, all (100%) of the *Kachumbari* salads were unsatisfactory. They had high contamination levels of TBC (4.8 – 6.7 log CFU/g) exceeding the established legal limit in vegetable and vegetable salads, which demonstrates inadequate hygiene of the food business. In agreement with our findings, a study in Addis Ababa, Ethiopia observed excessive TBC contamination levels (6.06 log CFU/g) in vegetable salads [14]. Further, Faour-Klingbeil et al. [39] in Beirut, Lebanon found that fresh-cut vegetables had TBC counts varying from 2.90 to 7.38 log CFU/g. Also, *S. aureus* (4.5 ± 1.9 log CFU/g) were excessively recovered from both restaurants and SFV above the set standard (2 log CFU/g). Equally, high counts of *E. coli* were recorded in the majority of vegetable salads from both restaurants and SFV, beyond the stipulated legal limits (i.e., *E. coli* absent) in fresh vegetables and salads. *Salmonella* spp. contamination was also detected in *Kachumbari*. In conformity with our findings, Kayombo and Mayo [19] in Dar es Salaam, Tanzania, recorded high contamination levels in fresh vegetable salads with *E. coli* and *Salmonella* beyond the established limits. Also, Kothe et al. [40] in Brazil and Mbae et al. [2] in Kenya observed high counts of *E. coli* (3.0 – 3.5 log CFU/g) in vegetables and vegetable salads, which exceeded the established standards (2 log CFU/g). Likewise, Aggarwal et al. [41] in India found that 10% of salad samples exceeded the set limits for *Salmonella* spp. in fresh vegetables. Thus, the occurrence of *S. aureus*, *E. coli* and *Salmonella* ssp. in the analyzed vegetable salads could be attributed to inadequate cleaning and improper food handling practices among the study FSE. Moreover, adhering to the recommended food hygiene and safety standards is particularly vital in food service facilities where large quantities of food are prepared and served every day in a short time, as there is a high possibility of food service workers making errors in the food handling [14]. Therefore, it is essential to implement the recommended food hygiene and safety measures in both restaurants and SFV to ensure the quality and safety of *Kachumbari* and other RTE foods.

Table 6. Mean values (log CFU/g) of TBC, *S. aureus* and *E. coli* in *Kachumbari* and chopping boards

	Mean values on chopping boards		
	TBC	*S. aureus*	*E. coli*
PCB	4.5^{a}	1.4^{b}	0.5^{a}
WCB	4.3^{a}	3.4^{c}	0.5^{a}
	Mean values in *Kachumbari* per chopping board type		
PCB	6.5^{a}	3.4^{a}	4.1^{a}
WCB	6.3^{a}	5.8^{b}	2.9^{a}

PCB = plastic chopping board, WCB = wooden chopping board. Means with different superscript letters in the same column are significantly different at P < 0.05.

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Table 7. Correlations between microbiological contamination levels of *Kachumbari* and hands

			Microbiological counts					
			Kachumbari (Log CFU/g)			Hand (Log CFU.cm^{-2})		
			TBC	*S. aureus*	*E. coli*	TBC	*S. aureus*	*E. coli*
Kachumbari (Log CFU/g)	TBC	r	1	.066	.173	.256	-.149	-.398**
		P		.729	.360	.172	.433	.030
	S. aureus	r	.066	1	-.014	.096	.125	.069
		P	.729		.940	.614	.511	.717
	E. coli	r	.173	-.014	1	-.025	-.451**	.269
		P	.360	.940		.897	.012	.151
Hand (Log CFU.cm^{-2})	*TBC*	r	.256	.096	-.025	1	.246	.378**
		P	.172	.614	.897		.190	.040
	S. aureus	r	-.149	.125	-.451**	.246	1	.129
		P	.433	.511	.012	.190		.498
	E. coli	r	-.398**	.069	.269	.378**	.129	1
		P	.030	.717	.151	.040	.498	

*r = Pearson correlation coefficient, **Correlation is significant at the 0.05 level (2-tailed).*

Table 8. Relationship between independent variables and *Kachumbari* contamination with *E. coli* and *S. aureus*

		SS. aureus contamination				
Variable		**Positive (%)**	**Negative (%)**	**χ^2**	**df**	**P-value**
FSE type	RES	8 (80.0)	2 (20.0)	0.12	1	0.73
	SFV	17 (85.0)	3 (15.0)			
Board type	PCB	10 (66.7)	5 (33.3)	6.00	1	0.01*
	WCB	15 (100)	0 (0)			
		***E. coli* contamination**				
FSE type	RES	2 (20.0)	8 (80.0)	1.79	1	0.18
	SFV	11 (55.0)	9 (45.0)			
Board type	PCB	11 (73.3)	4 (26.7)	1.29	1	0.26
	WCB	8 (53.3)	7 (46.7)			

*Chi-square test at α = 0.05, P values with * denotes significant relationships, FSE = Food Service Establishment, RES = restaurant, SFV = street food vending site, PCB = plastic chopping board, WCB = wooden chopping board, df = degrees of freedom*

Nevertheless, *Kachumbari* from restaurants had a significantly ($p < 0.05$) lower TBC mean value (5.2 ± 0.6 log CFU/g) than the one from SFV (6.5 ± 0.3 log CFU/g). Similarly, Kussaga and Nziku [30] in Morogoro, Tanzania, recorded relatively higher TBC counts (5.4 log CFU/g) in RTE foods from street vending sites than restaurants (5.2 log CFU/g). This indicates that restaurants are better at observing the recommended food hygiene rules and practices than street food vendors. On the other hand, contamination levels of TBC (6.4 ± 0.5 log CFU/g) in *Kachumbari* salads were significantly ($p < 0.05$) higher than that of *S. aureus* (4.5 ± 1.9 log CFU/g) and *E. coli* (4.0 ± 2.2 log CFU/g). This finding demonstrates that TBC is the most prevalent food hygiene indicator organism in RTEs including vegetable salads [39], and high counts of microorganisms of this group in food signify insufficient food handling as well as the potential presence of human pathogens.

Chopping boards are also an important source of cross-contamination to food [42]. In our study, high contamination levels of TBC (ranging from 3.5 to 4.7 log $CFU.cm^{-2}$) were observed on both WCB and PCB, indicating inadequate cleanliness and sanitization procedures among the food establishments. In line with this, a previous study by Giwa et al. [18], found high TBC counts (4.2 log $CFU.cm^{-2}$) on food chopping boards. On the other hand, excessive counts of *S. aureus* were recovered on both PCB and WCB. Nevertheless, *E. coli* contaminations remained generally low. In consistent with our findings, Bukhari et al. [43] in Mekkah City, Saudi Arabia, observed a prevalence of 17.7% for *E. coli* on food contact surfaces, including cutting boards. Also, Faour-Klingbeil et al. [39] reported the presence of *E. coli* in 31% of the analyzed cutting boards, with contaminations between 2.7 and 7.0 log $CFU.cm^{-2}$.

Interestingly, in our study, only one cutting board (plastic) was contaminated with *Salmonella* spp. However, some previous studies found that *Salmonella* spp. can readily be transferred from contaminated contact surfaces to food [31,44]. This suggests a high possibility of cross-contamination to food if a contact surface is contaminated with *Salmonella*. Chopping boards contaminated with pathogenic bacteria like *E. coli* and *Salmonella* spp. have been linked with food-borne disease outbreaks [12,45]. Therefore, it is critical to ensure that they are thoroughly and frequently cleaned before and after use, with food grade disinfectants.

In this study, facilities that used WCB to prepare *Kachumbari* provided more opportunities for cross-contamination compared with establishments that used PCB, as indicated by the significantly ($p < 0.05$) higher prevalence of *S. aureus* recovered in *Kachumbari* prepared by using WCB. A possible explanation for this is that the plastic surface could have been smooth and intact, facilitating easy removal of contaminants. On the contrary, the frequently used wooden surface could have developed scratches and crevices that would have retained contaminants. Likewise, a previous study in Iraq observed a statistically significantly ($p < 0.05$) higher prevalence of *S. aureus* on WCB (29.20%) that was used to chop vegetables than on PCB (19.8%) [31]. Although, no significant differences ($p > 0.05$) were observed in microbiological contamination with TBC and *E. coli* between *Kachumbari* which was chopped on WCB and the one that was sliced on PCB, the type of chopping board used to prepare food could have an impact on the microbiological quality of RTE foods, especially raw vegetable salads as they are neither heated nor processed further before consumption.

Microbiological cross-contamination from food contact surfaces like chopping boards can occur, if such surfaces are not cleaned effectively or remain wet between cleaning and use [46]. Of note, food cutting boards may harbor considerable amounts of microbiological contaminants, including food-borne pathogens, even after they have been cleaned with portable water and soap [47]. Moreover, the cleaning and maintenance of hygiene standards of food cutting boards are often neglected by the handlers [42]. In our previous study, we observed that FSE did not properly wash their chopping boards as there were no cleaning schedules for chopping boards [48]. Besides, the clean as you go principle is not commonly used which may result in multiplication of microorganisms.

Also, food handlers' hands may be a critical source of human pathogens [49]. Hands are in regular contact with the environment including nose, raw foods, and unclean contact surfaces, and as a result, a number of pathogens can reach food through hands [50,51]. Food can become contaminated via contaminated hands if proper hand hygiene is not practiced among the food handlers when handling food [49,51]. In our

study significant correlations between different types of indicator organisms on handlers' hands and in *Kachumbari* were observed during the analysis. Ironically, all the significant correlations were negative. However, correlations between microorganisms in food and their contact surfaces are normally positive [52], which indicates a positive relationship in contamination levels between a food contact surface and the food that was prepared on it. This signifies that proper hygiene can reduce or prevent cross-contamination of food. Although in this study some positive correlations were observed, they were not statistically significant ($p > 0.05$). In contrast to our findings, a study by Bartz et al. [52] in Mexico found a significant ($p < 0.05$) positive correlation between concentrations of *E. coli* on hands and fresh produce including vegetables. On the other hand, Rodríguez-Caturla et al. [51] in Spain found a significant negative correlation between the presence of *E. coli* in food and the cleanliness of the food handlers' hands ($r = -0.363$, $p < 0.05$), suggesting that cleanliness can play an important role in reducing or preventing cross-contamination from hands to food.

4. CONCLUSION

The findings of our study revealed that the food service establishments that prepare and serve fresh vegetable salads in Mwanza City displayed a high presence of hygiene indicator organisms (TBC) as well as foodborne pathogens (*Staphylococcus aureus*, *Escherichia coli*, and *Salmonella* ssp.) in vegetable salads, handlers' hands and chopping boards. Consequently, the consumption of fresh vegetable salads has the potential to cause illnesses in humans, as they were found to be contaminated with disease-causing organisms. It is likely that the bacterial contamination in the salads originated from the hands of the food handlers or the chopping boards, as both were found to be significantly contaminated with pathogenic bacteria. Therefore, it is critical to thoroughly clean vegetables and dip them in food-grade antimicrobial chemicals for sufficient time to eliminate pathogens and significantly reduce the microbiological load. It is also important to emphasize the practice of thorough hand and chopping board washing after each stage of food processing. Proper sanitization and hygienic handling should be implemented in food service establishments to minimize the risk of contamination during the preparation, storage, and serving of food. Moreover, it is essential to create and promote food safety awareness among consumers of fresh vegetable salads in order to protect public health.

CONSENT AND ETHICAL APPROVAL

They provided consent,and taking part in the study was entirely optional. Every participant was free to end their involvement at any moment. To ensure that the study participants remained anonymous, we did not record their identities on the data gathering tools. Participants were guaranteed confidentiality. Formal approval to conduct the study was received in writing from Sokoine University of Agriculture through its Institutional Research Ethics Review Board.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mir SA, Shah MA, Mir MM, Dar BN, Greiner R, Roohinejad S. Microbiological contamination of ready-to-eat vegetable salads in developing countries and potential solutions in the supply chain to control microbial pathogens. Food Control. 2018;85:235–244.
DOI: 10.1016/j.foodcont.2017.10.006.
2. Mbae KM, Ndwiga MK, Kiruki FG. Microbiological Quality of Kachumbari, a Raw Vegetable Salad Popularly Served Alongside Roast Meat in Kenya. J. Food Qual; 2018.
DOI: 10.1155/2018/8539029.
3. Namukwambi RN, Tuhadeleni ON, Van Neel R. The Knowledge and Practices of Handwashing Among Street Food Vendors in the Keetmanshoop Municipal Area," Res. Rev. 2022;5(3):1860–1865.
DOI: 10.52845/jmrhs/2022-5-4-1.
4. Rakha A, Fatima M, Bano Y, Khan MA, Chaudhary N, Aadil RM. Safety and quality perspective of street vended foods in developing countries. Food Control. August, 2022;138.
DOI: 10.1016/j.foodcont.2022.109001.
5. Ukenna SI, Ayodele AA. Applying the Extended Theory of Planned Behavior to Predict Sustainable Street Food Patronage in a Developing Economy," J. Food Prod. Mark. 2019;25(4):404–434.
DOI: 10.1080/10454446.2019.1572561.

6. Kapeleka JA, Sauli E, Sadik O, Ndakidemi PA. Co-exposure risks of pesticides residues and bacterial contamination in fresh fruits and vegetables under smallholder horticultural production systems in Tanzania," PLoS One. July 2020;15(7):1–23.
DOI: 10.1371/journal.pone.0235345.
7. Charles Aworh O. Promoting food security and enhancing Nigeria's small farmers' income through value-added processing of lesser-known and under-utilized indigenous fruits and vegetables. Food Res. Int. 2015;76(P4):986–991.
DOI: 10.1016/j.foodres.2015.06.003.
8. Pereira JAM, Berenguer CV, Andrade CFP, Câmara JS. Unveiling the Bioactive Potential of Fresh Fruit and Vegetable Waste in Human Health from a Consumer Perspective" Appl. Sci. 2022; 12(5).
DOI: 10.3390/app12052747.
9. Ndunguru JN, Ndossi DG. Bacteriological Analysis of Ready-to-eat Foods from Morogoro Municipal Market. Tanzania Vet. J. November 2020;37:17–24.
DOI: 10.4314/tvj.v37i1.4s.
10. Schuh V, et al. Evaluation of the microbiological quality of minimally processed vegetables," Food Sci. Technol. 2020;40(2)290–295.
DOI: 10.1590/fst.38118.
11. Little C, Gillespie IA. Prepared salads and public health. J. Appl. Microbiol. 2008; 105(6):1729–1743.
DOI: 10.1111/j.1365-2672.2008.03801.x.
12. Lynch MF, Tauxe RV, Hedberg CW. The growing burden of foodborne outbreaks due to contaminated fresh produce: Risks and opportunities," Epidemiol. Infect. 2009;137(3):307–315.
DOI:10.1017/S0950268808001969.
13. Ebel ED, Williams MS, Ward-Gokhale LA, Kisselburgh HM. Assessing the maximum size of annual foodborne outbreaks in the United States: An analysis of 1973–2016 outbreaks," Microb. Risk Anal. 2019;12: 20–26.
DOI:10.1016/j.mran.2019.02.002.
14. Kechero FK, Baye K, Tefera AT, Tessema TS. Bacteriological quality of commonly consumed fruit juices and vegetable salads sold in some fruit juice houses in Addis Ababa, Ethiopia," J. Food Saf. 2019;39(1): 1–9.
DOI: 10.1111/jfs.12563.
15. Osafo R, et al. "Microbial and parasitic contamination of vegetables in developing countries and their food safety guidelines. 2022;2022.
16. Aworh OC. Food safety issues in fresh produce supply chain with particular reference to sub-Saharan Africa," Food Control, no. October 2020;107737.
DOI: 10.1016/j.foodcont.2020.107737.
17. Othman OC. Post harvest physicochemical properties of soursop (*Annona muricata* L.) Fruits of Coast Region, Tanzania. J. Food Nutr. Sci. 2014;2(5):220.
DOI: 10.11648/j.jfns.20140205.13.
18. Giwa AS, et al. Microbiological survey of ready-to-eat foods and associated preparation surfaces in cafeterias of public sector universities," Environ. Pollut. Bioavailab. 2021;33(1):11–18.
DOI: 10.1080/26395940.2021.1880973.
19. Kayombo M, Mayo A. Assessment of microbial quality of vegetables irrigated with polluted waters in Dar es Salaam City, Tanzania. Environ. Ecol. Res. 2018;6(4): 229–239.
DOI: 10.13189/eer.2018.060403.
20. World Population Review, "world Population Review; 2022.
Available:https://worldpopulationreview.com/world-cities/mwanza
21. Lambrechts AA, Human IS, Doughari JH, Lues JFR. Bacterial contamination of the hands of food handlers as indicator of hand washing efficacy in some convenient food industries," Pakistan J. Med. Sci. 2014;30(4):755–758.
DOI: 10.12669/pjms.304.4400.
22. Berthe T, Ratajczak M, Clermont O, Denamur E, Petit F. Evidence for coexistence of distinct escherichia coli populations in various aquatic environments and their survival in estuary water," Appl. Environ. Microbiol. 2013; 79(15):4684–4693.
DOI: 10.1128/AEM.00698-13.
23. Luna-Guevara JJ, Arenas-Hernandez MMP, Martínez De La Peña C, Silva JL, Luna-Guevara ML. The role of pathogenic e. coli in fresh vegetables: Behavior, contamination factors, and preventive measures. Int. J. Microbiol.. 2019;2019.
DOI: 10.1155/2019/2894328.
24. Abebe E, Gugsa G, Ahmed M. Review on major food-borne zoonotic bacterial pathogens. J. Trop. Med.. 2020;2020.
DOI: 10.1155/2020/4674235.
25. Asfaw Geresu M, Assefa Wayuo B, Mamo Kassa G. Occurrence and antimicrobial susceptibility profile of *salmonella* isolates

from animal origin food items in selected areas of Arsi zone, southeastern Ethiopia, 2018/19," Int. J. Microbiol. 2021;2021.
DOI: 10.1155/2021/6633522.

26. Bennett SD, Sodha SV, Ayers TL, Lynch MF, Gould LH, Tauxe RV. Produce-associated foodborne disease outbreaks, USA. 2018;1998–2013.
27. Simpson KMJ, Hill-Cawthorne GA, Ward MP, Mor SM. Diversity of *Salmonella* serotypes from humans, food, domestic animals and wildlife in New South Wales, Australia 05 Environmental Sciences 0502 Environmental Science and Management 07 Agricultural and Veterinary Sciences 0707 Veterinary Sciences," BMC Infect. Dis. 2018;18(1):1–11.
DOI: 10.1186/s12879-018-3563-1.
28. Introduction A. Declaration of helsinki world medical association declaration of helsinki October 1975, 2001;79.
29. Szyma P, Buras I, Koło D. Assessment of the microbiological quality of ready-to-eat salads — Are There Any Reasons for Concern about Public Health ?; 2022.
30. Kussaga JB, Nziku D. Handling practices and microbiological status of food service establishments within morogoro municipality, Tanzania vol. 2023;22(1): 184–193,.
31. Mohammad G, Al-Taee S. Comparison of various types of cutting boards in bacterial contamination, Rafidain J. Sci. 2018;27(2): 12–18.
DOI: 10.33899/rjs.2018.145386.
32. Akoachere JFTK, Tatsinkou BF, Nkengfack JM. Bacterial and parasitic contaminants of salad vegetables sold in markets in Fako Division, Cameroon and evaluation of hygiene and handling practices of vendors," BMC Res. Notes. 2018;11(1):1–7.
DOI: 10.1186/s13104-018-3175-2.
33. Whyte William. Sterility assurance and models for assessing airborne bacterial contamination. Septembe 1986;40(5):188–97.
34. Gonelimali FD, et al. Antimicrobial properties and mechanism of action of some plant extracts against food pathogens and spoilage microorganisms. July 2018;9:1–9.
DOI: 10.3389/fmicb.2018.01639.
35. Beuchat LR. Ecological factors influencing survival and growth of human pathogens on raw fruits and vegetables. 2002;4:413–423.
36. Moss MO. Fungi, quality and safety issues in fresh fruits and vegetables. 2008;104(1997):1239–1243.
DOI: 10.1111/j.1365-2672.2007.03705.x.
37. Narayanan R. Factors influencing the development of microbes in food; 2020.
38. Odeyemi OA, Strateva M, Alegbeleye OO, Stratev D. Understanding spoilage microbial community and spoilage mechanisms in foods of animal origin. 2020April 2019;1–21.
DOI: 10.1111/1541-4337.12526.
39. Faour-Klingbeil D, Todd ECD, Kuri V. Microbiological quality of ready-to-eat fresh vegetables and their link to food safety environment and handling practices in restaurants," Lwt. 2016;74:224–233.
DOI:10.1016/j.lwt.2016.07.051.
40. Kothe CI, Pessoa JP, Malheiros PS, Tondo EC. Assessing the growth of staphylococcus aureus and escherichia coli on fruits and vegetables. J. Infect. Dev. Ctries. 2019;13(6):480–486.
DOI: 10.3855/jidc.10573.
41. Aggarwal D, Upadhyay SK, Kaur L, Kumar A, Bhalla H, Singh R. Assessment of microbial burden on vegetable salads for food safety and human health. Bull. Pure Appl. Sci. Zool. 2020;39a(1):130.
DOI: 10.5958/2320-3188.2020.00015.7.
42. Aviat F, et al. Microbial Safety of Wood in Contact with Food: A Review," Compr. Rev. Food Sci. Food Saf. 2016;15(3):491–505.
DOI: 10.1111/1541-4337.12199.
43. Bukhari M, et al. Assessment of microbiological quality of food preparation process in some restaurants of Makkah city," Saudi J. Biol. Sci. 2021;28(10):5993–5997.
DOI: 10.1016/j.sjbs.2021.06.050.
44. Jensen DA, Friedrich LM, Harris LJ, Danyluk MD, Schaffner DW. Quantifying transfer rates of *Salmonella* and Escherichia coli O157:H7 between fresh-cut produce and common kitchen surfaces," J. Food Prot. 2013;76(9):1530–1538.
DOI: 10.4315/0362-028X.JFP-13-098.
45. Little C, Sagoo S. Evaluation of the hygiene of ready-to-eat food preparation areas and practices in mobile food vendors in the UK.," Int. J. Environ. Health Res. 2009;19(6):431–443.
DOI: 10.1080/09603120903079364.
46. Evans JA, Russell SL, James C, Corry JEL. Microbial contamination of food

refrigeration equipment. J. Food Eng. 2004;62(3):225–232.
DOI: 10.1016/S0260-8774(03)00235-8.

47. Sekoai PT, et al. Insights into the microbiological safety of wooden cutting boards used for meat processing in Hong Kong's wet markets: A focus on food-contact surfaces, cross-contamination and the efficacy of traditional hygiene practices," Microorganisms. 2020;8(4).
DOI: 10.3390/microorganisms8040579.
48. Magambo JMJ, Kussaga JB, Majaliwa N. Assessment of handling practices of fresh vegetable salads in restaurants and street vendors: A Case of Mwanza. 2023;15(12):64–77.
DOI: 10.9734/EJNFS/2023/v15i121368.
49. Yap MIN, et al. Microbial Quality and Safety of Sushi Prepared with Gloved or Bare Hands: Food Handlers ' Impact on Retail Food Hygiene and Safety. 2019;82(4):615–622.
50. Lee HK, Halim HA, Thong KL, Chai LC. Assessment of food safety knowledge , attitude , self-reported practices , and microbiological hand hygiene of food handlers; 2017.
DOI: 10.3390/ijerph14010055.
51. Rodríguez-Caturla MY, Valero A, Carrasco E, Posada GD, García-Gimeno RM, Zurera G. Evaluation of hygiene practices and microbiological status of ready-to-eat vegetable salads in Spanish school canteens. J. Sci. Food Agric. Aug. 2012;92(11):2332–2340.
DOI: 10.1002/jsfa.5634.
52. Bartz FE, et al. Contamination of fresh produce by microbial indicators on farms and in packing facilities: Elucidation of environmental routes. Appl. Environ. Microbiol. 2017; 83(11):1–10.
DOI: 10.1128/AEM.02984-16.

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CHAPTER FOUR

4.0 GENERAL DISCUSSION

In East African countries, including Tanzania, vegetable salads, popularly known as *Kachumbari*, are a common dish in restaurants and street food vending sites (Kariuki *et al*., 2017; Mbae *et al*., 2018). In Mwanza City, people prefer to eat these salads with their main dish, like rice, roasted meat, fried potato, cassava, ugali or chicken. Although vegetable salads are an important component in the human diet, they are often handled by people with inadequate food safety knowledge (Adeleke *et al*., 2020; Kussaga and Nziku, 2023; Odonkor and Odonkor, 2020), which could compromise the quality and safety of these products.

Thus, food handlers' education, work experience in the food sector, and training on best food handling practices are key components in enhancing the hygiene and safety practices in order to improve the quality and safety of these products in food service facilities (Halim-lim *et al*., 2023; Ali and Immanuel, 2017; Odonkor and Odonkor, 2020). Interestingly, in our study all participants (100%) had finished primary school, and 53.3% of them had also completed secondary education. The large proportion of handlers possessing primary and secondary education in this study may be attributed to the Tanzanian government's efforts to ensure universal access to primary education. This initiative includes provision of free education in government schools from primary to secondary levels, with the aim of ensuring that every child attends school (Right-to-Education-Initiative, 2018). In conformity to our findings, a study by Mramba (2022) discovered that 61% of food service workers in Mwanza City had completed primary school education. This suggests that street food vending is often managed by individuals with lower literacy levels. However, education is critical to enhancing food safety practices in food service establishments (Halim-lim *et al*., 2023).

On the other hand, this study discovered that the majority of food handlers in street food vending sites (93.3%) lacked formal training on best food handling practices. This substantial proportion of untrained handlers aligns with findings from earlier studies conducted in different countries (Ali and Immanuel, 2017; Al-Kandari *et al.*, 2019). However, individuals who are either untrained or inadequately trained in food service roles often mishandle food, which could affect its quality and safety. Odonkor and Carolyn (2020), in Ghana observed a lack in

training on best food handling practices as a major obstacle to food safety in food service establishments.

Nonetheless, in Mwanza City, 100% of the restaurants were registered with both TRA and HMC while none of the street food selling outlets had a license or registration. These findings are consistent with previous studies from Tanzania (Marras, 2018; Mfinanga, 2018), which also found that street food vendors operated without a license or registration. The lack of registration among the FSE indicates that some of them could have operated in inadequately designed facilities and infrastructure. Food handling in such establishments may lead to food cross-contamination with a variety of food risks, including pathogenic microorganisms like *Salmonella* spp. and *Escherichia coli*.

Although, the Tanzanian food legislation requires food handlers to perform medical checkup at least twice every year (TBS, 2022). In this study, the majority of the food handlers (73.4%) did not check their health before being employed and after every six months. This implies that in some FSE in Mwanza City, food might have been handled by sick individuals. Conducting medical screening is a critical requirement of ensuring food safety, as it guarantees that food is not handled by sick people. Furthermore, the food safety practice level of the food handlers in the majority of food establishments was poor, with more than three quarters of the handlers not adhering to the recommended food hygiene and safety standards. Conversely, some previous studies indicated high levels of compliancy to the stipulated food safety standards in various food service establishments, including restaurants, cafeterias, and stationary street food vendors (Asmawi *et al*., 2018; Souza *et al*., 2018). The inconsistency observed in the level of food safety practices may be attributed to differences in the tools used for the studies, geographical locations, and socio-demographic characteristics. Additionally, the hygiene and safety of food processing environment was significantly inadequate. The majority of FSE (66.7%), used the same chopping board for all products, which raises concerns about potential cross-contamination between different food items, which could comprise the quality and safety of foods. Likewise, Ncube *et al*. (2020) observed high levels of food contamination and poisoning in food establishments, which were associated with the use of unhygienic food chopping boards.

On the other hand, the bacteriological analysis of vegetable salads revealed that all samples 30 (100%), from both street food vending sites (SFV) and restaurants, had TBC contamination levels exceeding

the stipulated maximum limits for total bacterial counts in vegetable salads as per Tanzanian Bureau of Standards. In correspondence to our findings, Kechero *et al*. (2019) reported a similar average TBC contamination level (6.06 log cfu/g) in vegetable salads. Additionally, Faour-Klingbeil *et al.* (2016) found that fresh-cut vegetables exhibited TBC counts ranging from 2.90 to 7.38 log cfu/g. In our study, the difference in TBC counts between restaurants and street vending sites was statistically significant ($p < 0.05$). Moreover, the contamination of *Kachumbari* with *S. aureus* was notably high in both restaurants and SFV, with a total of 22 samples (73.3%) failing to meet the satisfactory standard. Likewise*, E. coli* levels were beyond the legal threshold in 17 salad samples (53.3%), with 7 samples (23.3%) originating from restaurants and 10 samples (33.3%) from street food vending sites. In consistent with our results, multiple studies conducted in both developed and developing regions have reported the presence of *E. coli* in vegetables and vegetable salads (Mbae *et al.,* 2018; Frank *et al*., 2011). Additionally, *Salmonella* spp. contamination was detected in 2 samples (6.7%) from restaurants and 8 samples (26.7%) from street food vending sites. Thus, 10 samples (33.3%) exceeded the prescribed legal limits for *Salmonella*. Overall, these findings are in line with earlier studies in food service establishments, where a significant proportion of samples exceeded legal limits for indicator microorganisms in vegetables salads, indicating insufficient hygiene and safety standards (Mbae *et al*., 2018; Santana *et al*., 2009).

Moreover, the analysis of bacteriological quality of salad chopping boards identified varying contamination levels of total bacterial counts (TBC), *E. coli*, *S. aureus*, and *Salmonella* on both wooden and plastic cutting boards, suggesting irregular cleanliness and sanitization procedures among the food service establishments. The TBC ranged from 3.5 to 4.7 log $CFU.cm^{-2}$ for plastic boards and 4.1 to 4.7 log $CFU.cm^{-2}$ for wooden boards. On the other hand, some of the assessed cutting boards had total counts higher than the 4.2 $CFU.cm^{-2}$ reported by Giwa *et al*. (2021). Notably, salads sliced on wooden chopping boards had significantly higher ($p <0.05$) *S. aureus* (5.8 log CFU/g) than those sliced on plastic chopping boards (3.4 log CFU/g). Likewise, earlier studies found higher contamination rates in vegetables prepared on wooden boards than plastic boards (Mohammad and Al-Taee, 2018). Thus, the choice of chopping board for *Kachumbari* preparation could have a significant impact on microbial contamination levels.

CHAPTER FIVE

5.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the above findings of this study the following conclusions are made.

i. *Kachumbari* handlers in Mwanza City lack knowledge of best food handling practices and operate in unhygienic conditions. They wear unsuitable and unclean food processing clothes while handling food. The handlers do not check their health regularly as required by the Tanzanian food laws.
ii. Participants working in restaurants have relatively high knowledge of best food handling practices compared to those who work in street food vending sites.
iii. The food service establishments use inadequate facilities and equipment that cannot ensure hygiene and safety raising even more concerns on the quality and safety of products handled in such environment.
iv. *Kachumbari* was contaminated with high concentrations of hygiene indicator organisms (total bacterial counts) and foodborne pathogens (*Staphylococcus aureus*, *Escherichia coli,* and *Salmonella* spp.). Therefore, this product could significantly contribute to food borne diseases and infections affecting the health of the consumers, as well as, the economies of business owners, consumers and the nation as a whole.
v. Food handlers' hands and chopping boards are likely sources of *Kachumbari* contamination as they were found to be contaminated with pathogenic bacteria (*Staphylococcus aureus*, *Escherichia coli,* and *Salmonella* ssp.).

5.2 Recommendations

Based on our findings, the following are recommendations

i. The food control authorities should closely monitor food service establishments including restaurants and street food vending sites to ensure that they observe food safety and hygiene regulations.
ii. Food controllers should conduct frequent microbiological analysis of ready to eat foods including vegetable salads (*Kachumbari)* to monitor microbiological contamination levels in order to ensure that the products comply with the established standards, national or regional standards even international standards if applicable.

iii. The players in food service establishments need also to be regularly trained on best food handling practices to maintain the quality and safety across the food chain.
iv. Thorough cleaning of vegetables followed by dipping them in food-grade antimicrobial chemicals for sufficient time should be encouraged to eliminate pathogens and significantly reduce the microbiological load so as to maintain their safety and quality.
v. *Kachumbari* should be properly prepared according to the recommended food hygiene and safety rules, principles and procedures, and consumed immediately or refrigerated and not stored at ambient conditions for long periods of time.
vi. More studies should be encouraged on fresh vegetable salads especially on microbial pathogens profiles using modern techniques such as molecular methods. These studies will aid to provide evidences of infection risks due to improper food handling and thus pave ways of intervention to control those infections.

REFERENCES

Abdullahi, B. S., Maiha, S. B., & Lawal, H. K. (2020). *Hygiene, Food Safety Practices and Sanitation in Some Food Service Centres in Zaria, Kaduna State, Nigeria*. *8*(5), 206–210. https://doi.org/10.12691/ajfst-8-5-5.

Adeleke, R. A., Sulyok, M., Krska, R., & Ezekiel, C. N. (2020). *Microbiological safety of ready-to-eat foods in low- and middle-income countries: A comprehensive 10-year (2009 to 2018) review D I V E R S I T Y OF RT E s I N L M I C s in different regions of LMICs, RTEs are adopted and accepted*. *August 2019*, 1–30. https://doi.org/10.1111/1541-4337.12533.

Adeyemi, O. A., Fejukui, B. M., & Adeyemi, O. O. (2019). *Microbial Contamination of Fresh Vegetable Salads from Food Vendors in Oyo Metropolis*. *32*(1).

Aggarwal, D., Upadhyay, S. K., Kaur, L., Kumar, A., Bhalla, H., & Singh, R. (2020). Assessment of microbial burden on vegetable salads for food safety and human health. *Bulletin of Pure & Applied Sciences- Zoology*, *39a* (1), 130. https://doi.org/10.5958/2320-3188.2020.00015.7.

Al-Kandari, D., Al-abdeen, J., & Sidhu, J. (2019). Food safety knowledge, attitudes and practices of food handlers in restaurants in Kuwait. *Food Control*, *103*, 103–110. https://doi.org/10.1016/j.foodcont.2019.03.040.

Amor, M. G., Siala, M., Zayani, M., Grosset, N., Gautier, M., & Gdoura, R. (2018). *Isolation, Identification, Prevalence, and Genetic Diversity of Bacillus cereus Group Bacteria from Different Foodstuffs in Tunisia Collection of Food Samples*. *9*(March), 1–12. https://doi.org/10.3389/fmicb.2018.00447.

Asmawi, U. M. M., Norehan, A. A., Salikin, K., Rosdi, N. A. S., Munir, N. A. T. A., Basri, N. B. M., Selamat, M. I., & Nor, N. M. (2018). An assessment of knowledge, attitudes and practices in food safety among food handlers engaged in food courts. *Current Research in Nutrition and Food Science*, *6*(2), 346–353. https://doi.org/10.12944/CRNFSJ.6.2.09

Bennett, S. D., Sodha, S. V, Ayers, T. L., Lynch, M. F., Gould, L. H., & Tauxe, R. V. (2018). *Produce-associated foodborne disease outbreaks, USA, 1998 – 2013*.

Charles A. O. (2015). Promoting food security and enhancing Nigeria's small farmers' income through value-added processing of lesser-known and under-utilized indigenous fruits and vegetables. *Food Research International*, *76*(P4), 986–991. https://doi.org/10.1016/j.foodres.2015.06.003.

City, H., Ire, F. S., Imuh, V. T., & Harcourt, P. (2016). *Bacteriological Quality Evaluation and Safety of Randomly Selected Ready-to-Eat Foods Sold in Port*. *7*(1), 1–10. https://doi.org/10.9734/JALSI/2016/27939.

Faour-Klingbeil, D., Todd, E. C. D., & Kuri, V. (2016). Microbiological quality of ready-to-eat fresh vegetables and their link to food safety environment and handling practices in restaurants. *LWT*, *74*, 224–233. https://doi.org/10.1016/j.lwt.2016.07.051.

Frank, C., Werber, D., Cramer, J.P., Askar, M., Faber, M., Heiden, M., Bernard, H, F. A., Prager, R., Spode, A., Wadl, M., Zoufaly, A., & Jordan, S. (2011). Epidemic Profile of Shiga-Toxin–Producing. *New England Journal of Medicine*, *365*(19), 1771–1780.

Fung, F., Wang, H. S., & Menon, S. (2018). Food safety in the 21st century. *Biomedical Journal*, *41*(2), 88–95. https://doi.org/10.1016/j.bj.2018.03.003.

Giwa, A. S., Memon, A. G., Ahmed Shaikh, A., Korai, R., Maitlo, G. U., Maitlo, I., Ali, S., & Ahmad, J. (2021). Microbiological survey of ready-to-eat foods and associated preparation surfaces in cafeterias of public sector universities. *Environmental Pollutants and Bioavailability*, *33*(1), 11–18. https://doi.org/10.1080/26395940.2021.1880973.

Halim-lim, S. A., Mohamed, K., Sukki, F. M., David, W., Fatimah, U., Zainal, U., & Jamaludin, A. A. (2023). *Food Safety Knowledge, Attitude and Practices of Food Handlers in Restaurants in Mal é, Maldives*. 1–15.

Hoffmann, V., Moser, C., & Saak, A. (2019). Food safety in low and middle-income countries: The evidence through an economic lens. *World Development*, *123*, 104611. https://doi.org/10.1016/j.worlddev.2019.104611.

Idris Ali, A., & Immanuel, G. (2017). Assessment of Hygienic Practices and Microbiological Quality of Food in an Institutional Food Service Establishment. *Journal of Food Processing & Technology*, *08*(08). https://doi.org/10.4172/2157-7110.1000685.

Kapeleka, J. A., Sauli, E., Sadik, O., & Ndakidemi, P. A. (2020). Co-exposure risks of pesticides residues and bacterial contamination in fresh fruits and vegetables under smallholder horticultural production systems in Tanzania. *PLoS ONE*, *15*(7 July), 1–23. https://doi.org/10.1371/journal.pone.0235345.

Kariuki, E. N., Ng'ang'a, Z. W., & Wanzala, P. (2017). Bacteriological Contamination of Street Foods Among Street Food Vendors in Githurai and Gikomba Markets- Nairobi County. *International Journal of Innovative Research and Advanced Studies*, *4*(1), 337–346.

Kayombo, M., & Mayo, A. (2018). Assessment of Microbial Quality of Vegetables Irrigated with Polluted Waters in Dar es Salaam City, Tanzania. *Environment and Ecology Research*, *6*(4), 229–239. https://doi.org/10.13189/eer.2018.060403.

Kechero, F. K., Baye, K., Tefera, A. T., & Tessema, T. S. (2019). Bacteriological quality of commonly consumed fruit juices and vegetable salads sold in some fruit juice houses in Addis Ababa, Ethiopia. *Journal of Food Safety*, *39*(1), 1–9. https://doi.org/10.1111/jfs.12563.

Kharel, N., Palni, U., & Prakash, J. (2016). Microbiological assessment of ethnic street foods of the Himalayas. *Journal of Ethnic Foods*, *3*(3), 235–241. https://doi.org/10.1016/j.jef.2016.01.001.

Kintz, E., Byrne, L., Jenkins, C., Carthy, N. M. C., Vivancos, R., & Hunter, P. (2019). *Outbreaks of Shiga Toxin – Producing Escherichia coli Linked to Sprouted Seeds, Salad, and Leafy Greens: A Systematic Review*. *82*(11), 1950–1958.

Kraemer-Mbula, E., & W.V. (2016). The Informal Economy in Developing Nations. *Cambridge University Press*.

Kussaga, B. & Nziku, D. (2023). *Handling Practices and Microbiological Status of Food Service Establishments within Morogoro Municipality, Tanzania*. *22*(1), 184–193.

Lopes N. I., & Almeida,M. L. O. De. (2016). Nutritional Issues Concerning Street Foods. *Journal of Clinical Nutrition & Dietetics*, *02*(01), 1–9. https://doi.org/10.4172/2472-1921.100014.

Marras, S. (2018). *Street_Food_In_Tanzania_A_literature_rev (1)*. www.fao.org/publications.

Mbae, K. M., Ndwiga, M. K., & Kiruki, F. G. (2018). Microbiological Quality of Kachumbari, a Raw Vegetable Salad Popularly Served Alongside Roast Meat in Kenya. *Journal of Food Quality*, *2018*. https://doi.org/10.1155/2018/8539029.

Mfinanga, F. A. (2018). *Compliance of food vendors to food vending regulations in tanzania-a case of Dodoma Municipality*. http://www.ijmra.us.

Mir, S. A., Shah, M. A., Mir, M. M., Dar, B. N., Greiner, R., & Roohinejad, S. (2018). Microbiological contamination of ready-to-eat vegetable salads in developing countries and potential solutions in the supply chain to control microbial pathogens. *Food Control*, *85*, 235–244. https://doi.org/10.1016/j.foodcont.2017.10.006.

Mohammad, G., & Al Taee, S. (2018). Comparison of Various Types of Cutting Boards in Bacterial Contamination. *Rafidain Journal of Science*, *27*(2), 12–18. https://doi.org/10.33899/rjs.2018.145386.

Mramba, N. (2022). Exploring Street Vendors Characteristics and Social-Economic Significance in Mwanza Tanzania. *Journal of Business and Management Review*, *3*(3), 208–228. https://doi.org/10.47153/jbmr33.3382022.

Namukwambi, R. N., Tuhadeleni, O. N., & Neel, R. Van. (2022). The Knowledge and Practices of Handwashing Among Street Food Vendors in the Keetmanshoop Municipal Area. *Research Review*, *5*(3), 1860–1865. https://doi.org/10.52845/jmrhs/2022-5-4-.

Ncube, F., Kanda, A., Muzeketwa, D., & Chiripamberi, V. (2020). Risk factors for food poisoning among self- catering university students. *International Journal of Environmental Health Research*, *00*(00), 1–11. https://doi.org/10.1080/09603123.2020.1723498.

Ndunguru, J. N., & Ndossi, D. G. (2020). Bacteriological Analysis of Ready-to-eat Foods from Morogoro Municipal Market. *Tanzania Veterinary Journal*, *37*(November), 17–24. https://doi.org/10.4314/tvj.v37i1.4s.

Obinda, D. K., Njue, L., Abong, G. O., & Owade, J. O. (2021). Food Safety Knowledge and Hygienic Practices among Vendors of Vegetable Salads in Pipeline Ward of Nairobi County, Kenya. *East African Journal of Science, Technology and Innovation*, *2*(May), 1–16.

Odonkor, S. T., & Odonkor, C. J. A. (2020). An Assessment of Food Safety Knowledge and Practices in the Ghanaian Hospitality Industry. *Journal of Food Quality*, *2020*. https://doi.org/10.1155/2020/5618492.

Pereira, J. A. M., Berenguer, C. V., Andrade, C. F. P., & Câmara, J. S. (2022). Unveiling the Bioactive Potential of Fresh Fruit and Vegetable Waste in Human Health from a Consumer Perspective. *Applied Sciences (Switzerland)*, *12*(5). https://doi.org/10.3390/app12052747.

Rakha, A., Fatima, M., Bano, Y., Khan, M. A., Chaudhary, N., & Aadil, R. M. (2022). Safety and quality perspective of street vended foods in developing countries. *Food Control*, *138*(August). https://doi.org/10.1016/j.foodcont.2022.109001.

Right-to-Education-Initiative. (2018). *28 january 2016*. *January 2016*. www. right-to-education. Org.

Sabharwal, V., & Arya, C. V. (2020). Street Foods: Safety and Potential. In *Emerging Technologies in Food Science* (pp. 79–84).

Santana, N. G., Almeida, R. C. C., Ferreira, J. S., & Almeida, P. F. (2009). Microbiological quality and safety of meals served to children and adoption of good manufacturing practices in public school catering in Brazil. *Food Control*, *20*(3), 255–261. https://doi.org/10.1016/j.foodcont.2008.05.004.

Souza, C. V. S., de, Azevedo, P. R. M., de., & Seabra, L. M. A. J. (2018). Food safety in Brazilian popular public restaurants: Food handlers' knowledge and practices. *Journal of Food Safety*, *38*(5), 1–9. https://doi.org/10.1111/jfs.12512.

TBS. (2022). *TANZANIA STANDARD Food Hygiene – Code of hygienic practice for street-vended food*. *1*(1121), 1–7.

Toe, E., Dadié, A., Dako, E., & Loukou, G. (2017). *Bacteriological Quality and Risk Factors for Contamination of Raw Mixed Vegetable Salads Served in Collective Catering in Abidjan (Ivory Coast)*. 405–419. https://doi.org/10.4236/aim.2017.76033.

World Health Organization. (2015). Food-Borne Disease Burden Epidemiology Reference Group. *WHO Estimates of the Global Burden of Foodborne Diseases*, 1068–1069. https://doi.org/10.1007/978-3-662-43978-4_3884.

APPENDICES

Appendix 1: Questionnaire
HANDLING PRACTICES OF FRESH VEGETABLE SALADS IN FOOD SERVICE ESTABLISHMENTS IN MWANZA CITY TANZANIA

A questionnaire for assessment of handling practices of vegetable salads (*Kachumbari*) prepared and served in food service establishments in Mwanza City.

Vendor type (circle one): Street vendor Restaurant

A. **Socio-demographic information:**

1. Age, years (Circle)
   - below 18 • 18-25 • 25-45 • above 45
2. Gender (Circle)
   - Male • Female
3. Marital status (Circle)
   - Married • Not married
4. Educational status (Circle)
   - No school • Primary • Secondary • Vocational Training • University
5. How did you acquire knowledge on food preparation? (Circle)
   - Experience (Observation, trial and error) • Training
6. How long have you been working in the ready to eat food industry? (Circle)
   - Less than 1 year • 1-2years • More than 2 years
7. How much did you invest in your business/company (in TZS)? (Circle)
   - Less than 100,000
   - 500,000
   - 500,000-1,000,000
   - Above 1,000,000

B. *Kachumbari* preparation

8. List the raw materials used in preparing your *Kachumbari*.

A.	B.	C.	D.	E.
Ingredient (vegetables)	Preservatives and concentration. If YES list	Flavouring materials. If YES list	List equipment used in preparation	List detergents and disinfectants used in washing/disinfecting food contact surfaces
…	…	…	…	……
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.	…	…	…	……
.	…	…	…	……
.	…	…	…	……
.	…	…	…	……

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Preparation method
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9. How do you acquire the raw materials? (Circle)

- Produce myself from farm
- Buy from farmers
- Buy from vegetable hawkers
- Buy from the market
- Other (specify) ………………………………………………………………………………

C. Food safety knowledge, attitudes and practices

10. Do you and your staff regularly go for medical check-up? (Circle) YES NO
11. (If YES) How often do u do check-up? (Circle)

- Once a year
- Twice a year
- ≥ once a month When sick

12. When was the last time you went for check-up?
    - State Month and Year: ……
    - Don't remember

i. Food safety knowledge of handlers

Variable	**Yes**	**No**
13. Is covering raw materials crucial for food safety?		
14. Does inspecting raw materials enhance product safety?		
15. Is proper raw material cleaning essential for food safety?		
16. Can covering vegetable salads lower contamination risk?		
17. Does wearing gloves when serving salads prevent cross-contamination?		
18. Must one wear clean clothing when handling food?		
19. Should one wear a mask when distributing unwrapped food?		
20. Is proper handwashing vital for food safety?		
21. Can eating/drinking while chopping salad raise contamination risk?		
22. Can nail polish impact safety of food?		
23. Can accessories (like rings and bracelets) carry food-borne pathogens?		
24. Is daily pre-service establishment cleaning crucial for food safety?		
25. Is post-service establishment cleaning key to food safety?		
26. Does cleaning the food storage area reduce cross-contamination?		

ii. Food safety attitudes of handlers

Variable	Yes	No
30. Raw material quality specs not useful for quality and safety.		
31. No need to sanitize cutting boards between salad prep and other raw foods.		
32. Vegetables and raw meat can share the same chopping board.		
33. Distinguishing between chopping boards is crucial.		
34. Hand washing minimizes food contamination risk.		
35. Handling food along with other items increases contamination risk.		
36. Keeping food at fridge temperature (0 - 4°C) lowers contamination risk.		

iii. Food safety practices of handlers

Variable	Yes	No
37. Do you properly wash your hands before touching raw foods?		
38. Do you properly wash your hands after touching raw food?		
39. Do you properly wash utensils by soap and potable water?		
40. Do you wear nail polish while handling *Kachumbari?*		
41. Do you thoroughly wash the chopping board with soap and potable water?		
42. Do you eat while preparing *Kachumbari*?		
43. Do you separate raw materials from ready-to-eat *Kachumbari?*		
44. Do you keep *Kachumbari* at fridge temperature (0 - 4^{o}C)?		
45. Do you keep *Kachumbari* at ambient temperature?		
46. Do you cover the *Kachumbari container or plate* after preparation?		
47. Do you properly clean your tables after each meal?		
48. Do you wear clean, sterile gloves when		

Variable	Yes	No
serving *Kachumbari?*		
49. Do you wear clean protective clothing?		
50. Do you use chopping boards of different colors?		
51. Do you sanitize chopping boards when switching to another product?		
52. Do you have a special storage room for raw materials?		
53. Do you chop vegetables on the same board used to chop raw meat?		
54. Do you mix leftovers *Kachumbari* with fresh *Kachumbari?*		

General assessment (Tick in each box and indicate total score)

1. Location and premises

S/n	Item description	Very good 2	Good 1	Poor 0	Total Score
1	Location and surrounding				
2	Waste/garbage around that could harbor animals, insects or germs				
3	Dusts or bad smell				
4	No toxic substances				
5	No pets or nearby farm				
6	No waterlogged areas				
7	Enough lighting and ventilation				
Total					

2. Sanitation status

S/n	Item description	Very good 2	Good 1	Poor 0	Total Score
1	Water is available				
2	Water is clean and potable				
3	Lid type containers for waste disposal and are sufficient				
4	Proper disposal system				
5	Disinfectant and detergent present, acceptable and safe for food and handler				
6	Preventive structures for animal/ and insect infestation				
Total					

3. Processing and cleaning

S/n	Item description	Very good 2	Good 1	Poor 0	Total Score
1	Premise is clean and in good hygienic conditions				
2	Tools used are appropriate for food processing				
Total					

4. Personnel hygiene

S/n	Item description	Very good 2	Good 1	Poor 0	Total
1	Workers are healthy and not suffering from any communicable diseases must be				

	examined after every 6 months				
2	Suitable and clean clothes for processing				
3	No decorative articles				
4	Hands and nails clean				
5	Hand washing before and after work				
6	Gloves usage incase not measures for keeping hands clean are followed				
7	Hair net/ hat				
8	First aid kit for workers				
Total					

5. Maintenance and cleaning

S/n	Item description	Very good 2	Good 1	Poor 0	Total Score
1	Manufacturing building is clean and in good hygienic conditions				
2	Tools are clean and in good hygiene before and after production				
3	Tools used are proper for food processing				
4	Transportation tools are clean and proper				
5	Regular maintenance of equipment				
Total					

E. Other comments

……
……
……

……
……
……
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……
……

Thank you for completing this questionnaire

Appendix 2: Observation Checklist
Observation checklist for assessment of handling practices and bacteriological quality of vegetable salads served in food service establishments in Mwanza City

	Food safety practices and personal hygiene	**+ Yes** **- No**
1.	Do food handlers wash hands properly before touching raw foods?	
2.	Do food handlers wash hands properly after touching raw foods?	
3.	Are utensils washed using soap and potable water and dried properly before use?	
4.	Do food handlers wear nail polish when handling *Kachumbari*?	
5.	Are chopping boards thoroughly washed with soap and potable water and properly dried?	
6.	Do food handlers taste *Kachumbari* while preparing it?	
7.	Are raw materials and ready to eat *Kachumbari* separated?	

8.	Is *Kachumbari* kept at fridge temperature (4^{o}C)?	
9.	Is *Kachumbari* kept at ambient temperature?	
10.	Is the kachumbari container/plate covered after preparation?	
11.	Are tables properly cleaned after each meal?	
12.	Is *Kachumbari* served on unclean table with food remains?	
13.	Are clean, sterile gloves won during serving of *Kachumbari*?	
	Is an apron worn while preparing Kachumbari	
14.	Is the won apron clean?	
15.	Is a cap/hair net worn while working?	
16.	Is the worn cap/hair clean?	
17.	Do food handlers shake hands with visitors and other people while working?	

18.	Are chopping boards of different colours?	
19.	Are chopping boards sanitized when switching cutting one product to another?	
20.	Is a special raw material storage room available?	
21.	Is storage room/area cleaned properly before storing new products?	
22.	Are the vegetable salads covered?	
23.	Are vegetables chopped on the same chopping board used to chop raw meat?	
24.	Do workers wear suitable and clean clothes for processing?	
25.	No decorative articles?	
26.	Is store/spoiled *Kachumbari* mixed with fresh *Kachumbari*?	
27.	Do handlers touch other things while preparing *Kachumbari?*	
	Infrastructure, facility and equipment	
28.	Is potable water available?	
29.	Do they boil water for salad preparation?	
30.	Do they use same chopping board for all products?	
31.	Is stainless steel chopping board used in preparing *Kachumbari*?	
32.	Is plastic chopping board used in chopping *Kachumbari*?	
33.	Is wooden chopping board used in chopping *Kachumbari*?	
34.	Are Toilets available?	
35.	Are the toilets clean?	
36.	Is a hand washing facility available?	
37.	Is the knife used to chop salads clean?	
38.		

39.	Do they use the same knife to chop other products?	
40.	Do they thoroughly clean the knife before and after chopping products?	
41.	Is the knife stainless steel?	
42.	Has rust formed on the knife?	
43.	Is a refrigerator available, functioning and used to store *Kachumbari*?	
44.	Is a cool box available and used to store *Kachumbari*?	
45.	Is a waste disposable facility available?	
46.	Is the waste disposal container lid type and sufficient?	
47.	Are disinfectant and detergent present, acceptable and safe for food and handlers?	
	Location, surrounding and maintenance	
48.	Is an establishment located on the road side?	
49.	Is the establishment located near the damping site?	
50.	Is the establishment located near sewerage system?	
51.	Is the establishment located in a water logging place?	
52.	Is the establishment roofed?	
53.	Is the establishment made of mainly plastic material?	
54.	Is the establishment made of mainly metallic material?	
55.	Is the establishment made of plastic materials and metal roof?	
56.	Is the establishment made of concrete and metal roof?	

57.

58.	Is the place dusty?	
59.	Does the place smell bad?	
60.	Are pets found in the establishment?	
61.	Is lighting enough?	
62.	Is ventilation enough?	
63.	Is the premise clean and in good hygienic conditions?	
64.	Are tools used appropriate for food processing?	

Appendix 3: Clearance permit for conducting research in Tanzania, issued by SUA

CLEARANCE PERMIT FOR CONDUCTING RESEARCH IN TANZANIA

UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY.

SOKOINE UNIVERSITY OF AGRICULTURE
OFFICE OF THE VICE-CHANCELLOR

P.O Box 3000, CHUO KIKUU, MOROGORO, TANZANIA.
Phone: +255 (023) 2640006/7/8/9, Direct Line: +255 (023) 2640015,
E-mail:vc@sua.ac.tz, Website: https://www.sua.ac.tz

Please refer to:
Our Ref: SUA/ADM/R.1/8/1005 **Date:** 27th January, 2023

Permanent Secretary,
President's Office,
Regional Administration and Local Government,
P.O. Box 1923, Mji wa Serikali,
41185 DODOMA.
Email: ps@tamisemi.go.tz

RE: UNIVERSITY STAFF, STUDENTS AND RESEARCHERS CLEARANCE

The Sokoine University of Agriculture was established by University Act No. 7 of 2005 and SUA Charter, 2007 which became operational on 1st January 2007 repealing Act No. 6 of 1984. One of the mission objectives of the University is to generate and apply knowledge through research. For this reason the staff and researchers undertake research activities from time to time.

2. To facilitate the research function, the Vice Chancellor of the Sokoine University of Agriculture (SUA) is empowered to issue research clearance to staff, students, research associate and researchers of SUA on behalf of the Tanzania Commission for Science and Technology.

3. The purpose of this letter is to introduce to you **Mr. Juma Morigo John Magambo** a bonafide **MSc. (Food Quality and Safety Assurance)** student with Registration number **MFQ/D/2021/0003** of SUA. By this letter **Mr. Juma Morigo John Magambo** has been granted clearance to conduct research in the country. The title of the research in question is ***"ASSESSMENT OF HANDLING PRATICES AND BACTERIOLOGICAL QUALITY OF VEGETABLE SALADS SERVED IN FOOD SERVICE ESTABLISHMENTS IN MWANZA CITY."***

CLEARANCE PERMIT FOR CONDUCTING RESEARCH IN TANZANIA

4. The period for which this permission has been granted is from **February, 2023** to **July, 2023**. The research will be conducted in **Nyamagana and Ilemela Municipalities in Mwanza Region.**

5. Should some of these areas/institutions/offices be restricted, you are requested to kindly advice the researcher(s) on alternative areas/institutions/ offices which could be visited. In case you may require further information on the researcher please contact me.

6. We thank you in advance for your cooperation and facilitation of this research activity.

Yours sincerely,

Prof. Maulid W. Mwatawala
FOR: VICE-CHANCELLOR

MAKAMU MKUU WA CHUO
CHUO KIKUU CHA SOKOINE CHA KILIMO
S.L.P 3000
MOROGORO, TANZANIA

c.c. Director, DPRTC, SUA. - To note in file.
c.c. Student – **Mr. Juma Morigo John Magambo**

Appendix 4: Permit from the ministry of regional administration and local government to facilitate data collection in Mwanza city

JAMHURI YA MUUNGANO WA TANZANIA

OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

Anuani ya Simu "TAMISEMI" DODOMA
Simu Na: +255 26 2321607
Nukushi: +255 26 2322116
Barua pepe:ps@tamisemi.go.tz
Unapojibu tafadhali taja:-

Mji wa Serikali – Mtumba,
Mtaa wa TAMISEMI,
S.L.P. 1923,
41185 DODOMA.

Kumb. Na. AB/307323/01 **27 Februari, 2023**

Katibu Tawala wa Mkoa,
Ofisi ya Mkuu wa Mkoa,
S.L.P. 119,
MWANZA.

Yah: **KIBALI CHA KUFANYA UTAFITI**

Tafadhali husika na somo tajwa hapo juu.

2. Ofisi ya Rais -TAMISEMI, imepokea barua yenye Kumb.Na. SUA/ADM/R.1/972 ya tarehe 27/01/2023 kutoka Chuo Kikuu cha Kilimo Sokoine kuhusu somo tajwa.

3. Barua hiyo imeeleza kuwa Ndugu Juma Morigo John, mwanafunzi wa Shahada ya Uzamili (Ubora na Usalama wa Chakula) mwenye Namba ya Udahili MFQ/D/2021/0003 ameruhusiwa kufanya utafiti. Utafiti huo unahusu *"Assessment of handling Practices and Bacteriological Quality of Salads served in Food Service Establishments"* katika Jiji la Mwanza na Manispaa ya Ilemala kuanzia Februari hadi Mei, 2023.

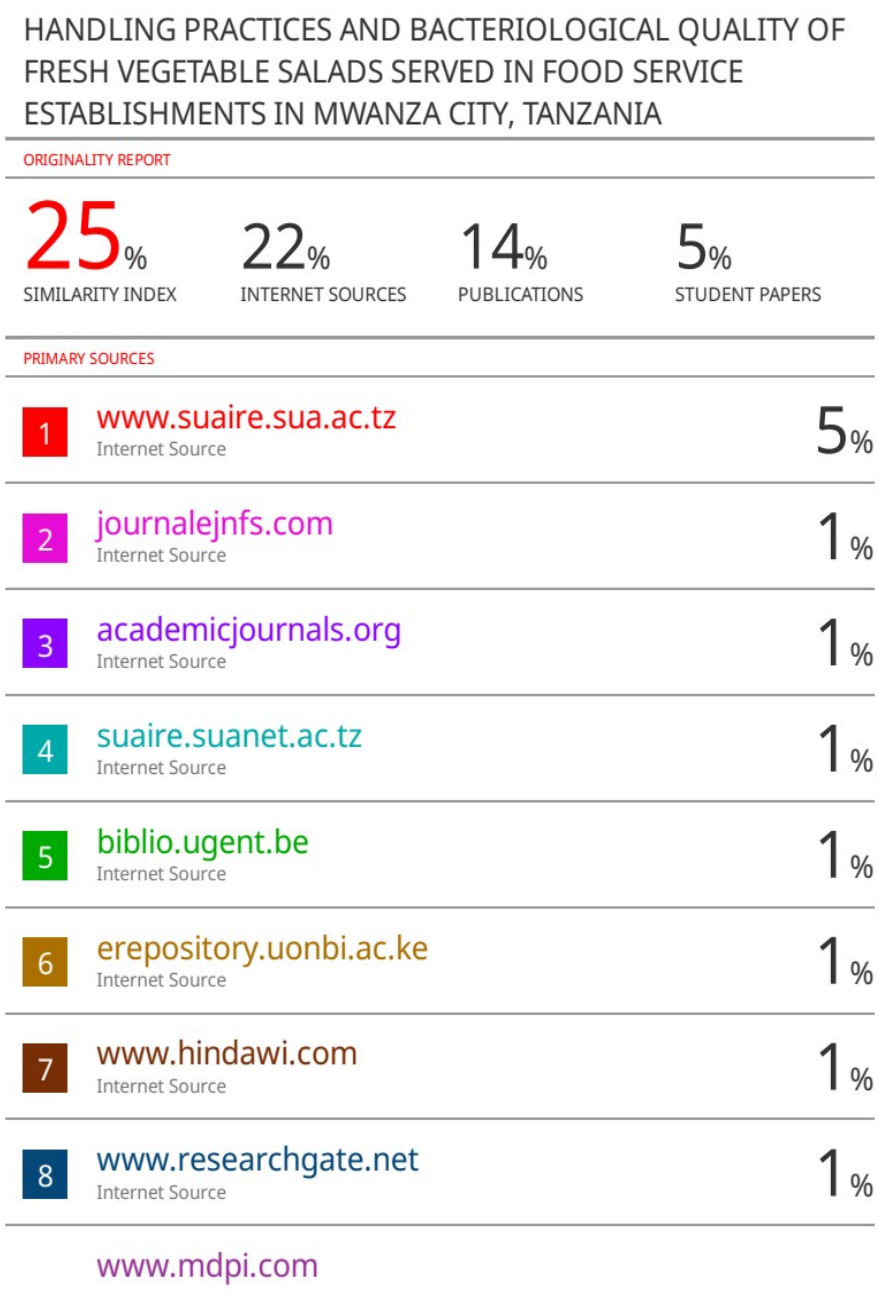
4. Kwa barua hii, tafadhali waelekeze Wakurugenzi wa Halmashauri hizo watoe ushirikiano utakaohitajika ili kufanikisha utafiti huo.

5. Ninakushukuru kwa ushirikiano wako.

Enock, EN ***ndc***
Kny: **KATIBU MKUU**

Nakala: Makamu Mkuu wa Chuo,
Chuo Kikuu cha Kilimo Sokoine,
S.L.P.3000,Chuo Kikuu,
MOROGORO.

Appendix 5: Plagiarism report



HANDLING PRACTICES AND BACTERIOLOGICAL QUALITY OF FRESH VEGETABLE SALADS SERVED IN FOOD SERVICE ESTABLISHMENTS IN MWANZA CITY, TANZANIA

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Kuhusu Tasnifu Hii

Utafiti huu unalenga kuboresha namna ya kuandaa na kuhifadhi kachumbari kwenye migahawa na mama lishe, ili kuhakikisha kuwa kachumbari inayoandaliwa ni bora na salama kwa walaji. Matokeo yanaonyesha kuwa asilimia kubwa ya waandaaji wa kachumbari hawana mafunzo rasmi ya uandaaji na uhifadhi salama wa vyakula, na hawazingatii kanuni za afya na usalama wa chakula. Aidha kachumbari haina ubora unaoridhisha, na ina viwango vya juu vya bakteria. Kwa matokeo haya kuna haja ya wizara ya afya pamoja na Shirika la Viwango nchini, kutoa mafunzo ya mara kwa mara kwa waandaaji wa vyakula, juu ya namna bora na salama ya kuaanda vyakula kwenye migahawa na mama lishe. Pia kusimamia sheria, kanuni na taratibu za usalama wa vyakula kwenye maeneo haya, ili kuboresha usalama wa vyakula. Jambo ambalo litasaidia kulinda afya ya walaji na kupunguza magonjwa kama vile homa ya matumbo na kuhara; hivyo kupunguza ghalama za matibabu.