**Assessment of Microbial Load in Freshly Cut Street Fruits and Its Health Implications in the Tamale Metropolis**

**Abstract**

The study aimed to examine the microbial load in some selected cut fruits in the Tamale Metropolis of Ghana. The study hinges on the positivist paradigm and employed the quantitative research approach and a descriptive cross-sectional study design to examine microbial load in some selected cut and vented fruits in the Tamale Metropolis. The study population consists of one hundred and thirty-one (131) vendors registered with the Health Directorate of the Metropolis who sell watermelons, oranges, Pawpaw, pineapples, mangoes and apples. Thirty (30) samples of freshly cut fruits were conveniently purchased from fruit vendors within the Tamale Metropolis. A standard laboratory was used to analyse the samples collected. Microsoft Excel 2010 was used to generate means and standard deviations for the microbial load for each of the samples taken from the ten vendors. In cases where bacterial levels were below the detectable limit, a value of zero was assigned for statistical analysis. Significant differences between means were calculated using one-way Analysis of Variance (ANOVA). A p-value ≤0.05 was considered as significant. Based on the findings, out of the sampled fruits from the ten respondents, the mean values indicated seven samples had *Staphylococcus aureus* and at levels higher than the recommended by Ghana Standard Authority (< 3 logs CFU/g), and only one vendor had fruit with *E. coli* present. It was also revealed that only fruits from the three respondents sampled had no *Listeria monocyte*. The results reveal that seven of the ten samples had traces of *Listeria Monocytoge*. Fruit safety-wise, consuming these fruits can result in fruit-borne diseases caused by *Listeria Monocytoge*. The impacts of *Listeria Monocytoge* on different groups of persons cannot be ignored. The results for *Staphylococcus Aureus, E. Coli,* and *Aerobic Mesophiles* revealed that three samples of *Staphylococcus Aureus* met the standard level of microbial load, whereas, in the aspect of E. *Coli,* all but one sample failed to meet the standard load measure.

**Keywords:** Microbial Load, Fruits, Health

1. **Introduction**

According to the Ministry of Food and Agriculture and the World Bank, in 2006, approximately 420,000 cases of food-borne diseases or disorders were recorded annually in Ghana, with a fatality rate of 65,000 (Ministry of Food and Agriculture/World Bank (2006). Writers have linked food-borne disease outbreaks in developed and developing countries to fresh-cut fruits (Kumar, Agarwal, Ghosh, & Ganguli, 2006). Similarly, a study conducted in Nigeria concluded that fresh-cut fruits across six States are infected with diverse enteric bacterial species, threatening food safety (Oyedele, Akinyemi, Kovač, Eze, & Ezekiel, 2020). This is evidence that fresh-cut fruits can be a source of food-borne diseases. This evidence in the literature indicates that the unhygienic handling of fresh-cut fruits has the possibility of causing food-borne diseases. However, little or no research on this all-important topic regarding food vendors dealing with fruits in Ghana has been conducted. Studies I have encountered on food safety issues were conducted on food vendors selling cooked foods, like yam, rice, 'banku', fufu and spices, among others (Aglidza, 2019; Bakobie, Addae, Duwiejuah, Cobbina, & Miniyila, 2017). Other studies examined vendors' knowledge and attitudes on hygiene and the safe handling of food other than fruits (Addo-Tham, Appiah-Brempong, Vampere, Acquah-Gyan, & Gyimah Akwasi, 2020; Akabanda, F., Hlortsi, & Owusu-Kwarteng, 2017). Individuals differ in many respects, and different geographical areas exhibit different weather conditions. Therefore, area-specific studies must be conducted on this topic to add to knowledge on this all-important topic. Therefore, an empirical investigation of the Microbial load in some selected cut and vented fruits, as well as the implications for food safety, has been identified for this study. The study aimed to examine the microbial load in some selected cut fruits in the Tamale Metropolis of Ghana. The study seeks to address these research questions – (1) What is the microbial load in freshly cut street fruits in the Tamale metropolis? (2) What health implications are associated with microbial load in sample cut fruits in the Tamale metropolis?

* 1. **Microbial Load in Freshly Cut Street Fruits**

Despite its health benefits, fresh fruit and vegetables can harbour various microorganisms. Studies used routine plate counts to determine the microbial densities in fruit samples (SPC) (Mahfuza, Arzina, Kamruzzaman, Afifa, Afzal, Rashed, & Roksana, 2016; Ogofure, Bello-Osagie, Ahonsi, Ighodaro, & Emoghene, 2017). Vendor A had a mean microbiological load of 1.33 x 106 - 1.82 x 107 cfu/ml, Vendor B had a mean microbial load of 9.9 x 106 - 3.0 x 107 cfu/ml, and Vendor C had a mean microbial load of 9 x 105 - 3.0 x 107 cfu/ml. The researchers isolated nine germs from eight different families. Staphylococcus aureus (292 per cent), Staphylococcus spp (12.5%), Klebsiella spp (12.5%), and Salmonella spp (12.5%) all followed in isolation frequency. It was found that the least common types of bacteria identified were actinomycetes (4.2%) and Escherichia coli (4.2%) (Mahfuza, Arzina, Kamruzzaman, Afifa, Afzal, Rashed, & Roksana, 2016; Ogofure, Bello-Osagie, Ahonsi, Ighodaro, & Emoghene, 2017).

Five different vegetables had their microbial load measured, and the results were compared to those obtained before and after being exposed to varying concentrations of acetic acid (vinegar; 0.5–2.5%) for 0–10 minutes. Varying the vinegar dosage from 0.5 to 2.5% resulted in a 15-82% decrease in microbial burdens. Vegetables exposed to a 2.5% vinegar solution for 10 minutes had the fewest microorganisms. The study's results indicated a need to reawaken consumers' consciousness of the risks of eating pathogen-contaminated foods and the importance of insisting on properly processed/stored sliced vegetables (Mahfuza, Arzina, Kamruzzaman, Afifa, Afzal, Rashed, & Roksana, 2016; Ogofure, Bello-Osagie, Ahonsi, Ighodaro, & Emoghene, 2017).

As a result of its low price per serving, high availability, low preparation time, and several health benefits, sliced and ready-to-eat fruits have seen a significant increase in popularity in Ghana over the past few years (Aboloma, Egbebi, Fajilade, & Adewale, 2016). Rising rates of food poisoning have been linked to the widespread consumption of pre-cut fruits. Accraans love their sliced Pawpaw, pineapple, watermelon, apple, and mango. Street vendors often offer sliced and peeled fresh fruits in small plastic bags for instant eating without further preparation or washing. Most street vendors are unregistered and lack proper training in food safety and sanitation (Abbott, 2019).

The health benefits of eating fruits every day are outweighed by the possibility of contracting an illness from eating them because of microbial contamination. The isolation of harmful bacterial species from various produce further supports the hypothesis that contamination is a widespread problem in the produce industry (Reddi, Kumar, Balakrishna, & Rao, 2015). Centres for Disease Control and Prevention in 2002 and 2006 Salmonella outbreaks in the United States were traced back to watermelons (Havelaar, Kirk, Torgerson, Gibb, Hald, Lake, & World Health Organization Food-borne Disease Burden Epidemiology Reference Group. 2015). Similarly, 63 confirmed incidents of food illness were linked to Brazilian watermelon imported to Europe in 2011. Watermelon slices sold by street sellers in Nigeria had an average aerobic count of 0.1-2.3 105 CFU g1, according to a study conducted to assess the fruit's microbiological quality. Carrot, runner bean, cucumber, fresh cut pineapple, green pepper, cabbage, spring onions, lettuce, watermelon, and apple were all found to have between 9.0 105 and 3.0 107 CFU/ml of Staphylococcus aureus, Klebsiella sp., Salmonella sp., and Escherichia coli isolated from them in a separate study conducted in Nigeria (Ugwu, & Edeh, 2019).

Additionally, Escherichia coli (36%), Staphylococcus aureus (33%), Klebsiella sp. (17%), and Bacillus sp. (15%) were found to be prevalent in the raw-mixed vegetable salads (Karam, Salloum, El Hage, Hassan, & Hassan, 2021). Despite widespread knowledge of the risks associated with consuming contaminated produce, little data exists in Ghana about the microbiological safety of fruits and vegetables sold in polyethylene bags from street vendors. As an additional note, human virus outbreaks linked to eating fresh or minimally processed fruits and vegetables have increased in recent years despite the fruits' nutritional and health benefits (Ugwu, & Edeh, 2019; Karam, Salloum, El Hage, Hassan, & Hassan, 2021). During food-related pandemics, enteric pathogens like Escherichia coli and Salmonella are significant causes of alarm. Vegetables produced in or treated with contaminated soil or sewage have been linked to several incidences of typhoid fever epidemic (Ugwu, & Edeh, 2019).. Since most individuals spend most of their time outside the house, the rise in infections traceable to eating tainted fruits and vegetables while away from home contributed to the problem. For example, street vendors of pre-sliced fruits and vegetables in Nigeria have just become widespread, and the business is booming (Orji, Ayogu, Amaobi, Moses, Elom, Uzoh, & Igwe, 2021). Another study also discovered bacteria on newly cut fruits, with watermelon and Pawpaw having mean total aerobic plate counts of 2.6 105-8.1 105 CFU g-1 and 3.7 104-7.1 104 CFU g-1, respectively. Mean coliform counts per gram of Pawpaw and watermelon were 1.2 x 103 and 8.1 x 103, respectively, while those of watermelon were 1.6 x 104 and 3.1 x 104. There was no statistically significant difference between suppliers and their competitors in terms of either aerobic bacteria or coliforms at a few distinct locations. However, Enterobacter species (33.3%), Citrobacter sp. (20.0%), and Klebsiella sp. (15.9%) were the most commonly isolated bacteria (Sathe, Rajput, Gunaga, Patel, & Bendre, 2019).

Research aimed at comparing the efficacy of four different low-cost disinfectants (sterile water, salt water, blanched, and vinegar) in decontaminating 12 different types of fruit and 10 different types of vegetables in terms of total viable bacteria (TVBC), total coliform (TCC), faecal coliform (TFC), pathogenic Pseudomonas spp., and Staphylococcus aureus. TVBC in fruit samples ranged from the lowest (3.18 0.27 log CFU/g) in Indian gooseberry to the highest (6.47 0.68 log CFU/g) in guava. All fruit samples included bacteria, with the range being from 2.04 0.53 to 5.10 0.02 log CFU/g for Staphylococci, 1.88 0.03 to 3.38 0.08 log CFU/g for Pseudomonas, and 2.60 0.18 to 7.50 0.15 log CFU/g for total fungus; however, no Salmonella was observed. When compared to other treatments, vinegar was the most effective at reducing the microbial load of specific fruits and vegetables. Fruits showed a 1.61-log decrease in TVBC and a 2.54-log decrease in TF after being treated with vinegar, whereas vegetables showed a 2.31-log decrease in TVBC and a 2.41-log decrease in TF. Overall, the bacterial load of the fruit and vegetable samples was reduced by all disinfectant treatments compared to the control by a statistically significant amount (p 0.01) (Orji, Ayogu, Amaobi, Moses, Elom, Uzoh, & Igwe, 2021). People have been sickened after eating tainted fresh veggies (Pesewu et al., 2014). Exposure to fecally infected manure fertilisers, irrigation with fecally contaminated water, and/or ice washing during handling and shipping contaminate FFV, leading to food-borne illness outbreaks (Yeleliere, Cobbina, & Abubakari, 2017). Researchers have found that many cases of food poisoning are caused by faecal coliform bacteria such as Escherichia coli, Shigella spp., Pseudomonas spp., Salmonella spp., Listeria monocytogenes, and Clostridium botulinum. In recent years, pathogenic E. coli outbreaks have been traced back to people eating raw carrots, radish sprouts, lettuce, alfalfa sprouts, spinach, grapes, and berries (Olaimat, Shahbaz, Fatima, Munir, & Holley, 2020). An alternative study indicated that eating sprouts and Chinese cabbage increased one’s risk of contracting E. coli O157:H7 in Japan and the Shiga toxin-related hemolytic uremic syndrome in Germany (Al-Kharousi et al., 2016). The average American eats 741 pounds of fresh fruits and vegetables yearly, which has climbed by at least 25% over the past two decades. Salad vegetable consumption in Europe is growing by 10% annually on average. In addition, the intake of raw fruit and vegetables has been related to an increase in various global epidemics caused by food-borne diseases (Sathe, Rajput, Gunaga, Patel, & Bendre, 2019).

In Bangladesh, food-borne related epidemics are most commonly caused by enteropathogenic E. coli, enterotoxigenic E. coli, and Vibrio cholerae, all of which are commonly found in tainted fresh produce. More than a third of Bangladeshi children younger than five suffer from food-borne illnesses each year. Consequently, over the past two decades, there has been a rise in the number of cases of food poisoning in Bangladesh that are traced back to eating fresh fruits. Frequent washing during post-harvest processing effectively removes soil and debris, but not harmful bacteria, which can contaminate other foods, cookware, and utensils Adebayo-Tayo, Olomitutu, & Adebami, 2021). When it comes to assessing the rising risk that worries both monitoring authorities and food consumers, microbiological investigation is a crucial tool. Washing fresh fruits and vegetables with a disinfectant is crucial for lowering germ burdens (Christiana Cudjoe, Balali, Titus, Osafo, & Taufiq, 2022). Several methods for cleaning freshly cut produce have been investigated. These methods include both physical and chemical treatments. The chlorinated solution is used to clean produce before it is eaten. As a liquid, chlorine is most common because of its inexpensive price and portability (Orji, Ayogu, Amaobi, Moses, Elom, Uzoh, & Igwe, 2021). Water with added organic acids, most likely acetic acid, citric acid, and sorbic acid, has also been demonstrated to decrease the microbial load on produce.

However, fresh-cut vegetables and fruits in Bangladesh seldom have microbial contamination reported (Chukwu, Nwaokorie, Coker, Avila-Campos, Solis, Llanco, & Ogunsola, 2016).). Similarly, 63 confirmed cases of Salmonella food illness were linked to watermelon imported from Brazil and consumed in Europe. Slicked watermelons from Nigerian street vendors have been found to have aerobic counts of between 0.1 and 2.3 105 CFU g1 on average, according to a study conducted to assess their microbiological quality (Beuchat, 2002). Staphylococcus aureus, Klebsiella sp., Salmonella sp., and Escherichia coli were recovered from carrots, runner bean, cucumber, fresh cut pineapple, green pepper, cabbage, spring onions, lettuce, watermelon, and apple in ranges between 9.0 105 and 3.0 107 CFU/ml in another Nigerian investigation (Beuchat, 2002). In addition, researchers in the Accra Metropolitan Area found a significant prevalence of Escherichia coli (36%), Staphylococcus aureus (33%), Klebsiella sp. (17%), and Bacillus sp. (15%) in raw-mixed vegetable salads. Despite widespread knowledge of the risks associated with consuming contaminated produce, little data exists in Ghana about the microbiological safety of fruits and vegetables sold in polyethene bags from street vendors. This research aimed to analyse the microbiological quality of sliced Pawpaw and watermelon supplied by street vendors in Accra that use polyethylene packaging.

In addition to being essential to human health, fruits are an exceptional nutritional source of minerals, micronutrients, vitamins, and fibre. Vitamin C and A deficiency and the development of numerous diseases may be avoided by consuming a well-balanced, fruit-rich diet [24]. Contact with soil, dust, and water, as well as improper harvesting and post-harvest handling, are significant sources of fruit microbial contamination. As a result, they provide a home for a wide variety of microorganisms, including diseases (Aluko, Ojeremi, Olaleke, & Ajidagba, 2014). Fruits sold by hawkers or vendors at farmers’ markets and other outdoor venues are often pre-sliced or peeled and packaged for easy consumption straight from the vendor’s wares (Buck, 2018). Small polyethene bags are the standard retail packaging for them. Vended fruit consumption in Nigeria has increased dramatically in recent years. This is because they are less expensive than whole fruits while being convenient and readily available. Other causes include the hectic pace of modern life, industry rise, recession, materialism, and a general lack of time to make a healthy, home-cooked dinner (Sathe, Rajput, Gunaga, Patel, & Bendre, 2019). The rising consumption rates and the potential health problems they may cause are a significant cause for alarm.

Most of the time, it is hard to verify the cleanliness of the processing facilities or the processors. This is aggravated by the fact that vended fruits are produced without suitable storage conditions, exposing the fruits to flies, dust, and other infections (Aluko, Ojeremi, Olaleke, & Ajidagba, 2014). Unlicensed vendors or local hawkers with little to no training in food hygiene sell fruits such as watermelon, pineapple, carrots, cucumber, and tiger nuts (also called aki Hausa) (Edeghor, John, & Origbu, 2019). This raises the danger of food poisoning from various microorganisms, including Salmonella, Staphylococcus aureus, and Enterobacteriaceae (Iacumin, & Comi, 2019). Furthermore, these diseases may infiltrate the fruit when processed, packaged, handled, or marketed (Aluko, Ojeremi, Olaleke, & Ajidagba, 2014). Including fruit in your daily diet has been suggested due to the many health benefits they provide. However, proper sanitation measures are often overlooked during the fresh fruit harvesting and processing phases, which result in ready-to-eat or vending machine-ready versions of the fruit. Pathogens have an easy time invading them as a result. Also, street vendors who lack proper training often place the fruits they sell on display or hawk them while using dirty or unclean equipment. Consumers are in danger from this. Consequently, some microbial assessments have been conducted to ascertain the safety of these vented fruits, making it necessary to capitalise on the results of some of these microbial assessments on vented fruits to educate consumers on the impact of their consumption and reduce risk by increasing the quality of these fruits. This will help reduce some health problems, illness outbreaks, and deaths (Amoah, & Simatele, 2021).

Vitamins, minerals, and other nutrients found in the earth are abundant in our daily foods. There may be health benefits for the population as a whole when people eat fresh fruit and drink fruit juices (Abadias et al., 2008). A perfect diet rich in fruits and vegetables can lower the chance of developing certain chronic diseases. A well-balanced diet rich in fruits and vegetables should be taken to prevent vitamin deficiencies, establish a blood lipid profile and detoxify the human body (Yafetto, Ekloh, Sarsah, Amenumey, & Adator, 2019). Eating sufficient vegetables, fruits, and fruit juices also controls blood pressure, lowers the risk of heart illnesses, reduces blood cholesterol levels and avoids some kinds of cancer (Adebukola, Opeyemi, & Ayodeji, 2015).

Fruits and fruit juices sold by street sellers or hawkers are "ready-to-eat" foods that customers can purchase and consume without preparing the ingredients at home by cutting, peeling, or rinsing (Savelli, Bradshaw, Ben Embarek, & Mateus, 2019).). Street food is the primary source of nutrition for the poor and middle class in developing countries. As entire fruits have increased in price, availability, and difficulty to transport, the use of fresh chopped fruits has increased. Fresh-cut fruits and vegetables, such as hog plum, cucumber, carrot, green mango, and pineapple, are commonly sold on the streets of Dhaka, the capital city of Bangladesh. Bacterial infections can enter these foods through punctures, wounds, and splits while growing or being harvested (Abadias et al., 2008). The total Viable Bacterial Count was evaluated using nutrient agar (DifcoTM, USA, PH 7.0-7.4) (TVBC). The preparation of the media followed the guidelines provided by the manufacturer. To recap, we autoclaved all our media at 121 degrees Celsius for 15 minutes to kill anything other than Salmonella and Shigella. Preparation of the Salmonella-Shigella agar required 15 minutes of boiling. Each sample was diluted appropriately, and then 100 l of the homogenate was pipetted into the appropriate culture medium and spread with a sterile glass spreader. The plates were inoculated and incubated at 370C for 24 to 28 hours. Once the plates had been incubated, the number of colonies on them could be recorded. TBC was calculated by multiplying the mean colony count by the dilution factor for a given concentration. Counts of microorganisms in fresh-cut produce and fruit juices were reported as cfu/g and cfu/ml, respectively (Amoah, & Simatele, 2021).

The same procedure was used to tally the total coliforms (TCC) in a sample cultured on MacConkey agar (Acumedia, USA) media. The TSS was determined by incubating Salmonella-shigella agar (Scharlau, Spain) at 370C for 24 to 28 hours. The cfu/g and cfu/ml values were calculated as the mean of at least three separate trials. The total coliform count (TCC) ranged from 1.0 x 103 to 4.9 x 102 cfu/g on average in fruit samples. The number of TCC in pineapple was lowest (1.0x101 cfu/g), whereas the number in guava was highest (4.9x102 cfu/g). Contrary to what the European Union Commission Regulation recommended, TCC was found to be excessively high in this investigation (2005). The total coliform count (TCC) in pineapple was reported to be 2.0 x 105 cfu/g by [33]. TCC levels in salad greens ranged from 2.60102 to 6.60102 cfu/g. The number of TCCs was lowest in tomatoes (3.9 x 103 cfu/g) and highest in carrots (4.3 x 103 cfu/g). Salad veggies, such as tomato and cucumber, were found to be infected with total coliforms by Alam et al. (2013) when purchased from vegetable markets. All the juice samples had total coliform counts (TCCs) between 2.3 x 102 and 3.7 x 103 cfu/ml. Sugarcane juice had the lowest TCC (6.3x104 cfu/ml), while lot symbol juice had the highest TCC (1.4x105 cfu/ml). One of the primary sources for the presence of coliforms in street meals is the washing and processing of water contaminated with faecal coliform. A study found that sugarcane, lime, carrot juice, apple, orange, pineapple, pomegranate, sweet lemon, and mixed fruit juice are often consumed in Mumbai, India (Yafetto, Ekloh, Sarsah, Amenumey, & Adator, 2019).

1. **Materials and Methods**

The study hinges on the positivist paradigm to anchor scientific investigation on the assumption that the world around us is accurate and that we can learn about it. Positivist researchers further believe that research is used to uncover an existing reality (Supramanium, 2021). This study employed the quantitative research approach and a descriptive cross-sectional study design to examine microbial load in some selected cut and vented fruits in the Tamale Metropolis. The study population consists of one hundred and thirty-one (131) vendors registered with the Health Directorate of the Metropolis who sell watermelons, oranges, Pawpaw, pineapples, mangoes and apples.

**2.1 Collection of Samples**

Thirty (30) samples of freshly cut fruits were conveniently purchased from fruit vendors within the Tamale Metropolis. The samples were wrapped in sterile ziplock polythene bags and labelled for identification according to the fruit, area, and vendor. They were immediately frozen and finally transported to the Food and Research Institute in the ice chest for laboratory analysis after the total sample was collected. This is because it is a standard laboratory that will give reliable results.

**2.1.1 Sample preparation**

For all samples (Pawpaw and watermelon), 10 g were homogenised 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 the 30s at normal speed. From appropriate ten-fold dilutions, *Aerobic mesophiles* were enumerated by pour plate on Plate Count Agar (Oxoid CM438 Oxoid Ltd., Basingstoke, Hampshire, UK), incubated at 300C for 72 h according to NMKL No. 86 (2011). E. coli were enumerated by pouring a plate on Tryptone Soy Agar (Oxoid CM126), pH 7.3, overlaid with Violet Red Bile Agar (Oxoid CM118), pH 7.4 and incubated at 440C for 24 h. suspected *E. coli* colonies were sub-cultured on EC Broth (Oxoid CM853), pH 6.9, followed by Tryptone Water (Oxoid CM89), pH 7.5, all incubated at 440C for 24 h according to NMKL. No. 125 (2005).

*Staphylococcus aureus* was determined by a spread plate on Baird Parker Agar (BP, CM 275 Oxoid Ltd, Hampshire, England) with Egg Yolk Tellurite Emulsion (SR75) added and Blood Agar Base (BAB, CM 55 Oxoid Ltd, Hampshire, England). Both media were incubated at 370C for 48 h. S. biochemical tests confirmed aureus counts according to NMKL Method No. 66 (2009).

*Salmonella spp*. was determined by weighing 25 g of a sample and re-suspended using 225 mL Buffered Peptone Water (BPW, Condalab CAT) pH 7.4 and incubated at 370C (Lab Incubator, Model NE8-240S, England) for 24 h. After pre-enrichment in BPW (Condalab CAT), 0.1 mL portions were transferred into 10 mL Rappaport and Vassiliadis broth (RV, Condalab CAT) pH 7.2 and incubated at 41.90C (Lab Incubator, Model) for 24 hrs. After enrichment in RV, a loop full of the culture was streak-plated on Xylose Lysine Deoxycholate (XLD, Condalab CAT)), pH 7.2 and incubated at 370C (Model NE8-240S) for 24h. Well-isolated colonies giving typical reactions were considered presumptive *Salmonella* and were purified by streaking onto nutrient agar plates (Condalab CAT) and confirmed according to NMKL Method No.71 (1999). From each cut fruit sample, 25 g was aseptically transferred into a stomacher bag with 225 ml of *Listeria* primary enrichment broth (UVM I, CM 863 - SR 142E, Oxoid). Samples were homogenised for 2 min at normal speed with a Seward laboratory stomacher and then incubated at 300C for 24 or 48 hrs. Samples (0.1 ml) of the UVM I broth were also transferred into a secondary selective enrichment medium (10 ml of UVM II, CM 863 \_ SR 142E, Oxoid). After 24 hrs of incubation at 30 0C, 0.1-ml samples of this secondary enrichment were plated onto Oxford *Listeria* selective agar (LSA; CM 856 \_ SR 206E, Oxoid) and polymyxin–acriflavin–lithium chloride–ceftazidime–aesculin–mannitol agar (PALCAM, CM 877\_ SR 150E, Oxoid). Typical small brown-black colonies with sunken black centres and halos on Oxford LSA and grey-green colonies with sunken black centres and black halos on PALCAM agar were selected and confirmed according to ISO 1129O-2 (2017).

The collected data was edited, coded, and keyed into Statistical Package for Social Sciences (SPSS), version 22 statistical software for processing. Microsoft Excel 2010 was used to generate means and standard deviations for the microbial load for each sample taken from the ten vendors. A zero value was assigned for statistical analysis in cases where bacterial levels were below the detectable limit. Significant differences between means were calculated using one-way Analysis of Variance (ANOVA). A p-value ≤0.05 was considered as significant.

1. **Results and discussion**

This section presents results and discusses the research questions that guided the study: (1) what is the microbial load in freshly cut street fruits in the Tamale metropolis? (2) What health implications are associated with microbial load in sample cut fruits in the Tamale metropolis?

**3.1 Microbial Load in Sampled Freshly Cut Street Fruits**

This section was guided by research question one - what is the microbial load in freshly cut street fruits in the Tamale metropolis? The study collected data through laboratory analysis of fruit samples taken from participants to examine the microbial load of five pathogens isolated in freshly cut street fruits in the Tamale Metropolis. This was to determine the connection of respondents’ practices with the possible microbial load of the fruits examined. Thirty (30) samples of cut pawpaw and watermelon samples from different vendors collected at different locations and times of the day were analysed at the laboratory, and the findings are presented in Tables 1, 2 and 3.

**Table 1: Microbial population in CFUg-1 in freshly cut street fruit samples from respondents in the morning**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Fruits  Samples | *Aerobic*  *Mesophiles* | *E.Coli* | *Staphylococus*  *Aureus* | *Salmonella*  *Spp* | *Listeria Monocytoge* |
| TUS1W | 3.56±02 | 0 | 2.85±00d | ND | Detected |
| TUS2W | 4.75±02ab | 0 | 3.67±01a | ND | Detected |
| TCM3W | 4.52±02b | 0 | 3.66±01a | ND | Detected |
| TCM4P | 4.54±02b | 0 | 3.25±01bc | ND | ND |
| TCM5P | 3.98±01bc | 0 | 0 | ND | Detected |
| TCM6P | 3.99±06bc | 0 | 3.22±02c | ND | Detected |
| HACK7P | 5.41±02a | 0 | 0 | ND | ND |
| HACK8W | 5.43±06a | 3.66±0 | 3.49±02ab | ND | Detected |
| HACK9P | 3.52±02c | 0 | 0 | ND | Detected |
| HACK10W | 4.64±02ab | 0 | 2.66±01d | ND | ND |

**NOTE: TUS= Tamale Hospital Road, TCM= Tamale Central Market, HACK= Hawkers along Agric road to Choggu.** The numbers 1-10 represent the vendors, while W and P are watermelon and Pawpaw, respectively.

**ND= not detected.** This means that people who do not share a letter are significantly different.

Source: Field survey, (2022)

The mean bacterial count obtained from the freshly cut fruit samples at zero hours from ten vendors is presented in Table 1. Aerobic mesophilic count ranged from 3.52 to 5.43 log CFUg-1 in samples collected from the ten vendors. However, there was significant (p < 0.05) variation in aerobic mesophilic count among the vendors. The highest *aerobic mesophilic* count was recorded from vendor HACK7P, while the lowest was from Vendor HACK9P. *E. coli* was only detected in the freshly cut fruit sampled from HACK8W out of the ten vendors. HACK8W had a microbial population of 3.66 log CFUg1.There were significant (p < 0.05) differences in *Staphylococcus aureus* counts among the vendors. *Staphylococcus aureus* counts ranged from 2.6 to 3.6 log CFU/g. *Salmonella* was not detected in any of the freshly cut fruit samples from any of the ten different vendors over the day. *Listeria monocytogenes* was detected in seven out of ten different vendors: Vendor TUS1W (Detected), Vendor TUS2W (Detected), Vendor TCM3W (Detected), Vendor TCM5 (Detected), Vendor TCM6P (Detected) Vendor, HACK8W (Detected) and Vendor HACK9P (Detected).

**Table 2: Microbial population in CFUg-1 in freshly cut street fruit samples from respondents in the afternoon**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Fruits  Samples | *Aerobic*  *Mesophiles* | *E. Coli* | *Staphylococcus*  *Aureus* | *Salmonella*  *Spp* | *Listeria*  *Monocytogenes* |
| TUS1W | 4.41±01e | 0 | 2.91±01g | ND | Detected |
| TUS2W | 5.80±01bc | 0 | 3.82±01e | ND | Detected |
| TCM3W | 5.56±01cd | 0 | 4.73±01a | ND | Detected |
| TCM4P | 5.32±01cd | 0 | 3.62±01f | ND | ND |
| TCM5P | 5.20±01d | 0 | 0 | ND | Detected |
| TCM6P | 6.37±01ab | 0 | 4.24±02d | ND | Detected |
| HACK7P | 6.36±05ab | 0 | 0 | ND | ND |
| HACK8W | 6.38±00ab | 4.81 | 4.591±02b | ND | Detected |
| HACK9PW | 6.59±02a | 0 | 0 | ND | Detected |
| HACK10 | 6.65±04a | 0 | 4.301±00c | ND | ND |

**NOTE: TUS= Tamale Hospital Road, TCM= Tamale Central Market, HACK= Hawkers along Agric road to Choggu.** The numbers 1-10 represent the vendors, while **W** and **P** are watermelon and Pawpaw, respectively.

**ND= not detected.** This means that people who do not share a letter are significantly different.

Source: Field survey, (2022)

Aerobic mesophilic count at four hours ranged from 4.41 to 6.65 log CFUg-1 in samples collected from the ten vendors. However, there was significant (p < 0.05) variation in aerobic mesophilic count among the vendors. The aerobic mesophilic count was 1 log unit higher than the concentrations recorded on the corresponding vendors. *E. coli* was only detected in the freshly cut fruit sampled from HACK8W out of the ten vendors. HACK8W had a microbial population of 4.81log CFUg1. The *E. coli* count was 1 log unit higher than the concentrations recorded on the corresponding vendors. There were significant (p < 0.05) differences in *Staphylococcus aureus* counts among the vendors. *Staphylococcus aureus* counts ranged from 2.9 to 4.7 log CFU/g. *Salmonella* was not detected in any of the ten different vendors' freshly cut fruit samples. Listeria monocytogenes was detected in seven out of ten different vendors: Vendor TUS1W (Detected), Vendor TUS2W (Detected), Vendor TCM3W (Detected), Vendor TCM5P (Detected), Vendor TCM6P (Detected), Vendor HACK8W (Detected) and Vendor HACK9P (Detected) as showed in Table 2

**Table 3: Microbial load of fruits sampled from respondents in the evening**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Fruits Samples | *Aerobic*  *Mesophiles* | *E. Coli* | *Staphylococcus*  *Aureus* | *Salmonella spp* | *Listeria Monocytoge* |
| TUS1W | 6.67 ±00b | 0 | 4.87±01ac | ND | Detected |
| TUS2W | 6.61±02b | 0 | 4.70±00c | ND | Detected |
| TCM3W | 7.82±01a | 0 | 5.40±00abc | ND | Detected |
| TCM4P | 7.82±01a | 0 | 5.40±06abc | ND | ND |
| TCM5P | 7.13±06ab | 0 | 0 | ND | Detected |
| TCM6P | 7.73±04a | 0 | 5.48±00abc | ND | Detected |
| HACK7P | 7.45±02a | 0 | 0 | ND | ND |
| HACK8W | 7.80±00a | 5.75±01 | 5.87±00a | ND | Detected |
| HACK9P | 6,40±00b | 0 | 0 | ND | Detected |
| HACK10W | 7.45±00a | 0 | 5.65±00a | ND | ND |

**NOTE: ND= not detected.** This means that people who do not share a letter are significantly different**.**

Source: Field survey, (2022)

Aerobic mesophilic count at four hours ranged from 6.40 to 7.82 log CFUg-1 in samples collected from the ten vendors. However, the Aerobic mesophilic count was 2 log units higher than the concentrations recorded on the corresponding vendors. *E. coli* was only detected in the freshly cut fruit sampled from HACK8W out of the ten vendors. HACK8W had a microbial population of 5.75 log CFUg1. The *E. coli* count was 2 log units higher than the concentrations recorded on the corresponding vendors. There were significant (p < 0.05) differences in *Staphylococcus aureus* counts among the vendors. *Staphylococcus aureus* counts ranged from 4.7 to 5.8 log CFU/g. *Salmonella* was not detected in any of the ten different vendors' freshly cut fruit samples. Similar patterns wereobserved *in Listeria monocytogenes* detection in ten vendors, as shown in Table 3. ANOVA is used to compare the means and standard deviations of Tables 1, 2 and 3.

**3.1.1 Microbial load in freshly cut street fruits**

Tables 1, 2, and 3 above present the data of microbial populations of the ten (10) samples taken in the morning, afternoon and evening and corresponding standard values to help establish the health implications of the microbial load measured from the samples**.** In this study, of the 30 samples analysed, 26 samples (87%) showed unacceptable *Aerobic mesophilic* bacteria counts (>3log CFU/g), while four samples (13%) showed acceptable *Aerobic mesophilic* counts (<3log CFU/g). An increase in *Aerobic mesophilic* bacteria count to levels above 3log CFU/g could be due to the ambient temperatures from where the samples were collected, which is proximate to the optimum temperature for growth of most *Aerobic mesophiles*. Also, it could be due to inappropriate processing, poor handling and unhygienic practices. A previous study reported similar results for microbiological analyses of freshly cut fruit collected from vendors in South Ethiopia markets, and more than 87% of samples tested were above aerobic mesophilic counts of 3 log CFU/g [35]. Another study reported 20 32 freshly cut fruit samples (62.5%) obtained from Nigerian markets, with *Aerobic mesophilic* counts of 6.6log CFU/g [36]. However, another study in Nigeria reported a lower mean aerobic count of 2.05 CFU/ g [37]. The enumeration of *E coli* is a good indicator of the product's quality and expected shelf life [38]. Most freshly cut fruit samples (90%) showed acceptable enumeration of *E. coli* (< 1log CFU/ g), and just three samples of the freshly cut fruits recorded higher counts of *E coli* (3.6log CFU/ g, 4.2 CFU/ g and 5.7 CFU/ g respectively).

*Aerobic mesophilic* microorganisms found in food are one of the microbiological indicators for food quality. The presence of aerobic organisms reveals the existence of favourable conditions for the growth of microorganisms**.** The high aerobic mesophilic count recorded from freshly cut fruit from ten different vendors sampled in the morning, afternoon and evening could be due to contaminated water used in washing the fruits, inappropriate processing, poor handling and hygienic practices. Some of the samples from the vendors had loads which were above the standard requirement of both Ghana Standard Authority (< 5 logs CFU/g) and UK Public Health Laboratory Services (6 to < 7 logs CFU/g), except samples taken from vendors in the morning which were within the limit.

The data presented in Tables 1, 2 and 3, representing samples taken in the morning, afternoon and evening, showed a progressive increase in microbial load over the day. Samples for HACK8W, for example, recorded *Aerobic Mesophiles* valuesof5.43±06 a, 6.38± 00 ab and 7.80±00a, respectively, over the day.This suggests that as the day advances, aerobic conditions for microbial growth, such as the presence of moisture and warmth, and so do personal hygiene conditions of vendors who handle and process the fruits worsen over the day, making conditions favourable for them to multiply. This justifies why samples were collected at different times of the day. A similar study posits that aerobic mesophilic count ranged from 3.4to 4.8 log CFU/g in South Ethiopia (Abisso, & Gugero, 2018).). Also, the findings aligned with the previous study that aerobic mesophilic counts ranged from 5.4 to 6.6 log CFU/ g in Nigeria (Gómez-Govea, Ramírez-Ahuja, Contreras-Perera, Jiménez-Camacho, Ruiz-Ayma, Villanueva-Segura, & Rodríguez-Sánchez, I2022).). However, another study in Nigeria reported a lower mean aerobic count of 2.05 to 3.05 CFU/ g (Adebayo-Tayo, Briggs-Kamara, & Salaam, 2021).). When collecting data, the conditions prevailing at the setting are primarily responsible for the load recorded for the sample. HACK7P recorded an Aerobic mesophilic count of 5.41±02a, 6.36±05ab and 7.45±02a, respectively, over the three periods in the day when the samples were taken.This was the only pathogen detected in the samples collected for this respondent, which shows the high level of food and personal hygiene practice compared with the other respondents. This indicates that it is possible to have practices that would not compromise the safety of the fruits offered to consumers as vendors. This makes the fruits safe for consumption and prevents any food-borne disease outbreak within the setting. Notwithstanding, the presence of *Aerobic mesophiles* can also cause concern for food safety.

The maximum value for *E. coli* in fresh-cut fruit is 1 log CFU/g [39]. In the present study, thermos-tolerant coliforms detected could be due to poor hygienic practices and the use of water contaminated with faecal waste for washing utensils like knives and trays, and contaminated polythene bags used for the packaging of the fruits after slicing or cutting, and also exposure of these fruits to low temperatures which encourage the microbial growth of these pathogens. According to guidelines from the Health Protection Agency, *E. coli* counts in 25g of ready-to-eat fruits > 102 CFU/g are considered. Hence, all samples that show the presence of *E. coli* were considered unsatisfactory for consumption (Hossain, Akhtar, & Anwar, 2015).

Contamination of food by enteric pathogens can arise from the vendors if water contaminated with human sewage is used to wash fruits. Such threats are further amplified if the fruits are mishandled during processing and preparations where pathogens could increase exponentially under advantageous conditions (Carvalheira, Silva, & Teixeira, 2017). As most of these products are eaten raw, their high microbial content may represent a risk factor for the consumer’s health (Saksena, Malik, & Gaind, 2020). The limit value for *Staphylococcus aureus* in fresh-cut fruit is 1 log CFU/g (Soares, Correia, Delerue-Matos, & Barroso, 2017). The presence of *Staphylococcus aureus* in the sliced fruits could result from contamination from hands used for the processing and packaging of the sliced fruit and unhygienic practices. Improper handling of food with contaminated hands or other improper food handling practices, such as coughing or sneezing during food preparation, usually contributes significantly to food contamination by *Staphylococcus aureus* (Amoah, & Simatele, 2021).

A previous scientific study revealed that *Staphylococcus aureus* is isolated from street-vended fruit juices in Amravati, India. Previous researchers recorded *Staphylococcus aureus* counts of 3.13 log CFU/g to 4.69 log CFU/g in street food (Gitahi, Muriithi, Owuor, Diiro, & Mohamed, 2019).). *Staphylococcus aureus* is known to cause food poisoning and diseases characterised by nausea, vomiting, and diarrhoea [36]. Consuming food contaminated with staphylococcal endotoxins of loads exceeding 105 CFU g−1 can also be fatal (Aluko, Ojeremi, Olaleke, & Ajidagba, 2014).

The study, upon examining the microbial load of freshly cut street fruits**,** revealed that none of the participants’ fruits had *Salmonella* detected at the laboratory during the analysis. This was an acceptable result because it shows that the vendors did not pre-dispose the fruits to conditions that could cause food contamination by *Salmonella*. The present finding contradicts an earlier study that recorded the detection of *Salmonella* in freshly cut fruits sold in Nigeria (Jakubczyk, Kamińska-Dwórznicka, Ostrowska-Ligęza, Górska, Wirkowska-Wojdyła, Mańko-Jurkowska, & Bryś, 2021).

The presence of these microbes indicates that there has been a serious compromise, most probably because there are no severe regulations and monitoring by the bodies responsible, or probably because the consumers do not demand better conditions than what they are offered. Thus, there is a need for greater hygienic/sanitary control during the processing and marketing stages and proper and regular checks by the regulatory bodies, as potentially pathogenic microorganisms may pose a potentially serious public health risk among fruit consumers in the Metropolis.

**3.2 Determining the health implications of microbial load present in sample cut fruits**

This sub-section was also addressed by the research question - What health implications are associated with microbial load in sample cut fruits in the Tamale metropolis? This was done to determine the health implications of the microbial load present in the sample cut fruits from vendors. The health implications were analysed by comparing the microbial loads detected in the samples with the standard load limits as proposed by the Ghana Standard Authority. The comparison was not the only means of answering the question; the researcher also discussed the 95% confidence level results, leaving only a 5% error level. Tables 4, 5, and 6 present the tables with standard load limits and measured load limits for all samples taken in the morning, afternoon, and evening.

**Table 4: Microbial population in CFUg-1 in freshly cut street fruit samples from respondents in the morning and Standard values**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fruits samples | *Aerobic*  *Mesophiles* | | *E.Coli* | | *Staphylococcus*  *Aureus* | | *Salmonella*  *Spp* | | *Listeria Monocytoge* | |
| **Measured** | **Stand.** | **Measured** | **Stand.** | **Measured** | **Stand.** | **M** | **S** | **M** | **S** |
| TUS1W | 3.56±02 | 3logCFUg-1 | 0 | 2logCFUg-1 | 2.85±00d | 2logCFUg-1 | ND | ND | Detected | ND |
| TUS2W | 4.75±02ab | 3logCFUg-1 | 0 | 2logCFUg-1 | 3.67±01a | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM3W | 4.52±02b | 3logCFUg-1 | 0 | 2logCFUg-1 | 3.66±01a | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM4P | 4.54±02b | 3logCFUg-1 | 0 | 2logCFUg-1 | 3.25±01bc | 2logCFUg-1 | ND | ND | ND | ND |
| TCM5P | 3.98±01bc | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM6P | 3.99±06bc | 3logCFUg-1 | 0 | 2logCFUg-1 | 3.22±02c | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK7P | 5.41±02a | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | ND | ND |
| HACK8W | 5.43±06a | 3logCFUg-1 | 3.66±0 | 2logCFUg-1 | 3.49±02ab | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK9P | 3.52±02c | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK10W | 4.64±02ab | 3logCFUg-1 | 0 | 2logCFUg-1 | 2.66±01d | 2logCFUg-1 | ND | ND | ND | ND |

Source: Field survey, (2022)

**Table 5: Microbial population in CFUg-1 in freshly cut street fruit samples from respondents in the afternoon and Standard values**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fruits  Samples | *Aerobic*  *Mesophiles* | | *E. Coli* | | *Staphylococcus*  *Aureus* | | *Salmonella*  *Spp* | | *Listeria*  *Monocytogenes* | |
| **Measured** | **Stand.** | **M** | **Stand.** | **Measured** | **Stand.** | **M** | **S** | **M** | **S** |
| TUS1W | 4.41±01e | 3logCFUg-1 | 0 | 2logCFUg-1 | 2.91±01g | 2logCFUg-1 | ND | ND | Detected | ND |
| TUS2W | 5.80±01bc | 3logCFUg-1 | 0 | 2logCFUg-1 | 3.82±01e | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM3W | 5.56±01cd | 3logCFUg-1 | 0 | 2logCFUg-1 | 4.73±01a | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM4P | 5.32±01cd | 3logCFUg-1 | 0 | 2logCFUg-1 | 3.62±01f | 2logCFUg-1 | ND | ND | ND | ND |
| TCM5P | 5.20±01d | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM6P | 6.37±01ab | 3logCFUg-1 | 0 | 2logCFUg-1 | 4.24±02d | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK7P | 6.36±05ab | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | ND | ND |
| HACK8W | 6.38±00ab | 3logCFUg-1 | 4.81 | 2logCFUg-1 | 4.591±02b | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK9P | 6.59±02a | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK10W | 6.65±04a | 3logCFUg-1 | 0 | 2logCFUg-1 | 4.301±00c | 2logCFUg-1 | ND | ND | ND | ND |

Source: Field survey, (2022)

**Table 6: Microbial load of fruits sampled from respondents in the evening and Standard values**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fruits Samples | *Aerobic*  *Mesophiles* | | *E. Coli* | | *Staphylococcus*  *Aureus* | | *Salmonella spp* | | *Listeria Monocytoge* | |
| **Measured** | **Stand.** | **M** | **Stand.** | **Measured** | **Stand.** | **M** | **S** | **M** | **S** |
| TUS1W | 6.67 ±00b | 3logCFUg-1 | 0 | 2logCFUg-1 | 4.87±01ac | 2logCFUg-1 | ND | ND | Detected | ND |
| TUS2W | 6.61±02b | 3logCFUg-1 | 0 | 2logCFUg-1 | 4.70±00c | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM3W | 7.82±01a | 3logCFUg-1 | 0 | 2logCFUg-1 | 5.40±00abc | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM4P | 7.82±01a | 3logCFUg-1 | 0 | 2logCFUg-1 | 5.40±06abc | 2logCFUg-1 | ND | ND | ND | ND |
| TCM5P | 7.13±06ab | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | Detected | ND |
| TCM6P | 7.73±04a | 3logCFUg-1 | 0 | 2logCFUg-1 | 5.48±00abc | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK7P | 7.45±02a | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | ND | ND |
| HACK8W | 7.80±00a | 3logCFUg-1 | 5.75±01 | 2logCFUg-1 | 5.87±00a | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK9P | 6,40±00b | 3logCFUg-1 | 0 | 2logCFUg-1 | 0 | 2logCFUg-1 | ND | ND | Detected | ND |
| HACK10W | 7.45±00a | 3logCFUg-1 | 0 | 2logCFUg-1 | 5.65±00a | 2logCFUg-1 | ND | ND | ND | ND |

Source: Field survey, (2022)

Tables 4, 5, and 6 above present the data of microbial populations of the ten (10) samples taken in the morning, afternoon and evening and corresponding standard values to help establish the health implications of the microbial load measured from the samples. About the standard scores from GSS 955 of the Ghana Standards Authority, *Salmonella Spp* should not be detected in any of the samples by the standard. Based on the standard, therefore, the samples have met the standard of the regulatory body, with none of the samples recording a microbial load of *Salmonella spp in any of the periods.* On a similar account, *Listeria Monocytoge,* according to the standard, should not be detected in any of the samples. However, the results reveal that seven out of every ten samples had traces of *Listeria Monocytoge*. Fruit safety-wise, consuming these fruits can result in fruit-borne diseases caused by *Listeria Monocytoge.* The impacts of *Listeria Monocytoge* on different groups of persons cannot be ignored. The results for *Staphylococcus Aureus, E. Coli,* and *Aerobic Mesophiles* revealed that three samples of *Staphylococcus Aureus* met the standard level of microbial load, whereas, in the aspect of E. *Coli,* all but one sample failed to meet the standard load measure. Finally, all samples failed to find the standard load measure considering Aerobic Mesophiles. The dynamics in the samples for all the periods for which data was collected indicate that although some samples passed the standard levels of the microbial load, many samples had microbial traces in them. The findings clearly show that the patronage of fresh-cut fruits from streets may result in some fruit-borne diseases since some fruits may have high levels of microbial loads beyond the standard levels as recorded.

The health implications for the appropriate levels have various impacts on different groups of people. The presence of *Listeria Monocytoge is* capable of affecting pregnant women adversely if higher loads are found in them, resulting in miscarriages and stillbirths. Like the aged, people with weakened immune systems may experience meningitis (Lani, Ismail, Hasim, Alias, Mansor, Hassan & Zakeri, 2022). The presence of *Staphylococcus Aureus* load can result in skin infections (Pal, Gutama, & Koliopoulos, 2021).The presence of *E. Coli* is capable of causing diarrhoea diseaseamong consumers (Shenge, Whong, Yakubu, Omolehin, Erbaugh, Miller, & LeJeune, J. 2015). Bacteria in fruit have many health implications and require proper hygienic measures.

1. **Conclusion**

Based on the findings, out of the sampled fruits from the ten respondents, the mean values indicated seven samples had *Staphylococcus aureus* and at levels higher than the recommended by Ghana Standard Authority (< 3 logs CFU/g), and only one vendor had fruit with *E. coli* present. It was also revealed that only fruits from the three respondents sampled had no *Listeria monocyte*. The results showed that the standard scores from GSS 955 of the Ghana Standards Authority, *Salmonella Spp,* should not be detected in any of the samples by the standard. Based on the standard, therefore, the samples have met the standard of the regulatory body, with none of the samples recording a microbial load of *Salmonella spp in any of the periods.* On a similar account, *Listeria Monocytoge* should not be detected in any of the samples according to the standard. However, the results reveal that seven of the ten samples had traces of *Listeria Monocytoge*. Fruit safety-wise, consuming these fruits can result in fruit-borne diseases caused by *Listeria Monocytoge*. The impacts of *Listeria Monocytoge* on different groups of persons cannot be ignored.

The results for *Staphylococcus Aureus, E. Coli,* and *Aerobic Mesophiles* revealed that three samples of *Staphylococcus Aureus* met the standard level of microbial load, whereas, in the aspect of E. *Coli,* all but one sample failed to meet the standard load measure. Finally, all samples failed to find the standard load measure considering Aerobic Mesophiles. The dynamics in the samples for all the periods for which data was collected indicate that although some samples passed the standard levels of the microbial load, many samples had microbial traces in them. The findings clearly show that the patronage of fresh-cut fruits from streets may result in some fruit-borne diseases since some fruits may have high levels of microbial loads beyond the standard levels as recorded.

**Data Availability Statement:** Data is available on request from the corresponding author.

**References**

Abadias, M., Usall, J., Anguera, M., Solsona, C., & Viñas, I. (2008). Microbiological quality of fresh, minimally-processed fruit and vegetables, and sprouts from retail establishments. *International journal of food microbiology*, *123*(1-2), 121-129.

Abisso, T. G., & Gugero, B. C. (2018). In vitro Study to Evaluate Inhibitory Effect of Garlic (Allium sativum) on Staphylococcus aureus and Salmonella typhi Bacterial Strain. *J Plant Physiol Pathol 6*, *3*, 2.

Abbott, D. (2019). Save the Children Feed the Future Ethiopia Growth through Nutrition Activity National Food Safety Landscape and Rural Households Food Safety Practices in Ethiopia: Assessment Report https://pdf. USAID. Gov/pdf\_docs. *PA00ZCDK. pdf*.

Aboloma, R. I., Egbebi, A. O., Fajilade, T. O., & Adewale, Y. A. (2016). Mycological analysis of rice from stores in Igbemo-Ekiti (a rice-producing area) of Ekiti State, Nigeria. *Microbiology Research International*, *4*(4), 63-68.

Adebayo-Tayo, B. C., Briggs-Kamara, A. I., & Salaam, A. M. (2021). Phytochemical composition, antioxidant, antimicrobial potential and gc-ms analysis of crude and partitioned Nigella sativa seed extract fractions. *Acta Microbiol. Bulg*, *37*, 34-45.

Adebayo-Tayo, B. C., Olomitutu, F. O., & Adebami, G. E. (2021). Journal of Agriculture and Food Research. *Journal of Agriculture and Food Research*, *6*, 100202.

Adebukola, O. C., Opeyemi, A. O., & Ayodeji, A. I. (2015). Knowledge of food-borne infection and food safety practices among local food handlers in Ijebu-Ode Local Government Area of Ogun State. *Journal of Public Health and Epidemiology*, *7*(9), 268-273.

Addo-Tham, R., Appiah-Brempong, E., Vampere, H., Acquah-Gyan, E., & Gyimah Akwasi, A. (2020). Knowledge of food safety and food-handling practices of street food vendors in Ejisu-Juaben municipality of Ghana. *Advances in Public Health*, *2020*.

Aglidza, E. M. (2019). *Assessment of hygienic practices among street food vendors in Sekondi, Ghana* (Doctoral dissertation, University of Cape Coast).

Akabanda, F., Hlortsi, E. H., & Owusu-Kwarteng, J. (2017). Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. *BMC Public Health*, *17*, 1-9.

Al-Kharousi, Z. S., Guizani, N., Al-Sadi, A. M., & Al-Bulushi, I. M. (2019). Antibiotic resistance of Enterobacteriaceae isolated from fresh fruits and vegetables and characterisation of their AmpC β-lactamases. *Journal of Food Protection*, *82*(11), 1857-1863.

Aluko, O. O., Ojeremi, T. T., Olaleke, D. A., & Ajidagba, E. B. (2014). Evaluation of food safety and sanitary practices among food vendors at car parks in Ile Ife, southwestern Nigeria. *Food Control*, *40*, 165-171.

Amoah, L. N. A., & Simatele, M. D. (2021). Food security and coping strategies of rural household livelihoods to climate change in the eastern cape of South Africa. *Frontiers in Sustainable Food Systems*, *5*, 692185.

Bakobie, N., Addae, A. S., Duwiejuah, A. B., Cobbina, S. J., & Miniyila, S. (2017). Microbial profile of common spices and spice blends used in Tamale, Ghana. *International journal of food contamination*, *4*, 1-5.

Beuchat, L. R. (2002, August). Difficulties in eliminating human pathogenic microorganisms on raw fruits and vegetables. In *XXVI International Horticultural Congress: Horticulture, Art and Science for Life-The Colloquia Presentations 642* (pp. 151-160).

Buck, P. (2018). The role of consumer advocacy in strengthening food safety policy. *Food safety economics: Incentives for a safer food supply*, 323-358.

Carvalheira, A., Silva, J., & Teixeira, P. (2017). Lettuce and fruits are a source of multidrug-resistant Acinetobacter spp. *Food Microbiology*, *64*, 119-125.

Christiana Cudjoe, D., Balali, G. I., Titus, O. O., Osafo, R., & Taufiq, M. (2022). Food safety in sub-Sahara Africa, an insight into Ghana and Nigeria. *Environmental Health Insights*, *16*, 11786302221142484.

Chukwu, E. E., Nwaokorie, F. O., Coker, A. O., Avila-Campos, M. J., Solis, R. L., Llanco, L. A., & Ogunsola, F. T. (2016). Detection of toxigenic Clostridium perfringens and Clostridium botulinum from food sold in Lagos, Nigeria. *Anaerobe*, *42*, 176-181.

Edeghor, U., John, G. E., & Origbu, C. (2019). Bacteriological profile of cut fruits sold in Calabar Metropolis. *World News of Natural Sciences*, *23*.

Gómez-Govea, M. A., Ramírez-Ahuja, M. D. L., Contreras-Perera, Y., Jiménez-Camacho, A. J., Ruiz-Ayma, G., Villanueva-Segura, O. K., ... & Rodríguez-Sánchez, I. P. (2022). Midgut microbiota suppresses pyrethroid susceptibility in Aedes aegypti*—Frontiers in Microbiology*, *13*, 761459.

Gitahi, D. W., Muriithi, B. W., Owuor, G., Diiro, G., & Mohamed, S. (2019). Willingness to pay for an integrated pest management strategy to suppress citrus infesting false codling moth, African citrus Trioza and greening disease among citrus producers in Kenya.

Havelaar, A. H., Kirk, M. D., Torgerson, P. R., Gibb, H. J., Hald, T., Lake, R. J., ... & World Health Organization Food-borne Disease Burden Epidemiology Reference Group. (2015). World Health Organization global estimates and regional comparisons of the burden of food-borne disease in 2010. *PLoS medicine*, *12*(12), e1001923.

Hossain, M. F., Akhtar, S., & Anwar, M. (2015). Health hazards posed by the consumption of artificially ripened fruits in Bangladesh. *International Food Research Journal*, *22*(5).

Iacumin, L., & Comi, G. (2019). Microbial quality of raw and ready-to-eat mung bean sprouts produced in Italy. *Food microbiology*, *82*, 371-377.

Jakubczyk, E., Kamińska-Dwórznicka, A., Ostrowska-Ligęza, E., Górska, A., Wirkowska-Wojdyła, M., Mańko-Jurkowska, D., ... & Bryś, J. (2021). Different compositions of apple puree gels and drying methods were applied to fabricate snacks with modified structures, storage stability, and hygroscopicity. *Applied Sciences*, *11*(21), 10286.

Lani, M. N., Ismail, A., Hasim, N. N., Alias, R., Mansor, A., Hassan, Z., & Zakeri, H. A. (2022). Antagonistic Activity and Surface Decontaminant Potential of Lactic Acid Bacteria from Fermented Oreochromis niloticus.

Karam, L., Salloum, T., El Hage, R., Hassan, H., & Hassan, H. F. (2021). How can packaging, source, and food safety management systems affect the microbiological quality of spices and dried herbs? The case of a developing country. *International Journal of Food Microbiology*, *353*, 109295.

Kumar, M., Agarwal, D., Ghosh, M., & Ganguli, A. (2006). Microbiological safety of street vended fruit chats in Patiala city*—Indian Journal of Medical Microbiology*, *24*(1), 75.

Mahfuza, I., Arzina, H., Kamruzzaman, M. M., Afifa, K., Afzal, H. M., Rashed, N., & Roksana, H. (2016). Microbial status of street vended fresh-cut fruits, salad vegetables and juices in Dhaka city of Bangladesh. *International Food Research Journal*, *23*(5).

Ministry of Food and Agriculture/World Bank (2006). Revised Food Safety Action Plan.

Ogofure, A., Bello-Osagie, I., Ahonsi, C., Ighodaro, V., & Emoghene, A. (2017). Bacteriological assessment of ready-to-eat Pawpaw (Carica papaya) sold in selected locations in Benin City. *African Science*, *18*, 157-162.

Olaimat, A. N., Shahbaz, H. M., Fatima, N., Munir, S., & Holley, R. A. (2020). Food safety during and after the era of COVID-19 pandemic. *Frontiers in microbiology*, *11*, 1854.

Oranusi, S., & Dahunsi, S. O. (2015). Preliminary study on Kokoro's hazards and critical control points, a Nigerian Indigenous fermented maise snack. *SpringerPlus*, *4*, 1-10.

Orji, J. O., Ayogu, T. E., Amaobi, C. B., Moses, I. B., Elom, E. E., Uzoh, C. V., ... & Igwe, C. P. (2021). Effect of bacteriocins from lactic acid bacteria obtained from Zea mays-based Ogi on food-borne bacteria from contaminated cabbage. *African Journal of Microbiology Research*, *15*(8), 440-446.

Oyedele, O. A., Akinyemi, M. O., Kovač, T., Eze, U. A., & Ezekiel, C. N. (2020). Food safety in the face of climate change: Consequences for consumers. *Croatian journal of food science and technology*, *12*(2), 280-286.

Pal, M., Gutama, K. P., & Koliopoulos, T. (2021). Staphylococcus aureus, an important pathogen of public health and economic importance: A comprehensive review. *Journal of Emerging Environmental Technologies and Health Protection*, *4*(2), 17-32.

Pesewu, G. A., Agyei, J. N., Gyimah, K. I., Olu-Taiwo, M. A., Osei-Djarbeng, S., Codjoe, F. S., & Ayeh-Kumi, P. F. (2014). Bacteriological assessment of the quality of raw-mixed vegetable salads prepared and sold by street food vendors in Korle-Gonno, Accra Metropolis, Ghana. *Journal of Health Science*, *2*(2), 560-566.

Reddi, S. L., Kumar, R. N., Balakrishna, N., & Rao, V. S. (2015). Microbiological quality of street vended fruit juices in Hyderabad, India and their association between food safety knowledge and practices of fruit juice vendors. *International Journal of Current Microbiology and Applied Sciences*, *4*(1), 970-982.

Shenge, K. C., Whong, C. M., Yakubu, L. L., Omolehin, R. A., Erbaugh, J. M., Miller, S. A., & LeJeune, J. T. (2015). Contamination of tomatoes with coliforms and Escherichia coli on farms and in markets of northwest Nigeria. *Journal of Food Protection*, *78*(1), 57-64.

Saksena, R., Malik, M., & Gaind, R. (2020). Bacterial contamination and prevalence of antimicrobial resistance phenotypes in raw fruits and vegetables sold in Delhi, India. *Journal of Food Safety*, *40*(1), e12739.

Sathe, P. S., Rajput, J. D., Gunaga, S. S., Patel, H. M., & Bendre, R. S. (2019). Synthesis, characterisation, and antioxidant activity of thymol-based paracetamol analogues. *Research on chemical intermediates*, *45*, 5487-5498.

Savelli, C. J., Bradshaw, A., Ben Embarek, P., & Mateus, C. (2019). The FAO/WHO International Food Safety Authorities Network in review, 2004–2018: Learning from the Past and Looking to the Future. *Food-borne pathogens and disease*, *16*(7), 480-488.

Soares, C., Correia, M., Delerue-Matos, C., & Barroso, M. F. (2017). Investigating the antioxidant capacity of fruits and fruit byproducts through an introductory food chemistry experiment for high school. *Journal of Chemical Education*, *94*(9), 1291-1295. [39] GSA, 2018)

Supramanium, S. (2021). Influence of Leadership Styles on Employee Performance in Food Safety and Health in Malaysia.

Ugwu, C., & Edeh, P. (2019). Evaluation of microbial quality of ready-to-eat fruits sold in different markets of Enugu Metropolis, Enugu State, Nigeria. *International Journal of Innovative Research and Advance Studies*, *6*, 48-52.

Yafetto, L., Ekloh, E., Sarsah, B., Amenumey, E. K., & Adator, E. H. (2019). Microbiological contamination of some fresh leafy vegetables sold in Cape Coast, Ghana. *Ghana Journal of Science*, *60*(2), 11-23.

Yeleliere, E., Cobbina, S. J., & Abubakari, Z. I. (2017). Review of microbial food contamination and food hygiene in selected capital cities of Ghana. *Cogent Food & Agriculture*, *3*(1), 1395102.