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MICROBIOLOGICAL QUALITY EVALUATION OF READY-TO-EAT MIXED VEGETABLE SALAD, FOOD INGREDIENTS AND SOME WATER SAMPLES FROM A RESTAURANT IN ACCRA: A CASE STUDY

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ABSTRACT

One serious threat to public health in both developed and developing countries is the microbial contamination of food. This problem poses a great challenge and consequently has economic implications. Causes of microbial contamination are diverse and these may be natural, environmental, or technological. The microbiological quality of most ready-to- eat foods is of great significance to human health because they require minimal or no processing when consumed. The aim of this research was to investigate the microbiological quality of some ready-to-eat mixed vegetable salad foods, ingredients as well as the wash water samples of an urban restaurant located in Accra, Ghana. A total of thirty (30) samples categorized into mixed vegetable salads, foods and water obtained from an urban restaurant in the national capital of Ghana, Accra. They were analyzed at the microbiology laboratory and food microbiology laboratories of School of Allied Health Sciences (UHAS) and Council for Scientific and Industrial Research-Food Research Institute (CSIR-FRI), Ghana, respectively. Standard microbiological methods that are per International Organization for Standardization (ISO) Methods and Nordic Committee on Food Analysis Methods (NMKL) were used in determining the presence and levels of bacteria and fungi. Data obtained were transformed from standard to logarithmic forms and reported as mean+standard deviations. The aerobic plate count samples ranged from 0- 4.73 log $_{10}$ CFU/g. *E-coli* counts also ranged between 0- 2.53 log $_{10}$ CFU, while *Bacillus cereus* counts were very low at 0-<10 log $_{10}$ CFU/g. *Clostridium perfringens* and *Staphylococcus aureus* counts were also very low ranging from 0- 1.0 $\log_{10}$ CFU/g. *Enterobacteriaceae* counts also ranged from 0- 1.90 $\log_{10}$ CFU/g. Molds and yeasts counts were generally low and ranged from 0- 2.48 log $_{10}$ CFU/g and 0- 1.0 $\log_{10}$ CFU/g, respectively. None of the samples tested contained *Listeria monocytogenes* and *Salmonella spp*. Fungal microbial loads were minimal given the quantities, and were deleterious to the health of consumers. The study revealed that the bacterial loads on mixed vegetable salads, ingredients and water samples used and served by an urban restaurant in Accra were within safe limits according to American Public Health Association (APHA) and International Commission for Microbiological Specifications for Foods (ICMSF) guidelines and, therefore, good for human consumption.

Key words: Ready-to-eat, Salads, water, Vegetables, Restaurant, Ghana, Microbial contamination, Consumer safety

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INTRODUCTION

Food is consumed by humans to provide the body with nutritional and energy needs. Salad, as defined by Ankita [1], is a food primarily composed of a mixture of raw vegetables and/or fruits. Salad vegetables are globally considered a major source of nutrients namely: vitamins, minerals, proteins and other relevant nutritional components for the proper functioning of the human body [2]. They are particularly a good source of bioactive phytochemicals with varied potentials such as supplying cancer-fighting agents [3], providing nourishment for the skin, fiber which aids in digestion and also prevents colon cancer. Recent studies by Coulibaly-Kalpy *et al.* [4] have established that consumption of salad vegetables contributes to a reduction in the incidence of certain diseases like diabetes, coronary heart disease, colon cancer, high blood pressure, obesity, and various digestive disorders in addition to preventing heart disease and skin cancers [5].

The likelihood of the occurrence of foodborne diseases is increased when salad vegetables are consumed without any thermal or chemical treatment, sometimes without washing and peeling [6]. Mensah *et al.* [7] implicated wash water used for rinsing the vegetables and sprinkling to keep them fresh as a source of contamination. Contamination with microorganisms according to Udo *et al*. [8] arises on fresh vegetables and fruits during cultivation, harvesting, sorting and packing as well as distribution. Furthermore, processing which includes cutting into desired shapes and sizes with knives or other shredding utensils can be a source of contamination [9].

According to WHO [10], although these pathogens cannot be unfortunately detected with the naked eye, felt, tasted or smelled, they have the potential to cause a myriad of diseases of varying severity and ultimately death. The propensity of their encounter is increased especially during processing, handling and storage of these foods which induce the growth conditions of these microorganisms, for example *Staphylococcus aureus, Escherichia coli* and some others. Their effects on the human body are directly proportional to the degree of infection or levels of contamination.

The chances of food contamination increase when food is prepared in bulk (commercial) and is handled by many individuals along the different food processing chains. The occurrence of unexpected contamination of food during bulk cooking usually leads to foodborne disease outbreaks, which can pose danger to the health of consumers and the national economy [11]. Again, regardless of their quantity, if not properly handled, ready-to-eat foods may become a channel of transmission of microbes into human bodies as they are not at all processed before consumption. In connection with the consumption of contaminated foods and drinks (including water), the World Health Organization [12] reported that diarrheal diseases are responsible for more than half of the global burden of foodborne diseases, causing 550 million people to fall ill and 230, 000 deaths every year. Children are at particular risk of foodborne diarrheal diseases, with 220 million falling ill and 96 000 dying every year.

An estimated 1.8 million people suffered and died from diarrheal diseases globally in 2005. There has been a general upsurge of foodborne related illnesses over the years and

this has adversely influenced the health and economic well-being of several developing countries [12].

Sabithi *et al*. [13] emphasized that poor personal hygiene often expedites the transmission of about 60 known pathogens into humans through ingested food. Bacteria such as *Salmonella species*, *Staphylococcus aureus, Clostridium perfringens, Campylobacter spp., Listeria monocytogenes, Vibrio parahaemolyticus, Proteus spp.* and *Escherichia coli* can be conveyed by food to cause food poisoning and other food-borne diseases such as tuberculosis, typhoid fever and cholera, dysentery, pneumonia, meningitis, whooping cough, hepatitis and sore throat [14]. Similarly, fungal species such as *Aspergillus spp., Fusarium spp., Penicillium spp., Claviceps spp., Cephalosporium spp. Trichothecium spp.* and others have also been implicated in some foodborne diseases with akin symptoms such as diarrhea, headaches, vomiting, chills, dizziness, and blurred vision [15], although rarely recognized. Fungal toxins produced are pliable and more intoxicating in causing some severe diseases such as cancer in addition to damaging vital organs such as the brain and nervous system, liver and kidney [16].

The aim of this research was to investigate the microbiological quality of some ready-to-eat mixed vegetable salad foods, ingredients as well as the wash water samples of an urban restaurant located in Accra, Ghana.

MATERIALS AND METHODS

Sample collection

A total of thirty samples (n=30) were obtained from a restaurant in Greater Accra region, Ghana. The samples were randomly sampled over a two-week period in July and August, 2018. Approximately 200g of each sample were collected and stored in sterile specimen containers (Nasco, USA) and transported in an ice chest freezer (Thermos 7750, China) with cold packs at a temperature of 10 ºC under aseptic conditions to the UHAS laboratory for microbiological analysis within 2 hours of collection.

Quantitative estimation of total aerobic bacteria

For all samples, 10g were homogenized in 90 ml sterile diluent (0.1% peptone, 0.8% NaCl, pH 7.2) in a stomacher (Lab Blender, Model 4001, Seward Medical, London, England) for 30s at normal speed. From appropriate ten-fold dilutions, aerobic mesophiles were enumerated by pour plate method on Plate Count Agar (Oxoid CM325; Oxoid Ltd., Basingstoke, Hampshire, UK), and incubated at 30°C for 72 h according to Nordic Committee on Food Analysis Methods (NMKL) No. 86 (2006).

Detection of *E-coli*

E. coli were enumerated by pour plate on Trypton Soy Agar (Oxoid CM131), pH 7.3 overlaid with Violet Red Bile Agar (Oxoid CM107), pH 7.4 and incubated at 37 °C for 24 h for total coliforms and 44 °C for 24 h for *E. coli*. Colonies suspected to be coliforms were confirmed on Brilliant Green Bile Broth (Oxoid CM31), pH 7.4, incubated at 37°C for 24 h according to NMKL No. 44 (2004) and suspected colonies of *E. coli* were sub-cultured into EC Broth (Oxoid CM853), pH 6.9, followed by Tryptone Water (Oxoid

CM87), pH 7.5, for indole test, all incubated at 44°C for 24 h according to NMKL. No.125 (2005).

Determination of *Staphylococcus spp.*

Staphylococcus aureus was determined using the spread plate method on Baird Parker Agar (BP, CM 275 Oxoid Ltd, Hampshire, England) containing Egg Yolk Tellurite Emulsion (SR54). Suspected colonies were confirmed for coagulase-positive on rabbit coagulase plasma (C14389) according to NMKL Method No. 66 (2009).

Determination of *Bacillus cereus*

Bacillus cereus was enumerated by the spread plate technique on Bacillus Cereus Agar Base (CM0617) to which Polymyxin B supplement (SR0099E) has been added and confirmed on Blood Agar Base (Oxoid CM0055), for the presence of hemolysis as described in NMKL No. 67, 2010.

Determination of *Enterobacteriaceae*

Enterobacteriaceae was enumerated according to NMKL No. 144, (2005), on Violet Red Bile Glucose Agar (Oxoid CM0485), pH 7.4 and overlaid with another VRBGA. The plates were incubated at 37 °C for 24 h. Suspected colonies were confirmed by the oxidase test. Detection of *Salmonella* was according to NMKL No. 71, (1999). This was carried out by taken 25 g of the sample and 225 ml of Buffered Peptone Water (CM0509) was used as pre-enrichment broth and incubated at 37 °C for 21 h. One (1) ml was sub-cultured into Rapapport Valisialdis Soya Peptone Broth (CM0866) and subsequently plated on XLD Agar (CM0469 Oxoid Ltd, Hampshire, England). Suspected *Salmonella species* was confirmed by biochemical test on Triple Sugar Iron Agar (Vm381715 214, Merck KGaA Darmstadt, Germany) and serological test using Salmonella Polyvalent Agglutinating Sera (30858501ZD01, UK).

Determination of *Listeria monocytogenes*

Listeria monocytogenes were determined by International Organization for Standardization Method (ISO) 11290 1 (2004). Here, 25 g of the test sample was weighed into 225 ml of half Frazer (CM 0895) as a pre-enrichment broth and incubated at 30 ^{0}C for 24 h. Afterward, 0.1 ml of the culture was sub-cultured into Frazer broth and incubated at 37 ^{0}C for 48 h. The culture medium was plated on Palcam (CM0877) Agar and Oxford Agar media and incubated at 37 ^{0} C for 24 h. Suspected colonies were confirmed for catalase, gram, motility test, and Blood Agar Base to determine the presence of hemolysis.

Quantitative Estimation of mycoflora population (Yeasts and Molds)

The initial mycoflora in the food and wash water samples was determined by transferring 10 g and 10 ml of samples, respectively into 250 ml Erlenmeyer flasks containing 100 ml of 0.1% peptone water as diluents. Each flask was shaken at 140 RPM for 20 minutes on an orbital shaker (Gallenkamp, England). Serial dilutions up to 1:10^{-4} were made and 1 ml aliquot was plated by spread plate on 20 ml of Dichloran Rose Bengal Chloramphenicol Agar (Oxoid CM0727), with pH adjusted to 5.6, and containing Chloramphenicol supplement to inhibit the growth of bacteria. The plates were incubated at 25oC for 3-5 days per ISO 21527-1:2008.

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RESULTS AND DISCUSSION

Results of the first category of samples of mixed vegetable salad (18/01, 18/02,18/03, 18/04, 18/05, 18/06, 18/07, 18/08,18/09, 18/10, 18/11, 18/12, 18/13, 18/14 and 18/15) investigated are presented in Table 1. The aerobic plate count of samples ranged from < 1.0±0.02– 4.73±0.8 log $_{10}$ CFU/g. *E-coli* counts also ranged <1.0±0.02- 2.53±0.3 log $_{10}$ CFU/g while *Bacillus cereus* counts were generally very low of 0-<1.0±0.02 $\log_{10}$ CFU/g. None of the samples tested contained *Listeria monocytogenes* and *Salmonella spp*. *Clostridium perfringens* and *Staphylococcus aureus* counts were also very low in range 0- < 1.0±0.02 $\log_{10}$ CFU/g of sample. *Enterobacteriaceae* counts also ranged from <1.0±0.02- 1.90±0.04 log $_{10}$ CFU/g. Counts of molds and yeasts were generally low and ranged 0- 2.48±0.4 log $_{10}$ CFU/g and 0- < 1.0±0.02 log $_{10}$ CFU/g, respectively.

The second category of samples was the foods (18/16, 18/17,18/18, 18/19, 18/20, 18/21, 18/22 and 18/23) , which recorded aerobic plate counts of range <1.0±0.01- 2.48±0.4 log $_{10}$ CFU/g. *E-coli* counts also ranged 0- <1.0±0.02 log $_{10}$ CFU/g. *Bacillus cereus* in most cases tested for, recorded very low counts of <1.0 log $_{10}$ CFU/g. Again, none of the samples tested contained *Listeria monocytogenes* and *Salmonella spp*. *Clostridium perfringens* and *Staphylococcus aureus* counts were also very low of range 0- <1.0±0.02 log $_{10}$ CFU/g of sample in most cases. Very low counts in the range 0- <1.0±0.02 log $_{10}$ CFU/g were recorded for *Enterobacteriaceae*. Molds and yeast counts were generally low (<1.0±0.02 log $_{10}$ CFU/g) (Table 2).

The third category of samples was the wash water samples (sample no.s 18/24, 18/25, 18/26, 18/27, 18/28, 18/29 and 18/30), which recorded aerobic plate counts, *E-coli* counts, and *Enterobactericea* all ranged 0- <1.0±0.04 log $_{10}$ CFU/g. *Bacillus cereus*, *Clostridium perfringens, Staphylococcus aureus*, molds, and yeast counts were not examined. Again, none of the samples tested contained *Listeria monocytogenes* and *Salmonella spp*. (Table 3).

In humans, some strains of *E. coli* when ingested via food could result in gastroenteritis and diarrhea [17]. *Escherichia coli* present in food samples is a suggestion of fecal contamination and improper hygienic practices by food handlers [18], although they do not usually lead to foodborne illness in humans. Nonetheless, their presence in food can cause stomach upset and diarrhea in children especially in less developed countries [19]. Doyle and Erickson [20] postulated that due to its better association with potential contaminants by members of the *Enterobacteriaceae*, *E. coli* is more appropriate as an indicator of fecal contamination than heat-tolerant coliforms. Results of *E. coli* contamination in the present study were found to be in the same range of values reported by Abadias *et al.* [21] for samples of freshly chopped vegetables from Spain (11.4 %) and the United Kingdom, 13% of the vegetable salads were contaminated as reported by Sagoo *et al*. [22]. However, from Brazil, Prado *et al*. [23] reported a relatively higher percentage of 30 % contamination with *E. coli* were detected in samples of minimally processed vegetables. Abakari *et al.* [24] also recorded high values of range 0- 7.56 $\log_{10}$ CFU/g representing 96.7 % of contaminated food samples in Tamale, Ghana.

In another related study, Oyinlonla *et al.* [25] also reported a range of 0.00±00-10.37±0.30 $\log_{10}$ CFU/g in lettuce vegetables in Nigeria. Contrary to these findings, results obtained in this work satisfied the guidelines prescribed by the Ghana Standards Authority [26] (Table 4), which provides that in 25 g of sampled ready-to-eat vegetables, *E. coli* load of $>10^5$ CFU/g is described as unsatisfactory for human consumption whereas a load of $<10^3$ or 3 $\log_{10}$ CFU/g is described as satisfactory (Table 4). This study recorded a low occurrence of *Bacillus cereus* in food samples investigated, which agreed with findings of Mensah *et al.* [7] as they sampled 511 different food samples and reported 5.5 % and 2.2 % contamination with *Bacillus cereus*. Similarly, Feglo and Sakyi [27] reported an occurrence of 2.2 % in salad samples from Kumasi, Ghana. In contrast, some other related studies showed much higher values than we found. Relatively high values of 26 % contamination (10^8-10^2 CFU/g) of pasta salad samples in Leuven Belgium were reported by Dierick *et al.* [28] while Kortei *et al.* [29] reported approx. 20 % of contamination in stored gamma-irradiated steamed ready-to-eat mushrooms samples. Abakari *et al*. [24] also reported a range of 0-7.44 log 10 (93.3 %) in salad foods.

Ghana Standards Authority [26] and the Food and Drugs Authority [30] emphasized that *Salmonella spp*. should not be detected in 25g of ready- to- eat foods to be satisfactory for human consumption otherwise it should be described as unsatisfactory (Table 4). Following these guidelines, all samples examined did not indicate the presence of *Salmonella spp*. The presence of *Salmonella spp.* in food depicts a greater human health risk for consumers of such contaminated foods. The bacterium is mostly associated with cross-contamination of food products, especially from eggs and egg products [31]. The incidence of *Salmonella spp*. in food is generally associated with cross-contamination and also depended on irregular time-temperature chain [32]. Presumably, the non-detection of *Salmonella spp*. may be attributed to good hygiene practices by the restaurant staff as suggested by Bakobie *et al*. [18], since it was evident that most of the restaurant premises were kept tidy enough and could not have also resulted from cross-contamination of the food substances. The present study recorded no incidence of *Salmonella spp*. in all the food samples investigated, which was in agreement with findings of Al-Katib *et al*. [33] on the microbiological quality of food samples from a restaurant in Palestine. However, it contradicts the findings of Boateng [34] who detected the presence of *Salmonella spp*. in 32 % samples of pepper vegetables. Abakari *et al.* [24] also reported *Salmonella spp*. contamination in some food samples in Tamale, Ghana within the range of 0- 4.54 $\log_{10}$ CFU/g.

Overall occurrence of *L. monocytogenes* in the vegetables analyzed in this study was low, in line with previous results reported by Porto and Eiroa [35] who detected 3.2 % and 0.6 %, respectively of samples positive for *L. monocytogenes* among surveyed diverse vegetable samples (lettuce, parsley, watercress and spinach) from Brazilian markets. Fröder *et al.* [36] also reported the isolation of *L. innocua* (0.9 %) and *L. welshimeri* (0.6 %) from lettuce samples. Published data reported by Lin *et al.* [37] from the USA stressed that the prevalence of *L. monocytogenes* in salad samples was low (1.6 %). Conversely, Poniah *et al*. [38] reported the detection of 22.5 % of *L. monocytogenes* in minimally processed vegetables tested in a study in Malaysia. In Ghana, human listeriosis according to Osei- Somuah *et al*. [39] is not well documented although the occurrence of the illness among some animals has been reported. Also, low incidences of mean counts of range

12- 45 $\log_{10}$ CFU/ml in salad coleslaw has been reported by Tano-Debrah *et al*. [40]. It must be highlighted that the low occurrence of *L. monocytogenes* in Ready-To-Eat foods be critically assessed, since this can sometimes be perceived as negative results (not present) due to low population of *Listeria spp*. However, in comparison with the greater micro-floral population where it is easier to detect the existence of listerial cells [41].

The occurrence of molds and yeasts was minimal and so differed with findings of Annan-Prah *et al.* [42] who reported a range of 4 $\log_{10}$- 5 $\log_{10}$ CFU/g from street vended foods in Cape Coast. Furthermore, Oranusi *et al.* [43] reported values of range 3.95- 6.97 $\log_{10}$ CFU/g in foods sold in the student cafeteria in Nigeria. In a related study, Kortei *et al.* [15] also recorded values of range 3.5- 4 $\log_{10}$ CFU/g on RTE steamed gamma-irradiated mushroom samples in Ghana.

Previous researchers [44, 45] have reported on the use of polluted river water or wastewater sewerage supplied by urban farmers to irrigate their vegetable crops which are used as salads. Thus, vegetables produced under such poor sanitation are highly prone to contamination [46]. Reported ranges of counts of previously done related works [24, 43, 47, 42] were high 10^4-10^8. Richardson *et al*. [48] underscored that groundwater is generally acknowledged to be a better alternative to pond water because the water quality is protected from contamination. Notably, lettuce, cabbage, carrots, onions and tomatoes which constitute the main ingredients of raw vegetables grown in contaminated water irrigated farms, need to get special consideration since potential pathogenic microorganisms that get in contact and finally end up in the food chain and could pose potential health risks for consumers [49].

Contrary to the published findings of the afore mentioned researchers, our results were of lower counts and were acceptable per guidelines of Ghana Standards Authority [26] (Table 4) and International Commission for Microbiological Specifications for Foods (ICMSF) [49] guidelines, which state that ready-to-eat food with plate counts ranges of between 0 – 10^3 (0- 3 $\log_{10}$ CFU) is acceptable, between 10^4 - ≤ 10^5 (4 -5 $\log_{10}$ CFU) is tolerable and 10^6 (6 $\log_{10}$ CFU) and above is unacceptable. Presumably, some good manufacturing practices (GMP) were followed in the preparation of these foods and so contamination was well controlled as evidenced in the quality of water used to process the vegetables. Amissah and Owusu [50] reiterated that the level and magnitude of sanitary practices/ hygienic practices by food vendors can have a great impact on the microbial load in foods. Oyinlola *et al.* [26] also emphasized that high concentrations of enteric microorganisms (*Enterobacteriaceae spp.*) in the environment, as well as increase in the risk of producing cross-contamination, could arise as a result of the lack of sanitary and sewage management facilities in an area coupled with close interactions between people, livestock, water sources as well as fresh produce. Again, staff of restaurants normally undergo refresher courses in food safety periodically so such occurrences are expected.

CONCLUSION

In conclusion, the results from this study revealed that majority of the ready-to-eat mixed vegetable salad foods, ingredients and water samples analyzed, were of acceptable

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microbiological quality per the guidelines stipulated by the International Commission for the Microbiological Specifications of Food (ICMSF) and the Ghana Standards Authority.

This is an indication of the need for the implementation of good hygienic practices by food processors and consumers to minimize the risks of transmission of foodborne pathogens through ready-to-eat foods.

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Table 1: Results of the microbiological examination of some mixed vegetable salad foods and sauces (n=15)

Sample No.	Sample Code/Description	Aerobic Plate Count @ 30°C/72h CFU/g NMKL 86 2013	*E. coli* Count CFU/g NMKL 125 2005	*B. cereus* Count CFU/g NMKL 67 2010	*Listeria monocytogenes/25g* ISO 11290-1 1996	*Cl. perfringens* Count CFU/g ISO 7937 2004	*Staph. aureus* Count CFU/g NMKL 66 2009	*Enterobacteriaceae Count* CFU/g NMKL 144 2005	*Salmonella* spp./25g NMKL 71 1999	Mold & Yeast Count CFU/g ISO 21527-1: 2008	
										Yeasts	Molds
18/01	CHUNKY TOMATOES & POTATO & CUCUMBER SALAD, DILL SPRIG, LETTUCE LINER	3.0±0.5 $\log_{10}$	2.53±0.3 $\log_{10}$	N/E	NOT DETECTED	N/E	< 1±0.02 $\log_{10}$	1.90±0.05 $\log_{10}$	NOT DETECTED	N/E	N/E
18/02	SMOKED SALMON, FENNEL FINELY SHAVED, SHAVED CUCUMBER, CAPERBERRY, LEMON	N/E	1.60±0.04 $\log_{10}$	N/E	NOT DETECTED	N/E	< 1±0.01 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	2.48±0.3 $\log_{10}$	< 1±0.02 $\log_{10}$
18/03	ROASTED BBQ CHICKEN THIGHS DEBONED, SPICY BBQ SAUCE, JOLLOF RICE, SAUTEED PEAS WITH ONIONS.	3.65±0.5 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	NOT DETECTED	N/E	N/E
18/04	BAKED SALMON, RED PEPPER COULIS, PAN FRIED ROSEMARY POLENTA, GRILLED COURGETTE, SAUTEED PEAS WITH ONIONS	3.60±0.5 $\log_{10}$	< 1± 0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.01 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	NOT DETECTED	N/E	N/E

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18/05	BEEF CHILLI CON CARNE WITH BLACK BEANS, WHITE STEAMED RICE, TOASTED SWEETCORN WITH GREEN PEAS AND DICED TOMATOES	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.01 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	NOT DETECTED	N/E	N/E
18/06	TIRAMISU, CARAMELIZED PINEAPPLE MINI TRIANGLES, ORANGES HONEY SAUCE, MINT SPRIG GARNISH	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	N/E	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$
18/07	BAKED CHEESECAKE, FRUIT COULIS	4.58±0.6 $\log_{10}$	< 1 ±0.02 $\log_{10}$	N/E	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1 ±0.02 $\log_{10}$
18/08	SMOKED SALMON	4.73±0.8 log10	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETETCED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	NOT DETECTED	N/E	N/E
18/09	ROASTED CHICKEN BREAST	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1± $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	N/E	N/E
18/10	APPLE LATTICE CAKE WITH VANILLA CUSTARD SAUCE	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	N/E	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$
18/11	BREAD	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$

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18/12	SAUTEED SPINACH	2.61±0.08 log_{10}	< 1±0.02 log_{10}	< 1±0.02 log_{10}	NOT DETECTED	< 1±0.02 log_{10}	< 1±0.01 log_{10}	< 1±0.02 log_{10}	NOT DETECTED	< 1± 0.02 log_{10}	< 1±0.02 log_{10}
18/13	WHITE FISH	< 1±0.02 log_{10}	< 1±0.02 log_{10}	< 1±0.02 log_{10}	NOT DETECTED	< 1±0.02 log_{10}	< 1±0.02 log_{10}	< 1±0.02 log_{10}	NOT DETECTED	< 1±0.02 log_{10}	< 1±0.02 log_{10}
18/14	MASHED POTATO	< 1±0.02 log_{10}	<1±0.02 log_{10}	< 1±0.02 log_{10}	NOT DETECTED	< 1±0.02 log_{10}	< 1±0.02 log_{10}	< 1±0.02 log_{10}	NOT DETECTED	< 1 ±0.02 log_{10}	< 1±0.02 log_{10}
18/15	BORDELAISE SAUCE	< 1±0.02 log_{10}	< 1±0.02 log_{10}	< 1±0.02 log_{10}	NOT DETECTED	< 1±0.02 log_{10}	< 1±0.02 log_{10}	< 1±0.02 log_{10}	NOT DETECTED	< 1±0.02 log_{10}	< 1± 0.02 log_{10}

N/E- Not Examined

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Table 2: Results of the microbiological examination of some food ingredients samples (n=8)

Sample No.	Sample Code/Description	Aerobic Plate Count @ 30°C/72h CFU/g NMKL 86 2013	*E. coli* Count CFU/g NMKL 125 2005	*B. cereus* Count CFU/g NMKL 67 2010	*Listeria monocytogenes/25g* ISO 11290-1 1996	*Cl. perfringens* Count CFU/g ISO 7937 2004	*Staph. aureus* Count CFU/g NMKL 66 2009	*Enterobacteriaceae Count* CFU/g NMKL 144 2005	*Salmonella* spp./25g NMKL 71 1999	Mold & Yeast Count CFU/g ISO 21527-1: 2008
										Molds
18/16	BUTTER BLOCK	2.48±0.4 $\log_{10}$	< 1±0.01 $\log_{10}$	N/E	NOT DETECTED	N/E	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$
18/17	PASTRY FLOUR	< 1±0.02 $\log_{10}$	< 1 ±0.02 $\log_{10}$	N/E	NOT DETECTED	< 1 ±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$
18/18	ALMONDS POWDER	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	N/E	NOT DETECTED	N/E	N/E	< 1±0.02 $\log_{10}$	NOT DETECTED	N/E
18/19	EGG LIQUID WHITE	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	N/E	NOT DETECTED	< 1±0.01 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	NOT DETECTED	N/E
18/20	EGG LIQUID (MIXED)	2.15±0.8 $\log_{10}$	< 1±0.02 $\log_{10}$	N/E	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	NOT DETECTED	N/E
18/21	APPLE TOPFIL	2.58±0.8 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1 ±0.02 $\log_{10}$	NOT DETECTED	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	< 1±0.01 $\log_{10}$	NOT DETECTED	N/E
18/22	MILK FULL CREAM	< 1±0.02 $\log_{10}$	< 1±0.02 $\log_{10}$	N/E	NOT DETECTED	N/E	< 1±0.02 $\log_{10}$	< 1±0.01 $\log_{10}$	NOT DETECTED	N/E
18/23	CUSTARD POWDER	N/E	< 1±0.02 $\log_{10}$	N/E	NOT DETECTED	N/E	N/E	N/E	NOT DETECTED	N/E

N/E- Not Examined

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Table 3: Results of the microbiological evaluation of water samples (n=7)

Sample No.	Sample Code/Description	Aerobic Plate Count @ 30°C/72h CFU/ml NMKL 86 2013	*Enterobacteriaceae Count* CFU/ml NMKL 144 2005	*E. coli* Count CFU/ml NMKL 125 2005	*Staph. aureus* Count CFU/ml NMKL 66 2009	*Cl. perfringens* Count CFU/ml ISO 7937 2004	*Salmonella* spp./25ml NMKL 71 1999	*Listeria monocytogenes/25ml* ISO 11290-1 1996	*B. cereus* Count CFU/ml NMKL 67 2010	Mold & Yeast Count CFU/ml ISO 21527-1: 2008 Molds
18/24	WATER FROM VEG PREPARATION TAP	< 1±0.04 $\log_{10}$	< 1±0.02 $\log_{10}$	< 1±0.04 $\log_{10}$	N/E	N/E	NOT DETECTED	NOT DETECTED	N/E	N/E
18/25	ICE FROM LEFT ICE MACHINE	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	N/E	N/E	NOT DETECTED	NOT DETECTED	N/E	N/E
18/26	WATER FROM PURCHASING (WASHING & DISINFECTION TAP)	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	N/E	N/E	NOT DETECTED	NOT DETECTED	N/E	N/E
18/27	WATER FROM VEG. INFECTION AREA	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	N/E	N/E	NOT DETECTED	NOT DETECTED	N/E	N/E
18/28	WATER FROM DISHWASHING AREA	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	N/E	N/E	NOT DETECTED	NOT DETECTED	N/E	N/E
18/29	WATER FROM HAND WASHING STATION	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	N/E	N/E	NOT DETECTED	NOT DETECTED	N/E	N/E
18/30	ICE FROM RIGHT ICE MAKING MACHINE	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	< 1±0.04 $\log_{10}$	N/E	N/E	NOT DETECTED	NOT DETECTED	N/E	N/E

N/E- Not Examined

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 20 No. 6 October 2020 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Table 4: Guidance on the interpretation of results for specific foodborne pathogens in ready-to-eat food in general (colony-forming unit (CFU/g)

Criterion	Satisfactory	Borderline	Unsatisfactory (potentially injurious to health and/or unfit for human consumption)
Escherichia coli 0157 (and other *Shiga* toxin-producing *E. coli* (STEC)	n.d. in 25g	N/A	Detected in 25g
Salmonella spp.	n.d. in 25g	N/A	Detected in 25g
Shigella spp.	n.d. in 25g	N/A	Detected in 25g
Bacillus cereus	$<10^2$ or 2 $\log_{10}$	10^2 to $<10^4$ 2 to 4 $\log_{10}$	$>10^4$ 4 $\log_{10}$
Hygiene indicator organism	satisfactory	borderline	Unsatisfactory (potentially injurious to health and/or unfit for human consumption)
Escherichia coli	<20 1.3 $\log_{10}$	20 to $< 10^2$ 1.3 to 2 $\log_{10}$	$>10^2$ 2 $\log_{10}$

Ghana Standards Authority Guidelines for assessing the Microbiological Safety of Ready-to-Eat foods

nd – Not determined

N/A- not applicable

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