

## Assessment of Bacterial Contaminants in Some Sliced Fruits Sold in Kaduna, Nigeria

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Food borne illnesses have been attributed to the increase in consumption of contaminated sliced fruit. This study was aimed at evaluating the bacteriological quality of sliced fruits sold in Kaduna, Nigeria. Sixty samples were purchased from ten different markets and analysed using standard microbiological methods. Mesophilic bacteria were enumerated as markers of food- borne microbial contamination. Using proximate analysis based on the manufacturer's instruction, result in this study shows that Orange had the highest protein content of (16.51 %), fat content (2.78%) and carbohydrate content (10.30%) while Pineapple had highest moisture contents (83.03%). From the mesophilic count, Pawpaw was found to be the most heavily contaminated followed by watermelon, pineapple and then orange. Percentage occurrence of bacterial isolates of the fruits analysed indicates that, Pawpaw had the highest *Escherichia coli* contaminants (20.45%), indicating faecal contamination likely be from contaminated water used in washing and processing. Also, *Pseudomonas* species (11.36%), *Staphylococcus* species (18.8%), and *Shigella* species (22.73%) all had highest isolation from Pawpaw samples. Pineapple had the highest *Lactobacillus* species (13.88%). This could be because it thrives well in an acid medium. Watermelon had the highest *Salmonella* species (25.64%). In conclusion, all the fruits analysed contained protein, fat, ash, carbohydrate and moisture and as such can be taken as supplements. As a result of heavy contamination observed in the samples analysed, sliced fruits sold by vendors in Kaduna metropolis are said to be unsafe for human consumption, hence the need for proper microbiological safety analysis of fruits for human consumption.

**Keywords:** Assessment, Bacterial, Contaminants, Proximate analysis, Sliced fruits

### INTRODUCTION

Sliced fruits are fruits that have been cut open and also sliced into bits but remain in its fresh slate and displayed for sale and for consumption (Abadias *et al.*, 2018). According to the International Fresh-Cut Produce Association (IFPA), fresh-cut fruit and vegetable products (FEVP) are defined as fruits or vegetables that have been trimmed, peeled or cut into a 100% usable product which has been packaged to offer consumers high nutrition and flavour, while still maintaining its freshness (Rico *et al.*, 2007). Such fruits are directly purchased from the roadside vendors or hawkers or at local market without necessarily/ having to undergo any further treatment before consumption (Barro *et al.*, 2016). In Nigeria, fruits are popularly displayed completely exposed for sales along busy and major streets and hawked by street food vendors in motor parks and markets.

Sliced fruits are commonly processed and sold by unlicensed vendors with poor educational levels and untrained in food hygiene and have been on the increase in many developing countries due to lack of formal jobs for the working age groups (Bukar *et al.*, 2017). However, the increase in consumption of sliced fruits has been linked with a parallel increase in food borne illness (Eni *et al.*, 2015). Fruits are known to

carry a natural non-pathogenic micro flora and have an epidermal layer of cells which provides a barrier for penetration of microorganisms. Cutting and slicing can eliminate the protections and microbes can invade the internal tissue. Thus, unsanitary processing and preservative methods could increase the possibilities of contamination (Allamin *et al.*, 2015).

Poorly processed sliced fruits have been identified to encourage sporadic visits by flies, cockroaches, rodents and dust and also an important cause of death in developing countries (Abadias *et al.*, 2018). Most bacteria species are known to be common environmental contaminants and bacteria that cause gastroenteritis can contaminate the sliced produce, thus exposing consumers to greater risk (Ali *et al.*, 2020).

Bacteria which is a member of a large group of unicellular microorganisms that could be Gram negative or Gram positive and includes *Escherichia coli*, *Bacillus* species, *Enterobacter* species, *Pseudomonas aeruginosa*, *Proteus*, *Micrococcus*, *Lactobacillus* species., *Staphylococcus aureus*, *Salmonella* species, *Shigella* species, and *Campylobacter* species, etc., have been isolated and known to contaminate sliced fruits could be traced through contact with sewage, contaminated water, packaging nylon, tray and contaminated knives

(Abadias *et al.*, 2018) . Some of these bacteria are known to be spore formers and thus can easily contaminate sliced fruits when not properly processed. However, this is worsened by the fact that sliced fruit street vending is done without adequate storage conditions, thereby exposing the sliced fruits to flies and other disease-causing agents, which when consumed cause health risk (Nwachukwu *et al.*, 2008), hence, a major reason for this study.

## LITERATURE REVIEW

### Nutritional Quality of Fruits

Fruits are good dietary source of nutrients, micronutrients, vitamins and fibre for humans and are thus vital for health and are also rich in vitamins, minerals, antioxidants and other phytonutrients. Fruits are essential parts of people's diet and are vital for health and well-being as it reduce the risk of several diseases (Bukar *et al.*, 2017). Well balanced diets, rich in fruits and vegetables, are especially valuable for their ability to prevent vitamins C and A deficiencies and are also reported to reduce the risk of several diseases (Allamin *et al.*, 2015).

Fresh and minimally processed fruits provide most of our daily requirements for vitamins, minerals and fibre and their role in reducing the risk of lifestyle associated illnesses such as heart disease, diabetes and cancer has resulted in a further increase in their desirability and consumption (Ali *et al.*, 2020). World Health Organisation, (2023), have recommended 5 -9 servings of fruits and vegetables to be taken daily because correct fresh produce intake alone could save 2.7 million lives a year because 31 % of heart disease cases are due to an insufficient intake of fresh produce. As a result of this recommendation, fruit and vegetable consumption increased by 29% per capital in the USA between 1980 and 2000 (Koffi *et al.*, 2021). Also, in South Africa, the Department of Health is promoting the consumption of fruits and vegetables through its '5-a- Day' eating programme, namely, consumption of least five portions of vegetables and fruit every day (Olu-Taiwo *et al.*, 2021).

However, unlike in the USA, where they are generally consumed by the majority of the population, fruits and vegetables are seldom consumed by economically and socially deprived communities in developing countries like Nigeria. Instead, dietary intakes and plant-based staple foods are consumed more often (Ali *et al.*, 2020). In view of the nutritional benefits of fruits, this study is aimed at determining the nutritional content of some fruits commonly consumed in Kaduna State of Nigeria.

### Sliced Fruits Contamination

Sliced Fruits products are becoming more popular both locally and globally as they are more popular both locally and globally as they are handier, accessible, and

economical (Nwachukwu & Osuocha, 2014). Fruits that have been cut open or sliced open, packaged in small white polyethylene bags, and carried around by streets sellers or hawkers at local markets or streets are known as retailed cut fruits. Such fruits can be eaten right away without needing to be sliced, peeled or rinsed.

Sliced fruits are commonly exhibited entirely exposed for sale at Nigerian shopping malls, markets, and congested roads/ major streets, security checkpoints, and poor sections on highways where cars are forced to slow down (Allamin *et al.*, 2015).

When cut fruits are produced without proper storage conditions, they are exposed to flies, ants, dust, and other microbiological diseases, making the situation much worse (Barro *et al.*, 2006). Pathogens such as bacteria [*Salmonella species*, *Staphylococcus aureus*, *Enterobacteriaceae*], fungi, viruses, and parasites cause some of these disorders, which increase the risk of food-borne diseases (Orji *et al.*, 2016). As a result, microbial contamination of such fruits is widespread due to contact with soil, dust, air, and water, as well as poor harvest and postharvest management techniques. Punctures, wounds, and cuts may potentially allow pathogenic germs to enter the fruits through damaged surfaces (Barro *et al.*, 2006).

## MATERIALS AND METHODS

### Sample Collection

A total of 60 samples (Pawpaw, Pineapple, Watermelon and Orange) were randomly selected from 10 different points of sale at Central market in Kaduna Metropolis. Each sliced fruit was aseptically collected and placed in sterile polythene bag and put in an ice cooler. This was immediately transported for analysis in the Microbiology laboratory of Kaduna State University.

**Preparation of Sample:** Ten grams (10g) of each sample was measured with the aid of a weighing balance and subsequently transferred into a blender. Ninety millilitres (90ml) of distilled water was thereafter added and the mixture homogenized at the speed of 15,000 rpm for 3minutes. The homogenate was then transferred into a sterile conical flask. This procedure was separately repeated on each of the fruit samples. A measuring cylinder was next used to obtain 90 ml of sterile distilled water and this was introduced into each of the conical flasks containing the different fruit samples (AOAC, 2000).

### Proximate Determination

The samples were subjected to proximate analysis, these include: Moisture content determination, Ash content, Protein determination, Carbohydrate and Fat Content which were conducted as prescribed (AOAC, 2000).

**Isolation and Enumeration of Bacteria from the fruit samples:** 0.1ml of the 10<sup>-5</sup> dilution for each of the various fruit samples was inoculated in duplicate plates on Nutrient agar, Eosin methylene blue agar (EMB) and Salmonella Shigella agar (SSA) which were used for bacterial enumeration. The inoculums on each plate were spread using a sterile glass rod and the plates were inverted and incubated for 24-48 hours at 37°C. Thereafter, the plates were examined for growth while the morphological and microscopic features of the colonies were also noted. Enumeration of total bacteria count was done using the plate count method with the colonies counted and recorded as colony forming unit (cfu/g). Sub-culturing of each isolate was carried out until pure colonies were obtained. The pure cultures were then refrigerated at 4 °C (Cheesbrough, 2002).

**Identification of Bacteria**

Identification of bacterial isolates was done using Gram stain technique and biochemical test such as catalase, indole, citrate utilization, oxidase, methyl red and Voges- Proskauer test (Cheesbrough, 2002).

**Results and Discussion**

**Proximate composition of sample**

Table 1: Proximate composition of fruit samples

Fruit Sample	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Moisture (%)
Pawpaw	13.64	2.54	11.03	10.22	37.33
Watermelon	3.20	0.50	2.80	8.90	46.10
Pineapple	3.67	2.35	1.70	7.90	83.03
Orange	16.51	2.78	5.51	10.30	70.10

**Percentage Occurrence of Bacterial Isolates of the Fruit Samples**

Percentage occurrence of bacterial contaminants in each of the fruits is as shown in Table 2 below. Enteric contamination represented by *Salmonella*,

*Shigella* and *Escherichia coli* was observed to be high in all the fruits whereas *Lactobacillus* specie had the lowest bacterial load in the fruits.

For paw-paw fruit, the percentage occurrence of *Salmonella* and *Shigella* species was (25.64%) and (22.73%) respectively, followed by *E. coli* (20.45%), *Staphylococcus aureus* (18.18%), *Pseudomonas species* (11.36%), and *Lactobacillus species* (4.5%). Percentage occurrence of *Salmonella species* in watermelon was (25.64%), *Shigella species* (23.7%), *E. coli* (17.94%), *Staphylococcus aureus* (15.38%), *Pseudomonas species* (10.2 5%), and *lactobacillus species* (7.69%). Percent Occurrence in pineapple sample; *Salmonella* spp, *E. coli* and *Shigella* species were (22.22%) each. *Staphylococcus aureus* (16.66%), *Lactobacillus* spp (13.88%), and *pseudomonas species* (2.77%). Percentage occurrence in the orange samples, the *E. coli* was (33.33%), while *Pseudomonas*, *Salmonella*, *Shigella*, and *Staphylococcus aureus* were

The result of proximate composition of the sliced fruit samples sold in Kaduna Metropolis is presented in Table 1 below. Pawpaw had compositions of (13.64%) protein, (2.54%) fat, (11.03%) ash, (10.22%) carbohydrate and (37.33%) moisture. Watermelon had a composition of (3.20%) protein, (0.50%) fat, (2.80%) ash, (8.90%) carbohydrate and (46.10%) moisture. Pineapple had a composition of (3.67%) protein, (2.35%) fat, (1.70%) ash, (7.90%) carbohydrate, and (46.10%) moisture. Pineapple had composition of (3.67%) protein, (2.35%) fat, (1.70%) ash, (7.90%) carbohydrate, and (83.03%) moisture. Orange had a composition of (16.51%) protein, (2.78%) fat, (5.51%) ash, (10.30%) carbohydrate and (70.10%) moisture respectively.

The high protein, fat, Ash, moisture and carbohydrate contents observed in orange and pawpaw could be due to the high nutritional and mineral contents found in the fruits, which supported the growth of microorganisms, as observed in the mean counts of the fruits. The disparities observed in the proximate composition indices are similar to the findings of Akoma *et al.* (2013) and Oyewole *et al.* (2020) who reported that nutritional contents of fruits are essential requirements for the growth of microorganisms.

(16.67%) each. *Lactobacillus species* was not found in the orange samples.

The bacterial contaminants isolated are *Escherichia coli*, *Staphylococcus aureus*, *Lactobacillus* spp, *Pseudomonas* spp, *Salmonella* spp and *Shigella* species indicating the presence of coliforms. This result is in agreement with the result of Ikpebievie *et al.* (2020) who reported 58.8% occurrence of *Escherichia coli* and *Staphylococcus spp*, 47.1% of *Bacillus spp* and *Klebsiella spp*, and 41.2% *Staphylococcus aureus* and 5.9% of *Proteus spp* which had the least occurrence.

The previous study of Ajiboye and Emmanuel (2021) on vegetable and fruits contamination in Ilorin and Port Harcourt metropolis in Nigeria also agrees with the present study. The implication of this contamination is an increase in the number of human infections and outbreaks related to consumption of fruits and vegetables as observed by the studies of Mashak *et al.* (2015) and Berg *et al.* (2014).

The high level of faecal bacterial contaminants such as *Salmonella*, *Shigella* and *Escherichia coli* can be attributed to contaminated water used in washing the knives, trays, the fruits before peeling or slicing. It can also be linked to houseflies perching on the fruits

which are always found in large numbers hovering around the area. This could lead to bloody diarrhoea and gastroenteritis in individuals who consume such contaminated fruits (Okechukwu *et al.*, 2016). The presence of coliforms in fruits could also be a result of faecal contamination or an indication of poor sanitary of the vendors (Ajiboye and Emmanuel, 2021). The presence of *Lactobacillus species* could be because it thrives well in an acid medium. Similarly, the presence of *Pseudomonas species* could be because it is commonly found on fruit surface which could end up being ingested by humans. They are also able to grow on a wide variety of organic substrate and are regular components of food spoilage and may even cause bacteraemia (Abadias *et al.*, 2018).

The frequency of isolation of *Staphylococcus species* may be explained by the fact they are normal flora of

the human body surface and orifice. This organism can be introduced into the fresh sliced fruits during handling, processing or vending and may lead to staphylococcal food poisoning (Abadias *et al.*, 2018). Fruits and vegetables have normal microflora which are often yeast, moulds and spoilage bacteria, it was also discovered that they can harbour harmful bacteria such as *Escherichia coli*, *Salmonella*, *Shigella*, *Listeria*, *Campylobacter*, *Monocytogenes*, *Yersinia enterocolitica*, *Clostridium botulinum*, *Bacillus cereus* as well as parasite (Nura *et al.*, 2022). According to Abakari and Cobbina (2018), *Salmonella spp.* should not be found in 25g of ready to eat fruits and vegetable meant for human consumption and therefore must be rejected.

Table 2: Percentage occurrence of bacterial isolates from the various fruit samples

Isolates	Pawpaw	Watermelon	Pineapple	Orange
<i>Lactobacillus</i>	4.5%	7.69%	13.88%	0.0%
<i>E. coli</i>	20.45%	17.94%	22.22%	33.3%
<i>Pseudomonas</i>	11.36%	10.25%	2.77%	16.67%
<i>Salmonella</i>	22.73%	25.64%	22.22%	16.67%
<i>Shigella</i>	22.73%	23.07%	22.22%	16.67%
<i>Staphylococcus.</i>	18.18%	15.38%	16.66%	16.67%

### Mesophilic Aerobic Plate Counts of the Fruit Samples

From Table 3, the bacterial count varied in all the fruits; it was lowest in watermelon but highest for pineapple. In pawpaw samples the counts ranged from  $1.4 \times 10^5$ -  $4.2 \times 10^5$  cfu/ml. The bacterial count for watermelon samples ranged from  $1.5 \times 10^5$ - $4.1 \times 10^5$  cfu/ml. The bacterial count for pineapple samples ranged from  $3.1 \times 10^5$ - $8.9 \times 10^5$  while the bacterial count for oranges ranged from  $1.9 \times 10^5$  -  $5.5 \times 10^5$ . The highest level of bacterial load was found in pawpaw fruit with the least in oranges. Contamination of

fruits is likely to occur from cross contamination with the water, leather for packaging and utensils such as knives, trays and chopping boards used during processing, hands of the vendors or the environment (Nura *et al.*, 2022). The values of bacterial loads reported by this study agree with that Nura *et al.* (2022) who reported total bacterial counts in pineapple as  $3.92 \times 10^6$  cfu/g. Similarly, Ikpebivie *et al.* (2020) reported bacterial count ranging from  $1.3 \times 10^5$  to  $2.4 \times 10^6$  cfu/ml for pineapple;  $1.9 \times 10^5$  to  $8.1 \times 10^6$  cfu/ml for watermelon and  $3.7 \times 10^6$  to  $7.6 \times 10^6$  cfu/ml for pawpaw samples.

Table 3: Mesophilic count of bacteria in the fruit samples in CFU/g

Market	Pawpaw	Watermelon	Pineapple	Orange
Kasuwa bacci	$1.4 \times 10^6$	$4.1 \times 10^5$	$3.1 \times 10^5$	$5.5 \times 10^5$
Abubakar Gumi	$1.38 \times 10^6$	$1.5 \times 10^6$	$4.6 \times 10^5$	$4.6 \times 10^5$
Kabala Doki	$1.36 \times 10^6$	$1.48 \times 10^6$	$5.5 \times 10^5$	$1.9 \times 10^5$
Kawo	$1.35 \times 10^6$	$7.8 \times 10^5$	$7.2 \times 10^5$	$5.0 \times 10^5$
Anguwan Dosa	$1.37 \times 10^5$	$7.6 \times 10^5$	$7.1 \times 10^5$	$5.0 \times 10^5$
Oki Panteka	$8.39 \times 10^5$	$1.3 \times 10^6$	$6.0 \times 10^5$	$4.9 \times 10^5$
Anguwan Rimi	$4.2 \times 10$	$4.3 \times 10^5$	$8.9 \times 10^5$	$2.0 \times 10^5$
Station Roundabout	$4.4 \times 10^5$	$1.5 \times 10^6$	$5.3 \times 10^5$	$5.4 \times 10^5$
Kakuri	$1.1 \times 10^6$	$4.2 \times 10^5$	$3.3 \times 10^5$	$4.8 \times 10^5$
Sabon Tasha	$9.0 \times 10^5$	$7.7 \times 10^5$	$4.7 \times 10^5$	$4.7 \times 10^5$

## CONCLUSION

The presence of *Escherichia coli*, *Salmonella* and *Shigella* is worrisome since most of these microorganisms are of significant public health concern. The present study has shown that ready-to eat fruits sold by street vendors in Kaduna Markets are not safe for human consumption and consumers are at health risk in terms of microbial quality. The presence of coliform organisms on the fruits implies that they are unfit for human consumption.

The bacterial contaminants identified in this study are *E. coli*, *pseudomonas* species, *salmonella* species, *Shigella* species and *staphylococcus* species in high numbers with the least being *lactobacillus* species. This study shows that there is an urgent need for food regulatory agencies to monitor fruit vendors in order to promote improvement in quality standards and safety of ready-to-eat fruits sold or hawked in Kaduna Markets.

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