



## Food safety and microbial risk assessment of mixed vegetable salads sold from Arua Park restaurants in Kampala city Centre. A cross-sectional study.

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### Abstract.

#### Background:

Foodborne illnesses remain a major public health concern globally and in Uganda, largely due to microbial contamination of ready-to-eat foods. This study assessed the microbial quality and associated health risks of mixed vegetable salads sold in Arua Park restaurants in Kampala City Centre.

#### Methodology:

A cross-sectional study design was employed. Twenty-seven mixed vegetable salad samples were collected from nine randomly selected canteens and analyzed for Aerobic Plate Count (APC), *Staphylococcus aureus*, and *Salmonella* spp. using standard microbiological methods. Additionally, 156 structured questionnaires were administered to consumers, and observational assessments were conducted to evaluate food handling practices. Data were analyzed using ANOVA at a 95% confidence level, while Quantitative Microbial Risk Assessment (QMRA) was performed using Monte Carlo simulation.

#### Results:

APC levels ranged from 3.1 to 4.83 log CFU/g, within acceptable limits. *Salmonella* spp. were not detected in any samples. However, *Staphylococcus aureus* counts ranged from 2.97 to 5.13 log CFU/g, with 66.67% of samples exceeding acceptable safety limits. Most canteens (77.78%) stored salads at room temperature and served them without heat treatment. The QMRA estimated a mean exposure dose of  $8.301 \times 10^6$  CFU/day and a mean probability of infection of 18.4%, indicating a considerable public health risk.

#### Conclusion:

Although general bacterial loads were within acceptable limits and *Salmonella* spp. were absent, the high prevalence of *Staphylococcus aureus* in most samples suggests poor hygiene and unsafe handling practices. This poses a significant risk of foodborne illness to consumers.

#### Recommendations:

Regular training of food handlers, strict enforcement of food safety regulations by authorities, and improved storage practices are recommended. Further studies should explore microbial risks in other foods and locations to strengthen food safety interventions in Uganda.

**Keywords:** Food safety, Microbial contamination, *Staphylococcus aureus*, *Salmonella* spp, Aerobic Plate Count (APC), Quantitative Microbial Risk Assessment (QMRA), Ready-to-eat foods, Hygiene practices, Kampala City.

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#### Background.

Food safety issues have been given much attention in recent times because of increasing food-related illnesses. Risk Analysis has been developed as a tool to help produce safe

foods in order to reduce the incidence of food-related illnesses (Collado et al., 2011). It is a useful tool that can be used to control microbial hazards in food by both the regulatory authorities and food processors to ensure that



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microbiologically safe foods are provided to unsuspecting consumers (Duffy et al., 2006). Risk assessment, one of the three components of risk analysis, employs scientific information and statistical probabilities to estimate the likelihood and severity of an adverse effect (illness or death) (Cassin et al., 1998; Duffy et al., 2006). Quantitative microbial risk assessment (QMRA) identifies microbial risks associated with the consumption of a particular food and provides estimates of the level of illness that a pathogen can cause in a given population exposed to the food concerned (Forsythe, 2002). According to Cassin et al. (1998), Quantitative Risk Assessment (QRA) can identify the contribution of each stage in the food supply chain (from production to consumption) to the risk of foodborne illnesses. This provides the benefit of ensuring that resources are purposefully directed to help minimize the risk posed by foodborne pathogens.

Food-borne illnesses, defined by WHO (2007) as infectious or toxic diseases caused by agents that enter the body through the ingestion of food, have become an important global issue. Bryan F.L. (1982) indicated that food alone is responsible for the transmission of over two hundred different diseases. Globally, millions of people are affected by foodborne and waterborne diarrheal diseases each year, and that outbreak of foodborne illnesses are responsible for 5000 and 500 deaths each year in the USA and England and Wales, respectively (Adak et al., 2002). In Uganda, it is estimated that one out of every 40 individuals suffers from foodborne illnesses, a very daunting situation that requires the collaboration of everyone to improve food safety.

Pathogenic bacteria, viruses, and parasites can contaminate vegetables at any stage from planting to consumption. The use of untreated wastewater and water supplies contaminated with sewage used for irrigation, post-harvest handling, and preparation in unhygienic environments in food services and home settings are among the commonly reported sources of vegetable contamination (Beuchat, 1996). *Staphylococcus aureus*, *Enterobacter* spp., *Salmonella typhi*, *Pseudomonas aeruginosa*, and *Shigella sonnei* are among the commonly isolated pathogens from vegetable salads (Poorna and Randhir, 2011). Microbial contamination of vegetables can have a negative effect on the product, including spoilage, decreased sensory appeal, and decreased shelf life. According to Halablab et al. (2011), outbreaks of foodborne illnesses related to vegetable consumption can be large or small, ranging from a few persons to thousands. For example, Meldrum et al. (2009) reported two large outbreaks in the United Kingdom which

were attributed to the consumption of contaminated vegetable salads. Consumption of vegetable salad away from home can significantly compound the problem of vegetable-related outbreaks of foodborne illnesses, since food handlers play a critical role in the spread of pathogens during food preparation. Green and Selman (2015) reported that, although food contamination may occur at any point from production, processing, distribution, and preparation, food handlers and other people responsible for food preparation have a critical role in the occurrence and spread of foodborne illnesses. Food workers' knowledge of microbial growth and survival in food and food service environments plays a major role in foodborne outbreak situations. Contamination can be transferred to and from workers through raw food, hands, clothing, food packages, and other environmental sources. Pathogens, for instance, can survive for extended periods of time on many surfaces, including skin. Stephen J. Forsythe and P. R. Hayes (2000) also noted from their study that cross-contamination during food preparation contributes notably to the occurrence of foodborne diseases. Therefore, because salad consumption is highly patronized in recent times, mostly outside the home, continuous training and monitoring of food workers, especially those involved in vegetable salad preparation, is needed for microbiologically safe products.

The understanding of foodborne microbes has increased tremendously in recent years, and more stringent food safety regulations are in place to ensure substantial food safety; however, several factors, including large-scale food production, adjustments in traditional methods of processing food, proliferation of heat-and-eat convenience foods, and nationwide distribution with increased potential for mishandling, still hamper the efforts to ensure pathogen-free products. High-risk foods with high moisture and nutrient value, such as vegetable salads, support the growth of pathogenic microorganisms (Wallace et al., 2016) and should be a major concern for all food handlers.

## Methodology.

### Study Setting.

This study was conducted in Arua Park Restaurants, which is found in Kampala City Centre. The area is among the highly populated areas in Kampala because of the socioeconomic activities carried out in the area, and also has a lot of foodstuffs prepared and served for city dwellers. Kampala is administered by Kampala Capital City Authority (KCCA) and is located in the central part of Uganda. The



city is dominated by different tribes, though it is inhabited by Baganda, making luganda to be a commonly spoken language. The area was chosen because of the good access to the researcher and the prevailing problem in the area.

### Sample Collection.

Mixed-vegetable salad samples were purchased from nine randomly selected canteens. Samples were taken on 3 separate occasions from each selected canteen. In all instances, each sample was placed in a labeled sterile polyethylene container, kept in an icebox (containing ice-blocks), and transported to the laboratory. A total of 27 mixed vegetable salads were collected for microbial analysis. A survey was also conducted alongside the sample collection using structured questionnaires that had both observational and responsive questions. General observations were carried out at the various canteens guided by the observational questions to evaluate the food handling practices employed by canteen workers during sales, while consumers' responses to the responsive questions were also used to establish the consumption pattern of mixed vegetable salads. A total of 200 questionnaires were distributed to consumers; however, 156 were retrieved.

### Bacteria Culture and Enumeration.

#### Media Preparation.

Salmonella-Shigella agar (SSA) (from Liofilchem diagnostici, Italy), Mannitol-salt agar (MSA), Plate Count agar (PCA), Nutrient agar, Selenite Cystine broth (SCB), and Buffered Peptone water (BPW), all from Oxoid Ltd, England, were prepared according to the manufacturer's instructions, and sterilized by autoclaving at 121 °C for 15 min. Salmonella-Shigella agar and Selenite Cystine broth, which did not require autoclaving, were sterilized by boiling for 15 min according to the manufacturer's instructions.

#### Aerobic plate count (APC).

Aerobic plate count (APC) was performed by the pour plate method (American Public Health Association, 2001) using plate count agar (PCA). A stock solution of  $10^{-1}$  dilution was prepared by homogenizing 1 g of the sample in 9 ml of physiological saline. Serial dilutions of  $10^{-1}$  to  $10^{-4}$  were prepared by tenfold dilution of each preceding dilution. A 1 ml aliquot from each dilution was poured onto the centre of Petri dishes, and sterile molten PCA was poured into the Petri dishes already containing the samples. The culture and the medium were mixed thoroughly by gently moving the

plates, and the plates were allowed to solidify and incubated at 370 °C for 24 hours in an inverted position. After 24-hour incubation, colonies on PCA were counted and recorded in CFU/g of salad samples using the colony counter.

### Enumeration and Isolation of *Staphylococcus aureus*

*Staphylococcus aureus* was enumerated and isolated by the pour plate method (American Public Health Association, 2001) using Mannitol-salt agar (MSA). The same serial dilutions and pour plate procedure used for APC were used for *Staphylococcus aureus*, using MSA in place of PCA. After 24-hour incubation at 370 °C, golden yellow colonies were counted and recorded as presumptive *Staphylococcus* spp. in CFU/g using the colony counter. Presumptive *Staphylococcus* spp. colonies on MSA were subcultured onto freshly prepared nutrient agar plates and confirmed by Gram's staining and coagulase test using rabbit plasma. Colonies on mannitol salt agar that were Gram-positive and coagulase-positive were taken as *Staphylococcus aureus*.

### Enumeration and isolation of *Salmonella* spp.

*Salmonella* spp. detection was carried out according to the ISO-6579 method (International Standards Organization, 2002) using buffered peptone water as pre-enrichment medium, selenite cystine broth (SCB) as selective enrichment medium, and Salmonella-Shigella agar (SSA) for selective plating. For enumeration, 1g sample was thoroughly mixed in 9 ml buffered peptone water and serial dilutions of  $10^{-1}$  to  $10^{-4}$  were prepared and spread on SSA, followed by 24-hour incubation at 370 °C. For *Salmonella* spp. isolation, serial dilutions of  $10^{-1}$  to  $10^{-4}$  were incubated at 370 °C for 24 hours, and a 0.1 ml aliquot of serial dilutions was inoculated onto 9 ml selenite cystine broth (SCB) followed by 48 hours incubation at 440 °C. After the 48 hours of incubation, another 0.1 ml of the selective enrichment cultures was streaked on the surface of already prepared sterile Salmonella-Shigella agar (SSA) and incubated immediately. The plates were incubated at 370 °C for 48 hours for *Salmonella* spp. isolation. Black colonies on SSA are typical colonies of *Salmonella* spp.

### Microbial Risk Assessment

For the microbial risk assessment, the focus of this study on the chain of vegetable salad production was the post salad preparation in various canteens to the point of consumption.



### Hazard Identification.

For the purpose of the risk assessment, *S. aureus* and *Salmonella* spp. were chosen as the model quantitative microbial risk assessment (QMRA) organisms. *S. aureus* is associated with staphylococcal food poisoning, which causes self-limiting, acutely intense illness in most people, while *Salmonella* serotypes *S. typhi* and *S. paratyphi* A are associated with typhoid fever (FDA, 2012). Their presence in food has been linked to cross-contamination and poor handling practices during food preparation (Gorman *et al.*, 2002; Dharod, 2007). Several studies have reported on outbreaks of foodborne illnesses related to vegetables and vegetable salads (Meldrum *et al.*, 2009) as well as *S. aureus* and *Salmonella* spp. associated with these products (Ameko *et al.*, 2012; Fung *et al.*, 2011). This research focused on the risk of infection associated with the consumption of already prepared mixed vegetable salads sold in the test canteens.

### Data analysis.

Data was analyzed by ANOVA appropriate to each experiment using Graph Pad Prism 5 software version 5.01 (2007), and any statistical significance of difference between means was tested at 95% confidence level ( $P < 0.05$ ). Monte Carlo simulation of the models was carried out using Microsoft Excel @ risk software version 6.2.0.0 (Palisade Corporation).

## RESULTS

### Microbial Load of the Mixed Vegetable Salads.

The levels of microorganisms used for the microbiological risk assessment of mixed vegetable salads of all analyzed samples are presented in Table 1. Mean values of log CFU/g  $\pm$  SD were used.

**Table 1: Loads of total bacteria, Aerobic Plate Count (APC), *S. aureus*, and *Salmonella* spp. of the mixed vegetable salad samples from the selected canteens.**

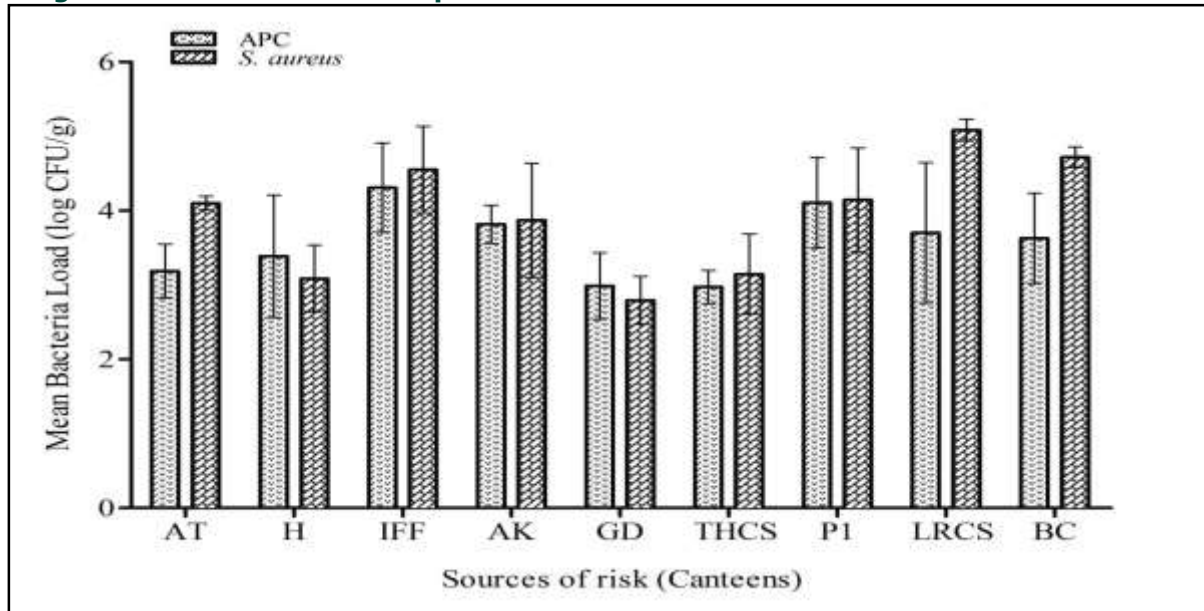
Code of the canteen	Load (log CFU/g)		
	APC <sup>a</sup>	<i>S. aureus</i> <sup>b</sup>	<i>Salmonella</i> spp. <sup>c</sup>
AT	3.41 $\pm$ 0.68	4.12 $\pm$ 0.16	ND
H	4.48 $\pm$ 1.96	3.38 $\pm$ 0.74	ND
IFF	4.77 $\pm$ 1.19	4.96 $\pm$ 1.12	ND
AK	3.98 $\pm$ 0.49	4.92 $\pm$ 1.85	ND
GD	3.28 $\pm$ 0.85	2.97 $\pm$ 0.60	ND
THCS	3.10 $\pm$ 0.42	3.60 $\pm$ 1.01	ND
PI	4.83 $\pm$ 1.38	4.90 $\pm$ 2.11	ND
LRCS	4.81 $\pm$ 2.08	5.13 $\pm$ 0.26	ND
BC	4.09 $\pm$ 1.19	4.77 $\pm$ 0.25	ND

ND = not detected, [<sup>a</sup>acceptable:  $10^6$  to  $< 10^7$  CFU/g (6 to  $< 7$  log CFU/g), <sup>b</sup>Unacceptable:  $\geq 10^4$  CFU/g ( $\geq 4$  log CFU/g), <sup>c</sup>Unacceptable: Detected in 25 g (PHLS, 2000); <sup>a</sup>acceptable:  $< 10^5$  CFU/g ( $< 5$  log CFU/g), <sup>b</sup>acceptable:  $< 10^4$  CFU/g ( $< 4$  log CFU/g) (GSB, 2003)]

From Table 1, *Salmonella* spp. was not detected in the mixed vegetable salads from any of the sources of risk (canteens). APC and *S. aureus* counts, however, varied among the risk sources. Mean APC and *S. aureus* counts ranged from 3.1 log CFU/g to 4.83 log CFU/g and 2.97 log CFU/g to 5.13

log CFU/g, respectively. The highest mean APC of 4.83 log CFU/g was recorded for canteen P1, and the lowest value of 3.1 log CFU/g for canteen THCS. The highest *S. aureus* count of 5.13 log CFU/g and the lowest value of 2.97 log CFU/g were recorded for canteens LRCS and GD, respectively. The differences in the mean total bacteria counts (APC) and *S. aureus* counts recorded for the mixed vegetable salads collected from the respective canteens were statistically insignificant ( $P > 0.05$ ).

Figure 1 shows the relationship between APC and *S. aureus* count from the test canteens.



**Fig. 1: APC and *S. aureus* loads in salad samples from the test canteens.**

From the Figure, apart from points H and GD, the mean *S. aureus* count from all other canteens was slightly higher than APC.

**Post-processing handling practices.**

Post salad processing handling details were determined by a structured questionnaire with both observational and responsive questions. The results are presented below. Salad details and post preparation practices employed by canteen operators, as determined by the questionnaire, are presented in Table 2. The results show that all (100%) of the canteens included in the study served mixed vegetable salad, and the majority of the canteens served salad with salad

dressing (88.89%). All the samples did not have the same composition, but were predominantly made of a mixture of cabbage (*Brassica oleracea* L.), lettuce (*Lactuca sativa* L.), cucumber (*Cucumis sativus* L.), carrots (*Daucus carota* L.), and spring onion (*Allium fistulosum* L.) in various proportions and combinations. The majority of the salads served in the various canteens were not heat-treated (77.78%) and stored at room temperature (77.78%) when serving to consumers. Samples from only two locations (22.22%), LRCS and P1 (all in UEW-K), were partially cooked, while all samples were dressed with salad cream or mayonnaise except one location (P1 in UEW-K). Most canteen operators also used containers with a cover and serving utensil dedicated for that purpose (77.78% and 66.67% respectively).



**Table 2: Post salad processing details**

Parameter	Distribution of Respondents (Consumers)		Frequency (n=9)	Percentage (%)
<b>Type of Salad</b>				
Lettuce only	0	0	0	<b>0</b>
Cabbage only	0	0	0	<b>0</b>
Cucumber only	0	0	0	<b>0</b>
Mixed vegetables	6	3	9	<b>100</b>
<b>State of salad served</b>				
Partially cooked	0	2	2	<b>22.22</b>
Not cooked	6	1	7	<b>77.78</b>
<b>Storage condition for service</b>				
Room temperature	5	2	7	<b>77.78</b>
Refrigerator	0	0	0	<b>0</b>
Not sure	1	1	2	<b>22.22</b>
<b>State of the storage container</b>				
Covered	5	2	7	<b>77.78</b>
Not covered	0	0	0	<b>0</b>
Not sure	1	1	2	<b>22.22</b>
<b>Salad dressing</b>				
Served with dressing	6	2	8	<b>88.89</b>
Served without dressing	0	1	1	<b>11.11</b>
<b>Utensil for serving</b>				
Designated utensil	5	1	6	<b>66.67</b>
Shared utensil	0	0	0	<b>0</b>
Gloves protected hands	0	0	0	<b>0</b>
Bare hands	0	1	1	<b>11.11</b>
Not sure	1	1	2	<b>22</b>

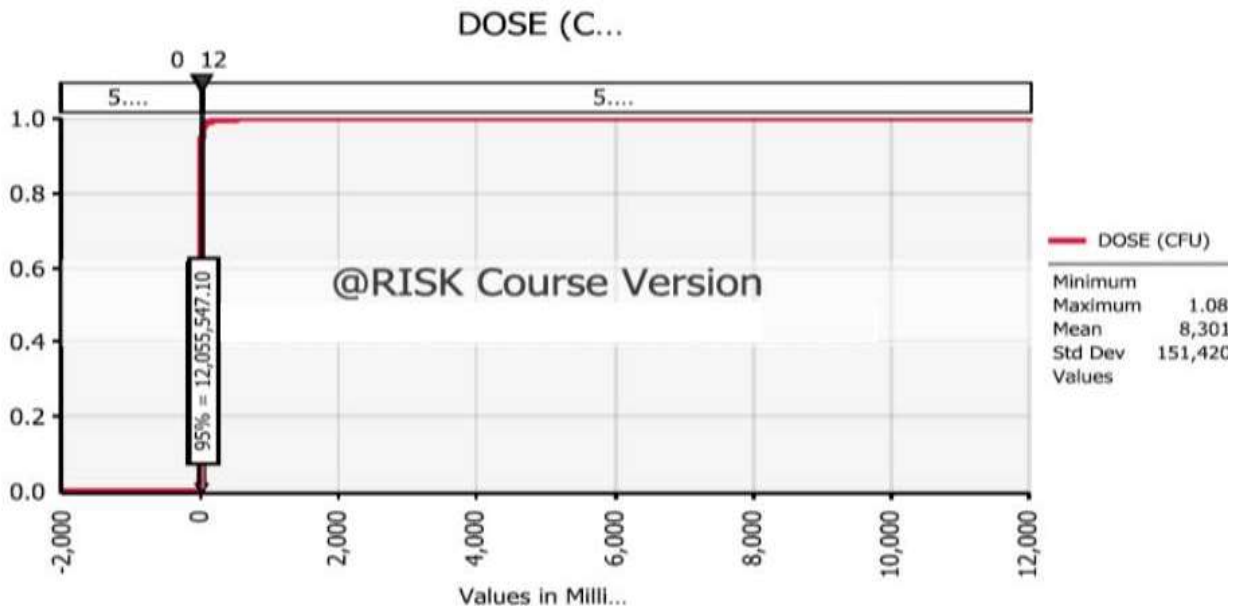
### Microbial Risk of Ready-To-Eat Mixed Vegetable Salads to Consumers.

Based on the outcome of the microbial count and the estimated quantity of salad consumed per person per day, a Monte Carlo simulation of *S. aureus* using the exponential model ( $r = 7.64 \times 10^{-8}$ ) was run for 10,000 iterations. Risk assessment for three exposure scenarios (frequent consumers, average consumers, and occasional consumers) determined by the salad consumption profile was simulated.

### Exposure Assessment and Hazard Characterization (Dose Response Assessment)

Figure 2 shows the dose of *S. aureus* consumed per person per day after a Monte Carlo simulation of 10,000 iterations. From the Figure, the mean dose of  $8.301 \times 10^6$  CFU (90% CI:  $0.00 \times 10^6$  CFU –  $1.20 \times 10^7$  CFU) was obtained after the simulation. Minimum and maximum doses of  $8.54 \times 10^2$  CFU and  $1.083 \times 10^{10}$  CFU, respectively, were also recorded. The result indicates that an average dose of  $8.301 \times 10^6$  CFU may be ingested from the consumption of mixed vegetable salad from the test canteens, with a 95 % probability that the dose of *S. aureus* that may be ingested will exceed  $0.00 \times 10^6$  but will, however, not exceed  $1.20 \times 10^7$  CFU.

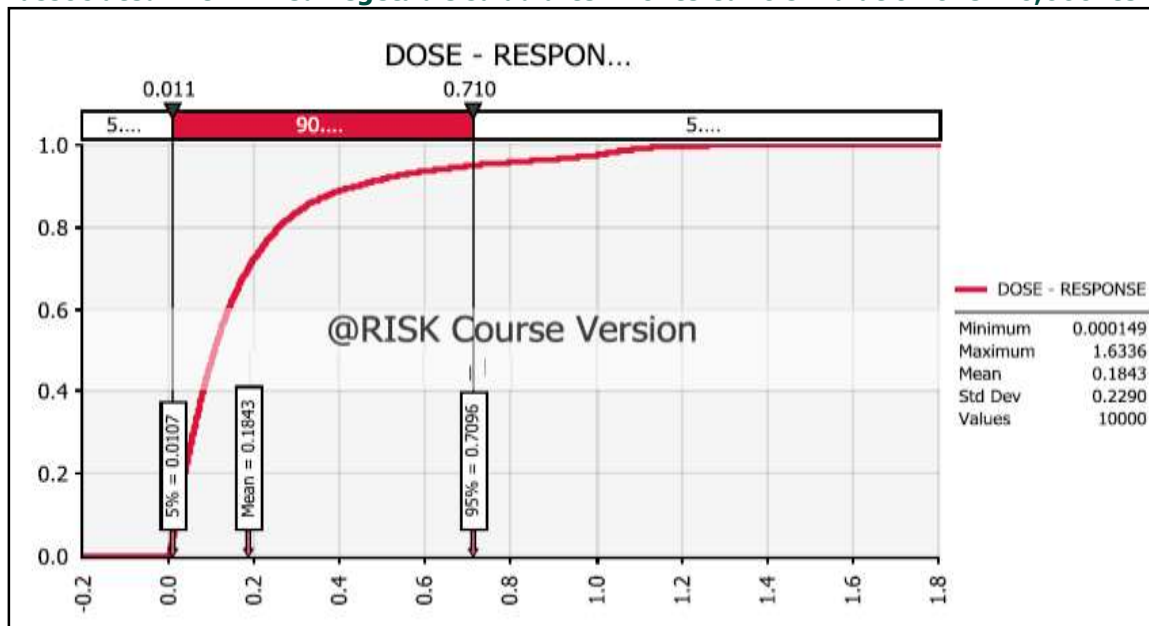
**Fig. 2: Cumulative ascending distribution of the dose of *S. aureus* consumed per person per day after Monte Carlo simulation over 10,000 iterations.**



The dose response assessment (hazard characterization) resulting from ingestion of mixed vegetable salad from the test canteens after Monte Carlo simulation is shown in Figure 4. Figure 4 indicates a mean probability of infection of  $1.84 \times 10^{-1}$  (90% CI:  $1.10 \times 10^{-2} - 7.10 \times 10^{-1}$ ) with minimum and maximum values being  $1.50 \times 10^{-4}$  and  $16.3 \times$

$10^{-1}$  respectively. This indicates that the average probability of *S. aureus* infection to consumers of mixed vegetable salad from the test canteens is most likely 18.4% with a 95 % probability that the probability of infection will exceed 1.1% but will, however, not exceed 71.0%.

**Fig. 3: Cumulative ascending distribution of the dose-response assessment of *S. aureus* associated with mixed vegetable salad after Monte Carlo simulation over 10,000 iterations.**



### Discussion of the findings.

Consumption of ready-to-eat mixed vegetable salads is greatly patronized, especially by the majority of city dwellers in Kampala. One of the main reasons for such a high patronage of the product is the well-reported nutritional and health benefits; however, it is also well-reported that fresh-cut vegetables, the main ingredients of mixed vegetable salads, are potential vehicles for the transmission of pathogenic foodborne microbes (Beuchat, 1996). From this study, all the samples examined from the various canteens were contaminated with total aerobic mesophiles (APC) and *S. aureus*.

From the results, APCs of 3.1 log CFU/g to 4.83 log CFU/g were recorded. APC of samples from all the test canteens were within the standard requirements of the UK Public Health Laboratory Services (6 to < 7 log CFU/g) (PHLS, 2000). APC for various salad ingredients has been reported by some researchers. Abdullahi and Abdulkareem (2010) observed average APC of  $2.3 \times 10^8$  CFU/g (8.36 log CFU/g) for cabbage,  $2.5 \times 10^8$  CFU/g (8.40 log CFU/g) for lettuce, and  $1.1 \times 10^6$  CFU/g (6.04 log CFU/g) for cucumber. Aboh *et al.* (2011) also reported APC ranging from  $1.6 \times 10^6$  CFU/g (6.2 log CFU/g) to  $2.9 \times 10^8$  CFU/g (8.46 log CFU/g)

for salad vegetables. In a related study in Accra (Mensah *et al.*, 2002) and Kumasi (Feglo and Sakyi, 2012), mean APC of 6.3 log CFU/g and 5.13 log CFU/g, respectively, were recorded in salad samples.

The APC results of this work generally appear relatively lower than most of the research findings, as well as the standard values of < 5 log CFU/g (GSB, 2003) and 6 to < 7 log CFU/g (PHLS, 2000). High APC may indicate poor handling, inappropriate processing, or a general lack of hygiene, indicating that the canteen operators involved in this study probably employed some level of proper handling and hygienic practices. APC determination may, however, include species that inhibit the growth of other pathogenic bacteria strains in a mixed population, such as *S. aureus*, and may even include strains like *Salmonella* and *Listeria*, which are considered unacceptable when detected in food samples. Moreover, bacteria have the potential to grow when provided with the right conditions over time; therefore, although the levels of APC as determined by this research are within an acceptable limit and are far lower than the results of similar research, canteen operators should still be encouraged to employ proper handling and hygienic practices during vegetable salad processing. This is



especially necessary considering the fact that the salads were kept at room temperature for an extended period of time during sales.

*S. aureus* is a pathogen known to be carried by food handlers (Beuchat, 1998). The presence of *S. aureus* in mixed fresh-cut vegetables indicates poor hygienic practices, and levels higher than 4 log CFU/g are potentially hazardous. From this study, *S. aureus* count ranged from 2.97 log CFU/g to 5.13 log CFU/g. Samples from canteens, H, GD and THCS were within the standard values of  $<10^4$  CFU/g ( $< 4$  log CFU/g) of both the Ghana Standards Board (GSB, 2003) and the United Kingdom Public Health Laboratory Services (PHLS, 2000) while samples from the remaining six points (AT, IFF, AK, LRCS, P1 and BC) were all above the standard values (Table 1). Various researchers have reported the isolation of *S. aureus* from vegetables and vegetable salads. Beuchat (1998) reported a mean *S. aureus* count of  $5.4 \times 10^2$  CFU/g (2.7 log CFU/g) in salad from parts of Accra. Gitahi *et al.* (2012) also recorded *S. aureus* counts of 3.13 log CFU/g to 4.69 log CFU/g in street food vegetables from five locations in the industrial area of Nairobi city. In a similar work in India, Sabbithi *et al.* (2014) reported *S. aureus* counts of 2.0 log CFU/g – 5.2 log CFU/g and 2.0 log CFU/g – 5.0 log CFU/g in carrot and onion, respectively. The *S. aureus* counts recorded in the current study are contrary to the findings of Myhara *et al.* (2003), which are within the acceptable standard of  $<4$  log CFU/g but are close to what was observed by Gitahi *et al.* (2012) and Sabbithi *et al.* (2014), where some of the findings are beyond the acceptable standard.

The high levels of *S. aureus* in most canteens (66.67%) indicate poor handling practices during and/or after salad preparation. The common sources of *S. aureus* food contamination are the nose, throat, skin, and hair of healthy humans and animals, as well as feathers of birds, where they occur naturally (Tatini, 1973; Smith *et al.*, 1983; Garvani, 1987). Food handlers are the main agents of transmission of *S. aureus* into food. According to Loir *et al.* (2003), improper handling of food by contaminated hands or other improper food handling practices, such as coughing or sneezing during food preparation, usually after heat treatment of the food, contribute significantly to *S. aureus* contamination of food. FDA (2012) also indicated that, unless heat processes are applied, staphylococci are expected to exist in any and all foods that are handled directly by humans or are of animal origin. Therefore, the high levels of *S. aureus* identified in samples from most of the test canteens (66.67%) suggest time and temperature

abuse of the product by most canteen operators and a lack of proper handling practices during sales.

*S. aureus* species are mainly involved in staphylococcal food intoxication cases (Khambaty *et al.*, 1994). According to the FDA (2012), the intoxication dose of staphylococcal enterotoxins (SE) is less than 1.0 $\mu$ g which can be produced when *S. aureus* populations exceed 100,000 organisms/g in food. From the results, the mean *S. aureus* count of  $1.35 \times 10^5$  CFU/g (5.13 log CFU/g) was recorded in the samples from canteen LRCS, which exceeds the minimum population of 100,000 CFU/g required to cause staphylococcal intoxication. The mean *S. aureus* count for canteens AT, IFF, AK, P1, and BC were:  $1.31 \times 10^4$  CFU/g (4.12 log CFU/g),  $9.17 \times 10^4$  CFU/g (4.96 log CFU/g),  $8.23 \times 10^4$  CFU/g (4.92 log CFU/g),  $7.87 \times 10^4$  CFU/g (4.90 log CFU/g), and  $5.85 \times 10^4$  CFU/g (4.77 log CFU/g) respectively. All these values exceed 10,000 CFU/g, the minimum bacteria population (10,000-20,000 CFU/g) required to produce 100 to 200 ng of enterotoxin, which can cause illness in delicate individuals (FDA, 2012). FDA (2012) also pointed out that the population of *S. aureus* at the time of analysis may be significantly different, and not representative of the highest population that occurred in the product, which in fact should be considered when examining foods. Thus, while consumption of mixed vegetable salads from canteen LRCS might present a serious microbiological risk that needs urgent intervention to avoid any outbreak with respect to *S. aureus*, canteens AT, IFF, AK, P1, and BC equally have the potential to cause outbreaks and require similar attention as point LRCS.

The results from this study also reveal that the mean *S. aureus* count from the majority of the canteens (H and GD excluded) was slightly higher than APC. For the canteens with *S. aureus* count slightly higher than APC, apart from point THCS, all the other points had *S. aureus* population highly likely to cause infection. This confirms that poor handling practices were employed during and/or after salad preparation in the majority of the canteens. In addition, according to Medved'ová and Valík (2012), staphylococci compete poorly with indigenous bacteria and are inhibited by the antagonistic activities of other organisms. They, therefore, recommended that the presence of *S. aureus* in foods must be considered in relation to the amount and types of the accompanying flora. This suggests that the APC of salad samples from the majority of the canteens possibly included species that interfered with *S. aureus* growth, along with other accompanying flora; however, on a selective media all other microbes were excluded, making it possible



for all viable organisms to grow. Moreover, correlation analysis of the data suggests a positive linear correlation between APC and *S. aureus* count ( $r_s = 0.6500$ ), but there was not enough evidence at 5% level of significance to conclude that there was a significant linear correlation between them. This suggests that all the quantity of *S. aureus* that were detected on the selective plates in the samples were not necessarily viable on the PCA to add up to the values of the APC.

*Salmonella* spp. is widely dispersed in nature. Poultry and other meat products, eggs and dairy products, are the most commonly implicated sources of outbreaks involving *Salmonella* (D'Aoust 2000; Olsen *et al.*, 2000); however, fresh produce has also been implicated as the source of major outbreaks, particularly in recent times (Mensah *et al.*, 2001; Fung *et al.*, 2011). From the results, *Salmonella* spp. was not detected in the samples from any of the canteens. According to PHLS (2000), the presence of *Salmonella* spp. in any quantity represents a high risk. In related studies in Accra and Lomé, Myhara *et al.* (2003) and Adjrah *et al.* (2013), respectively, did not detect *Salmonella* spp. in any of the salad samples evaluated, similar to the findings of this study. Other research carried out on salad and salad vegetables in Uganda (Wanyenya *et al.*, 2004) and Iran (Uzeh *et al.*, 2009) also recorded no *Salmonella* spp. in any of the samples analyzed. In this study, the salad samples from all the canteens met the standard requirement of no *Salmonella* in 25 g of food samples, and were comparable to the findings of some previous works. *Salmonella* originates from the gastrointestinal tract of man and animals, and their presence in food products therefore indicates faecal contamination and cross-contamination during preparation. Their absence, as determined by this research, suggests that the canteen operators used practices that eliminated or minimized cross-contamination of salad ingredients and finished product with meat and other products likely to be infested with *Salmonella* spp. It also suggests that the sources of salad ingredients were free of faecal contamination.

The results from the survey conducted for the test canteens show that mixed vegetable salads were served in all the canteens included in the study, while the majority (88.89%) served salad with salad dressing. This finding agrees with the works of Ameko *et al.* (2012), among street food vendors in Accra and Kumasi, respectively. Both studies identified that the salad served was composed of various kinds of vegetables, including lettuce, cabbage, tomato, onion, and carrot. While consumers may patronize mixed vegetable

salads due to the perceived nutritional benefits (James and Ngarmak, 2011), canteen operators are encouraged to serve the product to attract more customers and thus increase profit.

From the study, most canteen operators used containers with a cover (77.78%) and serving utensils dedicated for serving only salad (66.67%); however, the majority of the salad served in the various canteens was not heat-treated and stored at room temperature when serving to consumers (indicated by 77.78% in each case). This suggests that while most canteen operators may be well-intended and more concerned about the safety and well-being of consumers, they knowingly or unknowingly ignore measures that can prevent microbial multiplication in food products during sales. This finding agrees with the results of Akonor and Akonor (2013), who indicated that most domestic food handlers were more knowledgeable in the areas of food safety concerns, general and personal hygiene, and handling leftover food than they were in cross-contamination and the dynamics of pathogens in causing food-borne diseases. The findings of Ababio and Adi (2012) also indicated that most food handlers in the Kumasi Metropolis lacked adequate knowledge about foodborne diseases and failed to apply control measures. Perishable foods like vegetable salads can promote microbial growth when provided with the right temperature and other conditions. It is very important, therefore, that regulatory agencies such as the Food and Drug Authority (FDA) and metropolitan assemblies pay close attention to microbiological food safety control systems employed by canteen operators and other food vendors to ensure adequate food safety to consumers.

The microbiological risk of ready-to-eat mixed vegetable salads to consumers was evaluated using *S. aureus* and *Salmonella* spp. From the bacteriological analysis, *S. aureus* was determined in salad samples from all the canteens at levels likely to cause infection in the majority (66.67%) of the canteens, while *Salmonella* spp. was not detected in any of the samples.

The mean dose of *S. aureus* consumed per person per day from consumption of mixed vegetable salad was above the minimum population of 100,000 CFU required to cause infection (FDA, 2012). The exposure assessment indicated a mean dose of  $8.301 \times 10^6$  CFU per person per day for the three exposure scenarios. With 90% of the doses between  $0.00 \times 10^6$  CFU and  $1.20 \times 10^7$  CFU, there is the possibility of high risk of *S. aureus* infection from consumption of mixed vegetable salads from the canteens. The mean probability of consumers being infected with *S. aureus* was



$1.84 \times 10^{-1}$  and this represents 18.4% chances of an individual being infected with *S. aureus* from the consumption of vegetable salads. In 90% of the cases, the chances of consumers being infected with *S. aureus* from the consumption of vegetable salads were between 1.1% and 71.0% (90% CI:  $1.10 \times 10^{-2} - 7.10 \times 10^{-1}$ ). It may be argued that the mean probability of infection of  $1.84 \times 10^{-1}$  appears quite low (<20%); however, according to Haas *et al.* (1993), a single pathogen ingested can multiply to cause infection, therefore, the seemingly low probability of infection does not necessarily indicate low risk.

### Conclusion.

The aerobic plate count (APC) of mixed vegetable salads analyzed from the sources of risk (test canteens) ranged between 3.1 log CFU/g to 4.83 log CFU/g, which were all within both the Ghana Standard Board (GSB) and the UK Public Health Laboratory Services (PHLS) acceptable references of < 5.0 log CFU/g and 6 to < 7 log CFU/g, respectively. *Salmonella* spp. was not detected in salad samples from any of the test canteens in compliance with both GSB and PHLS standard requirements; however, *S. aureus* was isolated at levels ranging between 2.97 log CFU/g and 5.13 log CFU/g. The levels of *S. aureus* are higher than both the GSB and PHLS acceptable standards of < 4 log CFU/g in the majority (66.67%) of the test canteens, making the mixed vegetable salads sold in the majority of the canteens in Arua Park and their environs a potential source of food poisoning to consumers. From the study, the majority (77.78%) of canteen operators stored salad at room temperature during sales. Storage conditions of mixed vegetable salads during sales and the frequency of consumption, respectively, represent the post-processing handling practices that contribute significantly to the microbiological quality of mixed vegetable salads from canteens in and around Arua Park in Kampala Capital City and the risk of *S. aureus* infection. This represents a potentially high risk of *S. aureus* infection from the consumption of mixed vegetable salads sold in canteens located in and around Arua Park, with most frequent consumers being at higher risk than occasional consumers.

### Recommendations.

It is recommended that further research be conducted in other parts of Kampala and Uganda at large using other pathogens, other types of foods, and other food service establishments to establish a comprehensive profile of microbial risk and/or safety of various food products.

The relevant authorities, such as Kampala Capital City Authority, should also assess these food vendors and offer them some kind of training in order to empower them with recommended handling practices, among others.

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### List of abbreviations.

APC – Aerobic Plate Count  
ANOVA – Analysis of Variance  
BPW – Buffered Peptone Water  
CFU – Colony Forming Units  
CI – Confidence Interval  
FDA – Food and Drug Administration  
GSB – Ghana Standards Board  
ISO – International Organization for Standardization  
KCCA – Kampala Capital City Authority  
MSA – Mannitol Salt Agar  
ND – Not Detected  
PCA – Plate Count Agar  
PHLS – Public Health Laboratory Service  
QMRA – Quantitative Microbial Risk Assessment  
QRA – Quantitative Risk Assessment  
SCB – Selenite Cystine Broth  
SSA – Salmonella-Shigella Agar  
SD – Standard Deviation  
WHO – World Health Organization

### Informed Consent:

Written informed consent was obtained from all participants prior to their inclusion in the study. Participants were



informed about the purpose of the study, procedures involved, potential risks and benefits, and their right to withdraw at any time without penalty.

#### **Source of funding.**

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#### **Conflict of interest.**

There is no conflict of interest.

#### **Availability of data.**

Data used in this study are available upon request from the corresponding author.

#### **Authors contribution.**

JBO designed the study, conducted data collection, cleaned and analyzed data, and drafted the manuscript.

VS supervised all stages of the study from conceptualization of the topic to manuscript writing and submission.

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#### **References.**

1. Ababio, P. F., & Adi, D. D. (2012). Evaluating food safety compliance among food handlers in Kumasi, Ghana. *Food Control*, 26(2), 574-579. <https://doi.org/10.1016/j.foodcont.2012.02.015>
2. Abdullahi, I. O., & Abdulkareem, S. (2010). Bacteriological quality of some fresh vegetables sold in Ilorin metropolis, Nigeria. *Journal of Applied Sciences and Environmental Management*, 14(2), 29-32.
3. Adak, G. K., Long, S. M., & O'Brien, S. J. (2002). Trends in indigenous foodborne disease and deaths, England and Wales. *Gut*, 51(6), 832-841. <https://doi.org/10.1136/gut.51.6.832>
4. Adjrah, Y., et al. (2013). Socio-economic profile and microbiological quality of ready-to-eat salads in Lomé. *African Journal of Food Science*, 7(10), 310-315.
5. Ameko, E., Achio, S., Alhassan, S., & Kassim, A. (2012). Microbial safety of raw mixed vegetable salads sold in Accra, Ghana. *Research Journal of Microbiology*, 7(2), 130-138.
6. Akonor, P. T., & Akonor, M. A. (2013). Food safety knowledge: The case of domestic food handlers in Ghana. *Food Science and Quality Management*, 22, 49-54.
7. American Public Health Association (APHA). (2001). *Compendium of Methods for the Microbiological Examination of Foods* (4th ed.). Washington, DC: APHA.
8. Aboh, M. I., et al. (2011). Microbiological quality of some vegetables sold in markets in Nigeria. *African Journal of Food Science*, 5(2), 94-98.
9. Beuchat, L. R. (1996). Pathogenic microorganisms associated with fresh produce. *Journal of Food Protection*, 59(2), 204-216. <https://doi.org/10.4315/0362-028X-59.2.204>
10. Beuchat, L. R. (1998). Surface decontamination of fruits and vegetables eaten raw: A review. *World Health Organization Bulletin*, 76(1), 37-45.
11. Bryan, F. L. (1982). Diseases transmitted by food. Centers for Disease Control, Atlanta.
12. Cassin, M. H., Lammerding, A. M., Todd, E. C. D., Ross, W., & McColl, R. S. (1998). Quantitative risk assessment for *Escherichia coli* O157:H7 in ground beef hamburgers. *International Journal of Food Microbiology*, 41(1), 21-44. [https://doi.org/10.1016/S0168-1605\(98\)00028-2](https://doi.org/10.1016/S0168-1605(98)00028-2)
13. Collado, M. C., et al. (2011). Food safety and risk analysis in modern food production. *Food Research International*, 44(7), 1787-1792.
14. D'Aoust, J. Y. (2000). Salmonella. In B. M. Lund, T. C. Baird-Parker & G. W. Gould (Eds.), *The Microbiological Safety and Quality of Food* (Vol. 2, pp. 1233-1299). Gaithersburg: Aspen Publishers.
15. Dharod, J. M. (2007). Food handling practices and food safety knowledge among food handlers. *Journal of Food Safety*, 27(2), 150-165.
16. Duffy, G., Cummins, E., Nally, P., O'Brien, S., & Butler, F. (2006). A review of quantitative microbial risk assessment in the management of



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- food safety. *International Journal of Food Microbiology*, 112(3), 165-178.
17. Feglo, P., & Sakyi, K. (2012). Bacterial contamination of street vending food in Kumasi, Ghana. *Journal of Medical and Biomedical Sciences*, 1(1), 1-8.
  18. Forsythe, S. J. (2002). *Microbiology of Safe Food*. Oxford: Blackwell Science.
  19. Fung, F., Wang, H. S., & Menon, S. (2011). Food safety in the 21st century. *Biomedical Journal*, 34(5), 325-331.
  20. Garvani, M. (1987). Microbiology of foodborne pathogens. *Food Microbiology Journal*, 4(3), 123-130.
  21. Gitahi, M. G., et al. (2012). Microbial contamination of street foods in Nairobi. *East African Medical Journal*, 89(7), 230-234. <https://doi.org/10.3923/jm.2012.297.308>
  22. Green, L. R., & Selman, C. (2015). Factors impacting food workers' and managers' safe food preparation practices. *Food Protection Trends*, 35(4), 283-292.
  23. Halablab, M. A., Sheet, I. H., & Holail, H. M. (2011). Microbiological quality of raw vegetables. *Food Control*, 22(5), 800-803.
  24. Haas, C. N., Rose, J. B., & Gerba, C. P. (1993). *Quantitative Microbial Risk Assessment*. New York: Wiley.
  25. International Organization for Standardization (ISO). (2002). ISO 6579: Microbiology of food and animal feeding stuffs - Horizontal method for the detection of *Salmonella* spp. Geneva: ISO.
  26. James, J. B., & Ngarmasak, T. (2011). Processing of fresh-cut vegetables. *Journal of Food Science*, 76(4), R75-R81.
  27. Khambaty, F. M., et al. (1994). Staphylococcal food poisoning. *Clinical Microbiology Reviews*, 7(2), 173-183.
  28. Loir, Y. L., Baron, F., & Gautier, M. (2003). Staphylococcus aureus and food poisoning. *Genetics and Molecular Research*, 2(1), 63-76.
  29. Medved'ová, A., & Valík, E. (2012). Staphylococcus aureus: Growth and toxin production. *Food Microbiology*, 30(1), 1-10.
  30. Meldrum, R. J., et al. (2009). Outbreaks associated with fresh produce. *Epidemiology and Infection*, 137(3), 307-315. <https://doi.org/10.1017/S0950268808001969>
  31. Mensah, P., et al. (2001). Street foods in Accra, Ghana: How safe are they? *Bulletin of the World Health Organization*, 80(7), 546-554.
  32. Mensah, P., et al. (2002). Microbiological quality of street foods in Ghana. *Food Control*, 13(6-7), 389-394.
  33. Myhara, R. M., et al. (2003). Microbiological quality of ready-to-eat salads. *Food Control*, 14(6), 409-414.
  34. Olsen, S. J., et al. (2000). Trends in Salmonella infections. *Emerging Infectious Diseases*, 6(4), 1-7.
  35. Poorna, C., & Randhir, S. (2011). Microbial contamination of vegetables. *Journal of Food Safety*, 31(1), 27-34.
  36. Public Health Laboratory Service (PHLS). (2000). *Guidelines for the microbiological quality of ready-to-eat foods*. London: PHLS.
  37. Sabbithi, A., et al. (2014). Microbial quality of fresh vegetables. *International Journal of Food Microbiology*, 172, 1-6. <https://doi.org/10.1155/2014/932191>
  38. Smith, J. L., et al. (1983). Staphylococcal food poisoning. *Journal of Food Protection*, 46(4), 365-373. <https://doi.org/10.4315/0362-028X-46.6.545>
  39. Tatini, S. R. (1973). Staphylococcus aureus contamination. *Journal of Milk and Food Technology*, 36(1), 14-20. <https://doi.org/10.4315/0022-2747-36.11.559>
  40. Uzeh, R. E., et al. (2009). Microbial quality of street-vended foods. *African Journal of Biotechnology*, 8(8), 1450-1455.
  41. Wallace, C. A., Sperber, W. H., & Mortimore, S. E. (2016). *Food Safety for the 21st Century*. Oxford: Wiley-Blackwell.
  42. Wanyenya, I., et al. (2004). Microbiological safety of fresh produce in Uganda. *African Health Sciences*, 4(3), 189-193.
  43. World Health Organization (WHO). (2007). *Food Safety and Foodborne Illness*. Geneva: WHO.



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