MICROBIAL ANALYSIS AND FRUIT HANDLING PRACTICES OF READY-TO-EAT VENDED FRUITS IN UYO METROPOLIS, AKWA IBOM STATE

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ABSTRACT

The study investigated handling practices and Microbial analysis of selected ready-to-eat vended fruits in Uyo metropolis of Akwa Ibom State. Four purposes and four research questions were raised to guide the study. A quasi-experimental research design was adopted for the study. A structured questionnaire titled: Fruit Handling Practices Questionnaire (FHPQ) was used for data collection from eighty fruit vendors. Three types of fruits (Paw-paw, Pineapple and Watermelon) were bought from vendors close to a dumpsite and taken to the Microbiology laboratory for microbial analysis. The research questions were analysed using mean and standard deviation. Findings showed that watermelon was the most commonly vended fruit sold in the study area (x= 3.79); the fruit vendors clean the display surface daily (x= 3.90) as the major fruit handling practices; majority of the vendors indicated that they store fruits on dry floor (x= 3.96).The microbial load analysis result revealed that, Bacterial and fungal isolates such as Bacillus subtilis, Micrococcus sp., and Staphylococcus aureus, Proteus sp., Vibrio cholerae, Salmonella sp. and Aspergillus terreus, Rhizopus stolonifer, and Saccharomyces sp. were found on the ready-to-eat vended fruits. However, the result showed that ready-to-eat vended pineapples had the least microbial counts THBC (4.0 x 10^3); TCC (2.2 x 10^3); FC (0); SSC (2.2 x 10^3); SC (2.0 x 10^3); VC (0); CC (0); and FC (1.5 x 10^3), irrespective of the time of purchase. It is concluded that the fruit handling practices of ready-to-eat vended fruits in the study area are adequate, although there were microbial counts on selected ready to eat vended fruits based on the time of purchase. Amongst others, fruits vendors in Uyo metropolis should undergo targeted training and awareness programmes on proper fruit handling and storage practices.

Keywords: Fruit Handling, Storage Conditions, Microbial Analysis, Ready-to-eat Vended fruits.

INTRODUCTION

Fruits are the mature ovaries of flowering plants, typically containing seeds that develop from the fertilisation of a flower's ovule. They serve as a mechanism for seed dispersal in plants and are classified broadly into two categories: fleshy fruits (e.g., apples, bananas, and berries) and dry fruits (e.g., nuts and grains). According to Taiz and Zeiger (2015), fruits are botanically classified based on their origin and the structures involved in their formation, while nutritionally, they are valued for their high content of vitamins, minerals, and antioxidants. They are rich sources of essential vitamins, minerals, and antioxidants that play critical roles in maintaining overall health. They provide key nutrients such as vitamin C, potassium, and dietary fibre, which help strengthen the immune system, improve digestive health, and lower blood pressure (Taiz & Zeiger, 2015; Olayanju *et al.,* 2019). The consumption of fruits has also been linked to reduced risks of chronic diseases, such as cardiovascular diseases, cancer, and diabetes, due to their high antioxidant

content (World Health Organization, 2020; Adeoye *et al.*, 2022). Regular fruit intake has been shown to reduce the risk of non-communicable diseases. The fibre in fruits helps regulate blood sugar levels and improve gut health, while bioactive compounds like flavonoids and polyphenols reduce inflammation and oxidative stress (Smith *et al.*, 2020; Williams *et al.*, 2020). According to Jibril *et al.* (2021), individuals who consume adequate servings of fruits have a 30-40% lower risk of developing heart disease and obesity compared to those with inadequate intake.

According to Odebode *et al.*, (2019), fruits are naturally low in calories and high in water and fibre, making them ideal for weight management. They help promote satiety, reducing the likelihood of overeating. Apples, watermelons, and cucumbers have been identified as effective snacks for controlling appetite due to their high water content (Chukwudi *et al.*, 2017). Dietary fibre in fruits like oranges, bananas, and papayas supports bowel regularity and prevents constipation. Fibre also serves as a prebiotic, promoting the growth of healthy gut bacteria, which improves digestion and nutrient absorption (Adeoye *et al.*, 2022; Olumide *et al.*, 2018). Those with high water content, such as watermelon, oranges, and pineapples, contribute significantly to hydration. This is particularly important in tropical climates, where dehydration can be common (Ugbabe *et al.*, 2020). They not only replenish body fluids but also provide electrolytes, like potassium, which maintain cellular balance. Vitamins A and C, commonly found in citrus fruits, mangoes, and carrots, play important roles in skin health and vision improvement. These nutrients reduce skin damage caused by free radicals and protect the eyes from age-related degeneration (Olayanju *et al.*, 2019; Taiz & Zeiger, 2015).

Fruit handling refers to the procedures followed by vendors in preparing fruits for sale, including washing, peeling, cutting, and displaying. Inadequate handling practices can lead to contamination, compromising not only the nutritional quality of fruits but also their safety for consumption. According to Odebode *et al.* (2019), improper fruit handling practices such as failing to wash fruits properly, using contaminated utensils, and handling fruits without protective measures significantly increase the risk of microbial contamination, which in turn poses a serious public health threat. Such practices have been linked to outbreaks of foodborne diseases in several parts of Nigeria. In a similar vein, Akinmoladun *et al.* (2021) emphasized that improper storage and handling of fruits in informal markets are major contributors to the spread of pathogens, which can lead to gastrointestinal infections and other related diseases. This highlights the critical need for better hygiene practices to prevent health risks associated with fruit vending.

Proper storage conditions are crucial for maintaining the quality and safety of fruits, as inadequate practices can lead to spoilage and increase the risk of foodborne illnesses. Key factors influencing fruit storage include temperature, humidity, ventilation, and light exposure. Temperature: maintaining appropriate temperatures slows down respiration and metabolic rates in fruits, thereby extending their shelf life. The United States Department of Agriculture (USDA) recommends that refrigerators should maintain a temperature of 5°C (41°F) or lower, as colder temperatures can preserve freshness. Furthermore, specific fruits require temperatures between 0°C and 13°C (32°F to 55°F), depending on the type (University of Maine Cooperative Extension, 2023). Humidity: high relative humidity levels, generally between 80% and 95%, are essential for reducing water loss in fruits, thereby preserving their freshness and preventing shrivelling. However, excessive moisture can encourage mold growth, so careful humidity control is vital (University of Maine Cooperative Extension, 2023). Ventilation: adequate air circulation is necessary to avoid the build-up of ethylene gas, a natural plant hormone that accelerates ripening and can cause premature spoilage. Fruits are best stored in perforated bags or breathable containers to ensure proper ventilation and freshness (Summit Appliance, 2023). Light Exposure: storing fruits in dark environments is ideal to prevent degradation caused by light. Prolonged exposure to light can lead to discoloration and nutrient loss. For some fruits, such as apples, a cool,

dry, and dark place like a cupboard or cellar is recommended (Dietitians of Canada, *2023)*.

The growing population and urbanisation of Uyo Metropolis have led to an increased demand for fresh fruits and vegetables. This expansion presents both opportunities and challenges for food safety, as many vendors operate in informal settings with limited resources. As a result, the implementation of effective fruit handling and storage practices remains inconsistent across the city. Some vendors, particularly in more established markets, adopt good hygiene practices, such as handwashing, wearing gloves, and cleaning display surfaces regularly. However, others continue to operate without adequate knowledge of proper handling techniques, increasing the likelihood of contamination (Ugbabe *et al.*, 2020).

Furthermore, Uyo's vibrant food market environment, which serves as a hub for daily transactions, presents a unique challenge in regulating food safety standards. While some vendors maintain high standards of hygiene and fruit handling, the informal nature of the market means that enforcement of food safety regulations is often lax. This has resulted in an environment where consumers are exposed to potential health risks from improperly handled and stored fruits. In Uyo Metropolis, many vendors face significant challenges in maintaining optimal storage conditions due to a lack of proper infrastructure and resources. For example, many market stalls lack refrigeration facilities, and vendors may store fruits in unsuitable locations such as directly on the ground, in open containers, or in poorly ventilated areas (Akinlolu *et al.*, 2020). This lack of appropriate storage contributes to the rapid deterioration of produce and the spread of microbial contamination. While some vendors use makeshift storage solutions, such as covering fruits with leaves or sacks, these practices are not always effective in preventing spoilage or contamination.

Therefore, the adoption of better storage practices, such as using proper containers and storing fruits in well-ventilated spaces, is crucial for improving fruit quality and reducing food safety risks in Uyo Metropolis.

The importance of effective fruit handling and storage cannot be over-emphasised, particularly within the context of urban food vending practices. In rapidly developing cities like Uyo Metropolis, fruit vending has become a significant aspect of the local economy, contributing to both informal and formal food systems. However, the manner in which fruits are handled and stored before they reach the consumer plays a pivotal role in ensuring food safety and hygiene. The quality of fruits sold in these urban settings is not only influenced by their initial state at purchase but also by the subsequent conditions under which they are stored and handled. Fruit vendors, who often operate in bustling markets and streets, must therefore adopt specific practices that meet established hygiene and food safety standards to reduce the risks of contamination and foodborne illnesses (Afolabi *et al.*, 2020). Effective fruit handling and storage are essential components of food safety in Uyo Metropolis, where urban growth and increased consumer demand for fresh produce present both opportunities and challenges for fruit vendors. By adhering to proper handling practices and ensuring suitable storage conditions, vendors can significantly reduce the risk of foodborne illnesses and improve the quality of fruits offered to consumers. This study highlighted the current practices among vendors in Uyo Metropolis and recommended strategies for improving food safety, hygiene, and storage conditions, ultimately contributing to a safer and healthier urban food environment.

Fruit vending is a vital component of the local economy in Uyo Metropolis, providing affordable and accessible fresh produce to urban residents. However, there are growing concerns about the handling and storage practices employed by vendors, particularly in informal markets. Inadequate handling practices, such as the failure to wash or disinfect fruits, combined with poor storage

conditions, including exposure to direct sunlight and insufficient ventilation, significantly increase the risk of microbial contamination and foodborne illnesses (Singh, & Kumari, 2024).

Food safety is a critical public health issue, yet many fruit vendors in Uyo Metropolis lack formal training in hygienic practices and have limited access to resources necessary for maintaining optimal storage conditions. These deficiencies not only compromise the quality and safety of the fruits sold but also pose significant health risks to consumers (Johnson, 2019). Despite the urgency of addressing these concerns, there is a noticeable lack of research focusing on fruit handling and storage practices within this region, particularly their impact on food safety.

This study seeks to fill this research gap by examining the current practices of fruit vendors in Uyo Metropolis, assessing their implications for food safety, and recommending actionable strategies to enhance hygiene standards. Ultimately, the findings will contribute to reducing foodborne diseases and promoting safer fruit coal growth, further compromising their safety (Nkanga and Bassey, 2019.

A significant observation in Uyo is the sale of fruits near dumpsites and open waste areas. This practice is common in informal markets where vendors seek high-traffic areas to maximise sales. Unfortunately, these locations are often near refuse dumps, where the air is contaminated with harmful pathogens, and vectors like flies and rodents are abundant (Ezugwu *et al.*, 2019). Fruits sold in these environments are at a higher risk of contamination, which poses a serious health threat to consumers. Studies have demonstrated that fruits exposed to such unhygienic environments can harbour dangerous microorganisms. For instance, Staphylococcus aureus and Escherichia coli have been isolated from fruits sold in close proximity to dumpsites, indicating the direct transfer of contaminants from waste to food (Udofia *et al.*, 2020). This scenario presents a public health risk, as many consumers in Uyo may unknowingly purchase and consume these contaminated fruits consumption in the region.

Purpose of the Study: The purpose of the study was to investigate fruit handling practices and storage conditions of ready-to-eat fruits vended in Uyo metropolis of Akwa Ibom State. Specifically, the study sought to determine the:

1. types of fruits vended in Uyo metropolis.
2. handling practices of vendors of ready-to-eat fruits in Uyo metropolis;
3. storage conditions of ready-to-eat fruits vended in Uyo metropolis.
4. microbial counts on ready-to-eat vended fruits sold by fruit vendors in Uyo metropolis based on the time of purchase.

Research Questions: The study sought to answer the following research questions:

1. what are the types of fruits vended in Uyo metropolis?
2. What are the handling practices of vendors of ready-to-eat fruits in Uyo metropolis?
3. What are the storage conditions of ready-to-eat fruits vended in Uyo metropolis?
4. What are the microbial counts on ready-to-eat vended fruits sold by fruit vendors in Uyo metropolis based on the time of purchase?

METHODOLOGY

Research design: This study employed a quasi-experimental research design to examine the relationship between handling practices and microbial contamination of selected ready-to-eat fruits vended in Uyo metropolis. Quasi-experimental design refers to a research approach that aims to evaluate interventions or treatments without the use of random assignment. Unlike true experiments, participants or groups in quasi-experiments are not randomly assigned to treatment or control conditions, making them more feasible in real-world settings where randomization is

impractical or unethical. Shadish, Cook, and Campbell (2002) advocate for the use of quasi-experimental designs when randomisation is not feasible. This study, "handling practices and microbial analysis of selected ready-to-eat vended fruits" fits into a quasi-experimental design because, it is unlikely that vendors or fruit samples can be randomly assigned to different handling practices in a natural vending environment. The study would instead observe existing conditions or group vendors based on existing behaviuors, Real-world Setting: The research takes place in actual vending environments where manipulation is limited, making a quasi-experimental approach more suitable.

Area of study: The study was conducted in Uyo, the capital city of Akwa Ibom State, Uyo is located in the southern part of Nigeria. The metropolis serves as the political, commercial, and cultural hub of Akwa Ibom State (Effiong, 2016; Akomolafe and Awe, 2017). Uyo covers an area of about 1,975 square kilometers. The city is bordered by several local government areas, including Nsit Atai, Ibesikpo Asutan, Uruan, and Ikot Ekpene, and is situated near the Atlantic coastline, which influences its humid climate. Uyo is predominantly inhabited by the Ibibio people, one of the largest ethnic groups in Akwa Ibom State. The city has a diverse population, with other ethnic groups such as the Annang and Efik people also contributing to the cultural landscape. Uyo's population, according to the 2023 census, exceeds 600,000, making it one of the most populous cities in the region (Effiong, 2016; Olaniran and Abiodun, 2019). The metropolis features, a mix of urban and semi-urban settlements, a vibrant street food culture, including a high prevalence of ready-to-eat (RTE) fruits like pineapple, watermelon, pawpaw, and cucumber sold by roadside vendors and in open markets, High foot traffic from students (due to institutions like the University of Uyo), workers, and traders, increasing the demand for convenient, on-the-go snacks such as fresh fruits. The study was relevant in this location because of high consumption of ready-to-eat Fruits, the demand for convenience foods, including sliced fruits sold in transparent containers or bags.

Population of Study: The population comprised of 80 fruits vendors (unregistered) in Uyo metropolis who engage in active sales of vended fruits in the study area.

Sample and Sampling Techniques: All the 80 fruit vendors in study area were used as sample for the study. The population for the study was small thus an finite population was adopted for the study implying that there was no sampling. Yamane (1967) posits that when the population is small, it is preferable to conduct a census rather than sampling.

Instrumentation: A structured instrument tagged: Fruit Handling Practices Questionnaire (FHPQ) was used for data collection for the study. The instrument had four sections, A to D and 46 items**.** Section A, contained 8 items which sought to measure the demographic characteristics of fruit vendors in Uyo Metropolis; Section B, contained 15 items measuring the types of ready-to-eat vended fruits sold in the study area; Section C contained 11 items measuring handling Practices of ready-to-eat vended fruits while Section D contained 12 items measuring storage conditions of the vended fruits. The items where rated on a 4 point scale of: Strongly Agreed (SA)=4, Agreed (A)=3, Disagreed (D)=2 and Strongly Disagreed (SD)=1.

Validation and Reliability of the Instrument: Face and content validation of the instrument was done by three experts in related disciplines: a Home Economist, a Microbiologist and a Statistician. A draft copy of the purposes, research questions, hypotheses and the instrument were given to each of the validates to access the appropriateness in measuring the variables in the research. They assessed the instrument for clarity and made necessary corrections. Out of the 47 items sent for validation, only one item was deleted. To determine the internal consistency of the instrument. The questionnaires were administered to 20 respondents from Itam in Itu Local Government Area who did not take part in the main study but engage in fruit vending. The responses were analysed using Cronbach alpha statistical analysis and a reliability coefficient

of 0.89 was obtained which indicated that the instrument was considered reliable.

Method of Data Collection: The vendors were identified especially those who sell fruits close to dumpsites in the study area. They were administered the instruments which were filled and collected immediately by the researchers. Out of the 80 copies of instruments administered, 76 were correctly filed and returned indicating 96% retrieval rate. To obtain samples for the microbial analysis, fruit samples were bought from a fruit vendor who operates close to a dumpsite on September 12, 2024. Three types of ready-to-eat vended fruits were bought namely: pineapple, watermelon, and paw-paw. The first set of samples was bought by 9am and taken to the lab for analysis while the second set from the same location was bought by 5pm and taken to the laboratory for microbial analysis.

RESULTS

Research Question 1: What are the types of fruits vended in Uyo metropolis?

Table 1: Types of ready-to-eat vended fruits sold in Uyo Metropolis of Akwa Ibom State

S/N	Types of ready-to-eat vended fruits	X	SD
1.	I sell watermelon	3.79	1.25
2.	I sell pineapples	3.64	1.45
3.	I sell pawpaw	3.57	1.11
4.	I sell banana	3.29	1.18
5.	I sell orange	3.21	1.14
6.	I sell pear	3.07	0.95
7.	I sell quava	3.00	0.89
8.	I sell apple	3.00	1.05
9.	I sell coconut	2.91	0.83
10.	I sell grapes	2.71	0.95
11.	I sell soursop	2.71	1.14
12.	I sell mango	2.36	1.24
13.	I sell jackfruits	2.36	1.15
14.	I sell dates	2.36	1.11
15.	I sell tangerine	2.29	1.08

Table 1, shows that the types of ready-to-eat vended fruits in Uyo metropolis of Akwa Ibom State. The result revealed that watermelon had highest mean value of (x= 3.79) while pineapple and paw-paw had mean values of (x= 3.64) and (x= 3.57) respectively. All the other fruits had varying mean values.

Research Question 2: What are the handling practices of ready-to-eat vended fruits in Uyo metropolis of Akwa Ibom State?

Table 2: Fruits Handling Practices

S/N	Fruits handling practices	X	SD
1.	Clean the display surface daily	3.90	0.31
2.	Rinse knife and tray after use	3.65	0.55

3.	Sell fruits even when not healthy	3.50	0.70
4.	Cut fruits where they are sold	3.11	0.97
5.	Wash hands before handling fruits	2.97	0.65
6.	Wash fruits under running water	2.93	0.73
7.	Wear waterproof to cut fruits	2.53	0.98
8.	Wear waterproof to peel fruits	2.31	1.01
9.	Display fruits uncovered	1.88	0.76
10.	Wash fruits with salt water before selling	1.76	0.71
11.	Wipe fruits clean without washing	1.17	0.37

Table 2, shows the fruits handling practices of vendors in Uyo Metropolis. Eleven fruit handling practices were identified and used as parameters for assessing the fruit vendors. Findings revealed that cleaning display surfaces had the highest mean value of (x=3.90) followed by rinse knives and trays after use (x=3.65) and selling fruits even when not healthy (x=3.50). Other items varied in their mean values.

Research Question 3: What are the storage conditions of ready-to-eat vended fruits in Uyo metropolis?

Table 3: Storage conditions of ready-to-eat vended fruits

S/N	Storage conditions of ready-to-eat vended fruits	X	SD
1.	Store ripe fruits separately from the unripe ones	3.29	0.46
2.	Fruits are kept on a dry floor	3.96	0.48
3.	Ripe fruits are kept outside during the day	3.65	0.68
4.	Fruits are stored in a well-ventilated area	3.53	0.79
5.	Fruits are kept together	2.04	0.79
6.	Unripe fruits are kept in a sack to ripen	2.29	0.92
7.	Unripe fruits are kept in a cupboard	2.22	0.93
8.	Unripe fruits are kept in a basin and cover with leaves and sack	2.67	0.92
9.	Fruits are separated according to types	3.93	0.26
10.	Fruits are exposed to direct sunlight	3.35	0.80
11.	Fruits are sold without considering which one was bought first	1.88	0.53
12.	Ripe fruits are kept uncovered in a tray at night	3.50	0.82

Table 3, shows the storage conditions of ready-to-eat vended fruits in Uyo metropolis of Akwa Ibom State. Twelve storage conditions were identified and used in assessing the fruits vendors. The values were analysed and rated using mean and standard deviation. Results reveals that keeping fruits on a dry floor had the highest mean value of (x=3.96) closely followed by separating fruits according to types (x=3.93) and keeping ripe fruits outside during the day (x=3.65). Other storage conditions revealed varying mean values.

Research Question 4: What are the microbial counts on ready-to-eat fruits sold by fruit vendors in Uyo metropolis?

Table 4: Microbial Analysis of ready-to-eat vended fruits Samples

Sample	THBC (CFU/g)	TCC (CFU/g)	FC (CFU/g)	SSC (CFU/g)	SC (CFU/g)	VC (CFU/g)	CC (CFU/g)	FC (CFU/g)
Morning- 9am samples								
Pine-apple	4.8×10^3	2.2×10^3	NG	2.5×10^3	2.0×10^3	NG	NG	9.0×10^2
Water-melon	4.0×10^3	2.9×10^3	NG	1.9×10^3	7.0×10^3	NG	NG	8.0×10^2
Paw-paw	8.5×10^3	4.5×10^3	NG	1.7×10^3	5.0×10^3	NG	NG	4.0×10^2
Evening-5 pm samples								
Pine-apple	7.8×10^3	6.2×10^3	NG	2.2×10^3	2.6×10^3	NG	NG	1.5×10^3
Water-melon	9.0×10^3	6.2×10^3	NG	5.9×10^3	8.2×10^3	NG	NG	1.3×10^2
Paw-paw	1.35×10^4	8.5×10^3	NG	5.7×10^3	6.4×10^3	NG	5.0×10^3	7.0×10^2

Keywords:

THBC- Total heterotrophic bacteria count
TCC -Total coliform count
FC - Fecal coliform count
SSC – Salmonella and Shigella count
SC – Staphylococcus count
VC – Vibrio count
FC – Fungal count
AG- Acid and Gas
NG- No Growth
CFU/g- colony forming units/Gram

Table 4, shows the microbial analysis of some ready-to-eat fruits sold in Uyo metropolis of Akwa Ibom State based on time of purchase. Findings revealed that the total heterotrophic bacteria count (THBC) had the least count from pine-apple (4.0×10^3) and the highest count was observed from paw-paw (8.5×10^3) for morning samples and for evening sample the least count was obtained from pine-apple (7.8×10^3) and the highest count was seen in paw-paw (1.35×10^4); the total coliform count (TCC) had the least count from pine-apple (2.2×10^3) and the highest count was observed from paw-paw (4.5×10^3) for morning samples and for evening sample the least count was obtained from pine-apple and water-melon (6.2×10^3) and the highest count was seen in paw-paw (8.5×10^3); while There was no count for fecal caliform (FC) in the morning and evening sample; The result further shows that the *Salmonella* and *Shigella* count (SSC) had the least count from Paw-paw (1.7×10^3) and the highest count was observed from Pine-apple (2.5×10^3) for morning samples and for evening sample the least count was obtained from Pine-apple (2.2×10^3) and the highest count was seen in Water-melon (5.9×10^3); the *Staphylococcus* count (SC) had the least count from Pine-apple (2.0×10^3) and the highest count was observed from Paw-paw (5.0×10^3) for morning samples and for evening sample the least count was obtained from Pine-apple (2.6×10^3) and the highest count was seen in Water-melon (8.2×10^3);There was no growth for *Vibrio* count (VC); in clostridial Count (CC), the result indicated that there was no growth for morning sample while there was a count from Paw-paw (5.0×10^3) in the evening sample; the Fungal count (FC) had the least count from paw-paw (4.0×10^2) and the highest count was observed from pine-apple (9.0×10^2) for morning samples and for evening sample the least count was obtained from Water-melon (1.3×10^2) and the highest count was seen in Paw-paw (7.0×10^2).

The microbial load analysis result revealed that ready-to-eat vended pineapples had low microbial counts irrespective of the time of purchase; while paw-paw and watermelon varied in their microbial load based on the time of purchase.

Table 5: Biochemical Characterization and Identification of Bacterial Isolated from Fruits Samples

Gram Reaction	Shape	Catalase	Coagulase	Motility	Starch hydrolysis	Citrate	Urease	MR	VP	Spore formation	H_2S	Oxidase	Indole	Glucose	Maltose	Xylose	Lactose	Fructose	Sucrose	Mannitol	Galactose	Probable organisms
+ve	rod	+	-	+	+	-	-	-	+	+	-	-	-	AG	A	-	-	A	A	-	A	*Bacillus subtilis*
+ve	Coccin pairs	+	-	-	+	+	+	+	-	-	-	+	-	-	A	A	-	A	-	A	A	*Micrococcus sp*
+ve	Cocci in clusters	+	-	-	-	+	-	-	+	-	-	-	-	A	A	-	-	A	A	AG	A	*Staphylococus albus*
-ve	rod	+	-	+	-	-	+	+	-	-	+	-	-	AG	A	-	AG	AG	AG	-	AG	*Proteus sp*
+ve	Cocci in clusters	+	+	-	-	+	-	-	+	-	-	-	-	AG	A	AG	-	A	A	AG	A	*Staphylococus aureus*
-ve	comma	+	-	+	+	+	-	-	+	-	-	+	-	A	A	-	-	A	A	-	A	*Vibrio cholerae*
-ve	rod	+	-	+	-	+	-	+	-	-	+	-	-	A	A	A	-	-	-	AG	-	*Salmonella sp*
-ve	rod	+	-	+	-	-	-	+	-	-	+	-	-	A	AG	A	-	-	AG	AG	A	*Shigella sp*
-ve	rod	+	-	+	-	-	-	-	+	-	-	-	+	AG	AG	A	-	-	-	AG	-	*Enterobacter sp*

From Table 4.6 the biochemical characterization and identification showed the presence of the following bacterial isolates; *Bacillus subtilis*, *Micrococcus sp*, *Staphylococus albus*, *Proteus sp*, *Staphylococus aureus*, *Vibrio cholera*, *Salmonella sp*, *Shigella sp*, and *Enterobacter sp*.

Table 6: Macroscopic and microscopic Characteristics of Fungal Isolated from Fruits Samples

Colony colour	Types of soma	Nature of hyphae	Vegetation structure	Asexual spore	Special reproductive structure	Conical head	Vesicle shape	Probable organisms
Brownish colony becoming dark with age	Filamentous	Septate	Footcell	Globose conidia	Short conidiophores	Long columnar	hemispherical	*Aspergillus terreus*
White becoming greyish brown	Filamentous	Coenocytic	Stolons rhizoids	Ovoid sporangiospores	Tall sporangiophores in groups, black-brown sporangia	-	-	*Rhizopus stolonifer*
Creamy white moist colony	Pseudohyphae	Pseudo-hyphae	Anamorphs	Blastoconidia chlomydospores	Budding cells	Radiate	Dome shape	*Saccharomyces sp*
Cottony white to pale yellow	Filamentous	Septate	-	1-cell conidia in heads (cylindrical in shape)	Solitary phialides, chlamydospores absent	-	-	*Verticillium sp*
White smooth membranous colony	Filamentous	Septate dichotomously branched	-	Cylindrical conidia	-	Arthrosporous	-	*Geotricum candidum*
Creamish yellow colony	Filamentous	Coenocytic	-	Sporangiospore	Sympodially branched sporangiosphore	-	-	*Mucor sp*

The fungal characterization as shown in table 4.7 reveals the following fungal isolates *Aspergillus terreus*, *Rhizopus stolonifer*, *Saccharomyces sp*., *Verticillium sp*., *Geotricum candidum* and *Mucor sp*.

Table 7: Occurrence and Distribution of Diverse Species of Bacteria and fungi isolated from Fruits samples

Isolates	**Samples**								
	Pineapple	Morning	Evening	Watermelon	Morning	Evening	Pawpaw	Morning	Evening
Bacteria									
Bacillus subtilis		+	+		-	+		+	+
Micrococcus sp		+	+		+	+		+	+
Staphylococus albus		+	+		+	+		+	+
Proteus sp									
Staphylococus aureus		-	+		+	+		+	+
Vibrio cholera		-	-		-	-		-	+
Salmonella sp		-	+		+	+		+	+
Shigella sp		-	+		-	+		+	+
Enterobacter sp		-	+		-	+		-	+
Fungi									
Aspergillus terreus		-	-		-	+		+	+
Rhizopus stolonifer		+	+		+	+		+	+
Saccharomyces sp		+	+		+	+		+	+
Geotricum candidum		-	+		-	-		-	+
Mucor sp		+	+		+	+		-	+
Verticillium sp+		-	+		+	+		+	+

Key: +ve means the organism is present in the samples

-ve means the organism is not present in the sample

The microbiological analysis of the fruit samples—pineapple, watermelon, and paw-paw—revealed significant microbial presence in both morning and evening samples, with bacterial and fungal counts varying across different fruit types. The total heterotrophic bacteria count (THBC) was highest in paw-paw, particularly in the evening samples (1.35 x 10^4 CFU/g), indicating more bacterial growth over time. The total coliform count (TCC), which indicates potential faecal contamination, was also notable, with paw-paw having the highest TCC in the evening (8.5 x 10^3 CFU/g). Fungal counts were recorded in the morning and evening, particularly with paw-paw samples showing higher counts in the evening.

Bacterial isolates such as Bacillus subtilis, Micrococcus sp., and Staphylococcus aureus were identified based on biochemical tests. Additionally, potentially pathogenic bacteria like Proteus sp., Vibrio cholerae, and Salmonella sp. were isolated, which indicates the potential health risk associated with consuming these fruits, especially when handled improperly.

Fungal isolates included species such as Aspergillus terreus, Rhizopus stolonifer, and Saccharomyces sp., with Rhizopus being particularly common, known for its ability to cause spoilage in fruits.

DISCUSSION OF FINDINGS: The findings from the study revealed that the common types of ready-to-eat vended fruits in Uyo metropolis of Akwa Ibom State were watermelon (x=3.79), pineapples (x=3.64) and pawpaw (x=3.57). Other fruits were less popular compared to the top-ranking fruits. This finding aligns with Okoye (2019) who identified watermelon, bananas, oranges, and pineapples as the predominant fruits sold in Enugu urban markets, citing their long shelf life and consumer preference as the main reasons for their popularity. Similarly, Bamidele (2021) observed that watermelon, cucumber, pineapple, and pawpaw were commonly sold in Ilorin, particularly during the dry season, with availability heavily influenced by seasonal harvest patterns. Abdullahi (2022) also found that fruits such as apples, pineapples, bananas, and oranges were favored in Abuja due to their health benefits and ease of consumption. While these studies contributed to understanding fruit diversity, they did not explore aspects such as handling practices or microbial safety, which were addressed in the recent study. The current research fills this gap by not only documenting the types of fruits vended in Uyo metropolis but also considering the potential risks involved in their handling and consumption. This provides a more comprehensive understanding of the ready-to-eat fruit market in the region, as it goes beyond availability and consumer preference to include important aspects of food safety.

The finding on the handling practices of ready-to-eat vended fruits in Uyo metropolis revealed a mixture of both good and inadequate hygiene practices by vendors. Several positive practices were observed, such as rinsing knives and trays after use (x= 3.65), cleaning display surfaces daily (x = 3.90), and washing hands before handling fruits (x= 2.97). These practices indicate that vendors in Uyo generally demonstrate a reasonable level of hygiene practices, particularly regarding cleanliness of tools and surfaces that come into contact with the fruits. However, there are areas where improvements are needed. For instance, protective clothing such as wearing waterproofs to peel or cut fruits received lower ratings (x= 2.31) suggesting that vendors do not consistently use protective gear during fruit handling. Furthermore, practices such as selling fruits even when they are not healthy (x = 3.50) and leaving fruits uncovered for display (x = 1.88) also highlight concerns about food safety. The fact that certain fruits were displayed without covers and unhealthy fruits were sold, points to gaps in maintaining food quality and

reducing contamination risks.

These findings are consistent with studies conducted in other regions, such as Chukwu et al., (2021), who noted that fruit vendors in Abuja often became less careful as the day progressed, leaving fruits exposed to environmental contaminants. Similarly, Powell et al., (2019) observed that while vendors adhered to good hygiene practices in the morning, handling deteriorated as the day went on, especially in busy areas, leading to a higher risk of cross-contamination. Thakur et al., (2022) also found that in Delhi, fruits bought in the afternoon were often handled less hygienically, further supporting the need for consistent handling practices throughout the day. This study therefore, aligns with international researches in highlighting that while some fruit vendors exhibit good hygiene practices, there is a clear need for improvement, particularly in using protective clothing, ensuring the healthiness of fruits sold, and avoiding exposure to contaminants. This underscores the importance of continuous vendor training and public awareness campaigns to improve the safety of ready-to-eat vended fruit.

Further findings on the storage conditions of ready-to-eat vended fruits in Uyo metropolis showed a combination of adequate and inadequate practices. Several storage techniques were deemed appropriate, such as storing ripe fruits separately from unripe ones (x = 3.29), keeping fruits on a dry floor (x = 3.96), and storing fruits in well-ventilated areas (x= 3.53). These practices help maintain the quality of the fruits and reduce the risk of contamination. Similarly, vendors displayed good storage habits by keeping ripe fruits outside during the day (x= 3.65) and separating fruits according to types (x = 3.93), which further enhances their freshness and prevents cross-contamination. However, practices such as the storage of unripe fruits in sacks (x = 2.29) or cupboards (x = 2.22) was not considered adequate, as these methods may hinder proper ripening and expose the fruits to contamination. Additionally, keeping ripe fruits uncovered in trays at night (mean = 3.50) and exposing fruits to direct sunlight (mean = 3.35) are also areas for concern. These practices may increase the risk of microbial growth and deterioration, especially if the fruits are left in warm or humid conditions for extended periods.

These findings align with previous studies on fruit storage conditions. For example, Nwosu (2019) found that poor storage practices, such as placing fruits directly on the ground and failing to cover them, significantly affected fruit quality and safety. Similarly, Adewale (2021) observed that many vendors used polyethylene bags, which accelerated spoilage, while Daniels (2018) highlighted the dangers of storing fruits near waste bins or drainage systems. Adeyemi (2022) further emphasized that improper storage conditions, such as leaving fruits in open spaces, were a major cause of microbial contamination. These studies reinforce the need for better storage methods and suggest that vendors in Uyo metropolis could benefit from improved storage techniques, such as using covered containers and avoiding direct exposure to sunlight.

In conclusion, although there are several positive storage practices in Uyo, there is still room for improvement in ensuring that fruits are stored in optimal conditions to prevent contamination and preserve their quality.

The microbiological analysis of the fruit samples—pineapple, watermelon, and paw-paw—revealed significant microbial presence in both morning and evening samples, with bacterial and fungal counts varying across different fruit types. The total heterotrophic bacteria count (THBC) was highest in paw-paw, particularly in the evening samples (1.35 x 10^4 CFU/g), indicating more bacterial growth over time. The total coliform count (TCC), which indicates potential

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Bacterial isolates such as Bacillus subtilis, Micrococcus sp., and Staphylococcus aureus were identified based on biochemical tests. Additionally, potentially pathogenic bacteria like Proteus sp., Vibrio cholerae, and Salmonella sp. were isolated, which indicates the potential health risk associated with consuming these fruits, especially when handled improperly. Fungal isolates included species such as Aspergillus terreus, Rhizopus stolonifer, and Saccharomyces sp., with Rhizopus being particularly common, known for its ability to cause spoilage in fruits.

The microbial load analysis result revealed that it is safer to buy ready-to-eat pineapple anytime of the day because it is safe for consumption whereas, the consumption of ready-to-eat paw-paw at anytime of the day is not encouraged.

Overall, the results suggest that microbial contamination in vended fruits increases over time, highlighting the importance of proper handling and storage practices to minimize health risks to consumers.

CONCLUSION: The researchers examined Fruit Handling Practices and Microbial Analysis of ready-to-eat vended fruits in Uyo metropolis of Akwa Ibom State. Based on the findings of the study it can be concluded that although the fruit handling practices of ready-to-eat vended fruits in the study area are adequate. However, the fruits are usually infested with microorganisms such as Bacillus subtilis, Micrococcus sp., and *Staphylococcus aureus*, others are Proteus sp., *Vibrio cholerae,* and *Salmonella sp.* They also contain Fungal isolates which are potential sources of contamination and health risk.

RECOMMENDATIONS: Based on the findings, the following recommendations were made:

i. Fruit vendors in Uyo metropolis should undergo targeted training and awareness programmes on proper fruit handling and storage practices.
ii. Hygiene standards for ready-to-eat fruit vending should be enforced through regular inspections and the provision of necessary facilities.
iii. Vendors should be encouraged to use protective clothing and appropriate tools to minimize contamination risks during fruit handling and vending.
iv. Improved storage conditions, such as proper ventilation and covering of fruits, should be adopted by vendors to prevent exposure to contaminants.
v. Public health campaigns should be strengthened to educate consumers on the risks of consuming improperly handled fruits and the importance of purchasing from reliable vendors.

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