MICROBIOLOGICAL ANALYSIS OF READY TO EAT VENDED FRUITS IN BENIN CITY.

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UNIVERSITY OF BENIN

BENIN CITY

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF MICROBIOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FUFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF B.Sc. (HONS) IN MICROBIOLOGY, UNIVERSITY OF BENIN, BENIN CITY.

DECEMBER 2024.

CERTIFICATION

This is to certify that this project work was successfully carried out by **JOSIAH MFONOBONG AKPAN** with matriculation number **LSC2006986.** A 400level student of the department of Microbiology, Faculty of Life Sciences, University of Benin, Benin City, Edo State, Nigeria, under my supervision.

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(Project Supervisor)

APPROVAL

This project work was carried out by **JOSIAH MFONOBONG AKPAN** with matriculation number **LSC2006986,** in partial fulfillment of the award of a Bachelor of Science, B.Sc. (Hons) degree in the Department of Microbiology, University of Benin, Benin City.

_____ _____

Prof. Mrs. F.I AKINNIBOSUN **Date**

(Head of Department)

DEDICATION

This report is primarily dedicated to the Divine Providence for His abundant blessings, mercy, and guidance throughout my university journey. I extend heartfelt gratitude to my dear mother, Mrs. Akpan, as well as my siblings, for their unwavering love and steadfast support in both my personal and academic endeavors.

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I say, remain blessed by God Almighty, I love you all, you all are the best!

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ABSTRACT

The consumption of ready-to-eat vended fruits has become increasingly popular in urban areas, particularly in developing countries. These fruits, often sold by street vendors, are convenient and accessible, providing a quick source of nutrition for many consumers. However, this convenience comes with significant health risks due to potential microbial contamination. Fresh fruits are rich in essential nutrients, including vitamins, minerals, and phytochemicals, making them an integral part of a balanced diet. Fruits can become contaminated with pathogenic microorganisms at various stages, including during harvesting, processing, and selling. Common sources of contamination include unsanitary water used for washing, improper handling by vendors, and exposure to environmental contaminants. Research has identified several bacterial pathogens associated with vended fruits, including *Escherichia coli*, *Salmonella spp.*, *Shigella spp.*, and *Staphylococcus aureus*. These pathogens pose a significant risk of foodborne illnesses, which can lead to severe gastrointestinal diseases in consumers. In Nigeria, the rising trend of consuming ready-to-eat fruits has been noted, particularly in markets where hygiene standards are often overlooked. The primary issue is the high prevalence of pathogenic microorganisms such as *Escherichia coli*, *Salmonella spp.*, *Shigella spp.*, and *Staphylococcus aureus* on these fruits. These pathogens can easily contaminate fruits through contact with sewage, contaminated utensils, and water, increasing the risk of foodborne illnesses among consumers. The presence of these microbial contaminants not only compromises the safety of ready-to-eat vended fruits but also poses a significant public health risk. The high bacterial and fungal loads observed in these fruits suggest that they are unfit for human consumption, necessitating urgent intervention to improve hygiene standards and food safety practices among vendors. The microbial contamination of ready-to-eat vended fruits is a significant concern. Studies have shown that these fruits can harbor a variety of microorganisms due to exposure to soil, dust, water, and mishandling during harvest and post-harvest processing. The microbial load in the vended fruits was assessed by determining the colony-forming units (CFU) per gram of fruit. The results indicate varying levels of microbial contamination across different fruits. The findings from this study reveal significant microbial contamination in ready-to-eat vended fruits from Ekosodin Community and the environs of the University of Benin. The results indicate a high microbial load across all fruit samples, with both bacterial and fungal contaminants identified. The

presence of these bacteria and fungi suggests potential health risks, as they can cause foodborne illnesses if consumed.

CHAPTER 1

INTRODUCTION

1.2. Background of the Study

The consumption of ready-to-eat vended fruits has become increasingly popular in urban areas, particularly in developing countries. These fruits, often sold by street vendors, are convenient and accessible, providing a quick source of nutrition for many consumers. However, this convenience comes with significant health risks due to potential microbial contamination. The hygienic practices of vendors and the environmental conditions in which these fruits are sold play a crucial role in determining their safety for consumption.

Fresh fruits are rich in essential nutrients, including vitamins, minerals, and phytochemicals, making them an integral part of a balanced diet. Despite their health benefits, the handling and preparation of ready-to-eat fruits are often inadequate. Fruits can become contaminated with pathogenic microorganisms at various stages, including during harvesting, processing, and selling. Common sources of contamination include unsanitary water used for washing, improper handling by vendors, and exposure to environmental contaminants such as dust and insects (Micheal *et al.,* 2022).

Research has identified several bacterial pathogens associated with vended fruits, including *Escherichia coli*, *Salmonella spp.*, *Shigella spp.*, and *Staphylococcus aureus*. These pathogens pose a significant risk of foodborne illnesses, which can lead to severe gastrointestinal diseases in consumers (Igiehon *et al.,* 2020). The lack of proper sanitation practices among vendors, coupled with the high likelihood of fruits being exposed to contaminated surfaces and utensils, exacerbates the risk of microbial contamination (Oje *et al.,* 2018).

In Nigeria, the rising trend of consuming ready-to-eat fruits has been noted, particularly in markets where hygiene standards are often overlooked. Studies have shown that the total aerobic plate counts in these fruits can be alarmingly high, indicating a substantial microbial load that can compromise consumer health (Micheal *et al.,* 2022). The need for systematic microbial assessments of vended fruits is critical to understanding these risks and implementing measures to improve food safety standards.

This study aims to evaluate the microbiological quality of ready-to-eat vended fruits, focusing on the prevalence of microbial contaminants and the implications for public health. By highlighting the potential hazards associated with the consumption of these fruits, the research seeks to foster greater awareness among consumers and encourage regulatory bodies to enforce stricter hygiene standards in the food vending industry.

1.2. Problem Statement

The consumption of ready-to-eat vended fruits has become increasingly popular, particularly in urban areas. However, these fruits often pose significant health risks due to microbial contamination. The primary issue is the high prevalence of pathogenic microorganisms such as *Escherichia coli*, *Salmonella spp.*, *Shigella spp.*, and *Staphylococcus aureus* on these fruits. These pathogens can easily contaminate fruits through contact with sewage, contaminated utensils, and water, increasing the risk of foodborne illnesses among consumers (Igiehon *et al.,* 2020).

Several studies have highlighted the poor hygiene practices of vendors and environmental factors as major contributors to the microbial contamination of these fruits. For instance, a study conducted in Abakpa Main Market, Abakaliki, Nigeria, revealed that the total aerobic plate count

in vended fruits ranged from 3.5 x 10^5 to 1.03 x 10^6 CFU/ml, with tiger nuts showing the highest count (Orji *et al.,* 2016). Similarly, another study found that the presence of coliforms in these fruits indicated poor sanitary quality during processing (Igiehon *et al.,* 2020).

The presence of these microbial contaminants not only compromises the safety of ready-to-eat vended fruits but also poses a significant public health risk. The high bacterial and fungal loads observed in these fruits suggest that they are unfit for human consumption, necessitating urgent intervention to improve hygiene standards and food safety practices among vendors (Shitu *et al.,* 2024). This study aims to address these issues by evaluating the microbiological quality of ready-to-eat vended fruits and advocating for better regulatory oversight to ensure consumer safety.

1.3. Objectives of the Study

The objectives of this study are to comprehensively assess the microbiological quality of ready-to-eat vended fruits. The specific aims include:

1. Determination of Microbial Counts: To measure the total aerobic bacteria and fungi counts in the samples of ready-to-eat vended fruits. This will help in understanding the extent of microbial contamination present in these fruits (Shitu *et al.,* 2024).

2. Isolation and Identification of Microorganisms: To isolate and identify the bacterial and fungal contaminants present in the fruit samples. This involves using standard microbiological techniques to determine the types of pathogens that are commonly found on these fruits (Malik *et al.,* 2020).

3. Frequency Distribution Analysis: To determine the percentage frequency distribution of the microbial isolates on the ready-to-eat vended fruits. This analysis will provide insights into

which pathogens are most prevalent and pose the greatest risk to consumer health (Igiehon *et al.,* 2020).

4. Public Health Implications: To evaluate the potential public health risks associated with consuming these fruits, given their microbial contamination levels. This includes assessing how these contaminants could lead to foodborne illnesses among consumers (Shitu *et al.,* 2024).

5. Recommendations for Improvement: To propose measures for improving hygiene practices among vendors and suggest regulatory interventions to enhance food safety standards in the vending industry (Malik *et al.,* 2020).

These objectives aim to contribute to a better understanding of the microbiological risks associated with ready-to-eat vended fruits and to promote safer consumption practices.

1.4. Significance of the Study

The significance of this study lies in its potential to address critical public health concerns associated with the consumption of ready-to-eat vended fruits. Here are the key aspects of its significance:

1. Public Health Awareness: By evaluating the microbiological quality of ready-to-eat vended fruits, the study aims to raise awareness about the potential health risks associated with consuming these fruits. This awareness is crucial for consumers, vendors, and regulatory bodies to understand the importance of maintaining high hygiene standards in food vending.

2. Policy Formulation: The findings from this study can inform policymakers and health authorities about the need for stringent regulations and enforcement of hygiene practices in the

fruit vending industry. This could lead to the development of policies that ensure safer food handling and preparation practices among vendors.

3. Reduction of Foodborne Illnesses: By identifying common microbial contaminants such as *Escherichia coli*, *Salmonella spp.*, and *Staphylococcus aureus*, the study can help in implementing measures to reduce the incidence of foodborne illnesses. This is particularly important in regions where such illnesses are prevalent due to poor food safety practices.

4. Economic Impact: Improved food safety standards can lead to reduced economic losses associated with foodborne illnesses, including healthcare costs and lost productivity. By promoting safer food vending practices, the study contributes to economic stability and public health.

5. Advancement of Scientific Knowledge: This research adds to the existing body of knowledge on microbiological assessments of street-vended foods, providing valuable data for future studies and interventions aimed at enhancing food safety in similar contexts.

The study's significance is rooted in its ability to contribute to public health safety, policy development, and economic well-being by addressing the critical issue of microbial contamination in ready-to-eat vended fruits.

CHAPTER 2

LITERATURE REVIEW

2.1. Overview of Ready-to-Eat Vended Fruits

Ready-to-eat vended fruits are a popular choice for consumers due to their convenience and accessibility. These fruits, often sold by street vendors, are typically cut or sliced and packaged for immediate consumption. The trend of consuming these fruits has increased globally, driven by factors such as modernization, industrialization, and economic constraints that limit time for meal preparation (Micheal *et al.,* 2022).

2.1.1. Types of Vended Fruits

Common types of ready-to-eat vended fruits include watermelons, pineapples, cucumbers, mangoes, oranges, and pawpaws. These fruits are chosen for their nutritional value and ease of preparation. However, the processing and handling of these fruits often involve inadequate hygiene practices, which can lead to microbial contamination (Erhirhie *et al.,* 2020).

2.1.2. Microbial Contamination

The microbial contamination of ready-to-eat vended fruits is a significant concern. Studies have shown that these fruits can harbor a variety of microorganisms due to exposure to soil, dust, water, and mishandling during harvest and post-harvest processing (Orji *et al.,* 2016). Common pathogens identified in these fruits include *Escherichia coli*, *Salmonella spp.*, *Staphylococcus aureus*, and *Shigella spp.* (Oku *et al.,* 2020). The presence of these pathogens poses a risk of foodborne illnesses to consumers.

2.1.3. Microbial Load and Public Health Risks

Research indicates that the total aerobic plate count in vended fruits can be alarmingly high. For instance, a study in Nigeria found that the total aerobic plate count in vended fruits ranged from 3.5 X 10^5 to 1.03 X 10^6 CFU/ml (Igiehon *et al.,* 2020). Such high microbial loads suggest that these fruits are often unfit for human consumption, highlighting the need for improved hygiene practices among vendors.

2.1.4. Factors Contributing to Contamination

Several factors contribute to the microbial contamination of ready-to-eat vended fruits:

i. Hygiene Practices: Poor hygiene among vendors is a major factor. Many vendors do not follow proper sanitation procedures during handling and preparation (Oku *et al.,* 2020).
ii. Environmental Conditions: The environmental conditions under which these fruits are sold can also contribute to contamination. Dust, insects, and unsanitary water used for washing can introduce pathogens to the fruits (Orji *et al.,* 2016).
iii. Packaging Materials: The use of non-sterile packaging materials can further increase the risk of contamination (Shitu *et al.,* 2024).

2.1.5. Public Health Implications

The consumption of contaminated ready-to-eat vended fruits can lead to serious health risks, including foodborne illnesses. The presence of pathogens such as *Escherichia coli* and *Salmonella spp.* in these fruits underscores the potential for outbreaks of gastrointestinal diseases

among consumers (Shitu *et al.,* 2024). Therefore, it is crucial to address these issues through improved hygiene standards and regulatory oversight.

While ready-to-eat vended fruits offer convenience and nutritional benefits, they also pose significant health risks due to microbial contamination. Addressing these risks requires a comprehensive approach that includes better hygiene practices among vendors and stricter regulatory measures to ensure consumer safety.

2.2. Microbial Contamination in Fruits

Microbial contamination in fruits, particularly those that are ready-to-eat and vended by street vendors, is a significant public health concern. This contamination can occur at various stages of the supply chain, including production, harvesting, transportation, and handling. The presence of pathogenic microorganisms in these fruits poses a risk of foodborne illnesses to consumers.

2.2.1. Types of Microbial Pathogens

Several microbial pathogens are commonly associated with fresh fruits:

i. *Escherichia coli*: This bacterium is often found in the intestines of animals and humans. While most strains are harmless, some, like *E. coli* O157:H7, can cause severe illnesses such as hemorrhagic colitis and hemolytic uremic syndrome (Micheal *et al.,* 2022).

ii. *Salmonella spp.*: Known for causing salmonellosis, this bacterium can lead to symptoms like nausea, vomiting, abdominal cramps, and fever. It is frequently linked to outbreaks involving fresh produce (Micheal *et al.,* 2022).

iii. *Staphylococcus aureus*: This bacterium is commonly found on human skin and can cause foodborne illnesses through the production of toxins. It is often introduced to fruits through contact with contaminated hands or surfaces (Demisie and Melese 2024).

iv. *Shigella spp.*: This pathogen is associated with shigellosis, characterized by symptoms such as abdominal pain, cramps, diarrhea, and fever. It is often linked to poor personal hygiene of food handlers (Ajiboye 2021).

v. *Listeria monocytogenes*: This bacterium causes listeriosis, a serious infection that can affect pregnant women, the elderly, and immunocompromised individuals. It is often found in raw vegetables and can contaminate fruits during handling (Demisie and Melese 2024).

2.2.2. Factors Contributing to Contamination

Several factors contribute to the microbial contamination of fruits:

i. Hygiene Practices: Poor hygiene among vendors and handlers is a major factor. Many vendors do not follow proper sanitation procedures during handling and preparation (Alegbeleye *et al.,* 2018).

ii. Environmental Conditions: The environmental conditions under which these fruits are sold can also contribute to contamination. Dust, insects, and unsanitary water used for washing can introduce pathogens to the fruits (Tenea *et al.,* 2023).

iii. Packaging Materials: The use of non-sterile packaging materials can further increase the risk of contamination (Ajiboye 2021).

2.2.3. Public Health Implications

The consumption of contaminated fruits can lead to serious health risks, including foodborne illnesses. The presence of pathogens such as *Escherichia coli* and *Salmonella spp.* in these fruits underscores the potential for outbreaks of gastrointestinal diseases among consumers. Therefore, it is crucial to address these issues through improved hygiene standards and regulatory oversight.

While fruits offer nutritional benefits, they also pose significant health risks due to microbial contamination. Addressing these risks requires a comprehensive approach that includes better hygiene practices among vendors and stricter regulatory measures to ensure consumer safety.

2.3. Health Risks Associated with Contaminated Fruits

The consumption of contaminated fruits poses significant health risks due to the presence of pathogenic microorganisms. These pathogens can lead to a variety of foodborne illnesses, which can have serious health consequences, especially for vulnerable populations such as young children, the elderly, and individuals with compromised immune systems.

2.3.1. Types of Pathogens

Several types of pathogens are commonly associated with contaminated fruits:

i. Bacterial Pathogens:

- *Escherichia coli* O157:H7 can cause severe illnesses such as hemorrhagic colitis and hemolytic uremic syndrome, particularly affecting young children (Tenea *et al.,* 2023).
- *Salmonella spp.* is linked to salmonellosis, characterized by symptoms like nausea, vomiting, abdominal cramps, and fever (Tenea *et al.,* 2023).
- *Listeria monocytogenes* can cause listeriosis, a serious infection that affects pregnant women, the elderly, and immunocompromised individuals (Demisie and Melese 2024).
- *Shigella spp.* is associated with shigellosis, causing symptoms such as abdominal pain, cramps, diarrhea, and fever.

ii. Viral Pathogens:

- Hepatitis A virus can cause a serious disease characterized by fever, malaise, nausea, anorexia, and abdominal discomfort, followed by jaundice (Oladele *et al.,* 2022).
- Norovirus is linked to acute gastroenteritis and has been associated with outbreaks involving fresh produce (Oladele *et al.,* 2022).

2.3.2 Health Implications

The health implications of consuming contaminated fruits are significant:

i. Foodborne Illnesses: The presence of these pathogens in fruits can lead to outbreaks of foodborne illnesses. For example, outbreaks of salmonellosis and listeriosis have been linked to contaminated fruits like cantaloupes and apples (Melo and Quintas 2023).

ii. Vulnerable Populations: Individuals with weakened immune systems, such as the elderly and young children, are particularly at risk. These groups may experience more severe symptoms and complications from foodborne illnesses (Demisie and Melese 2024).

iii. Public Health Concerns: The widespread consumption of contaminated fruits can lead to public health crises, necessitating interventions to improve food safety practices and reduce the risk of illness (Melo and Quintas 2023).

2.3.3. Prevention and Mitigation

To mitigate these health risks, several measures can be implemented:

i. Improved Hygiene Practices: Ensuring proper sanitation and hygiene during the handling and preparation of fruits can significantly reduce contamination risks (Khan *et al.,* 2020).

ii. Regulatory Oversight: Strengthening regulations and enforcement of food safety standards in markets and vending operations can help ensure that fruits are safe for consumption (Melo and Quintas 2023)..

iii. Consumer Awareness: Educating consumers about the risks associated with contaminated fruits and promoting safe food handling practices can further reduce the incidence of foodborne illnesses (Demisie and Melese 2024)..

The health risks associated with contaminated fruits are substantial, but they can be managed through improved hygiene practices, regulatory measures, and consumer education.

2.4. Previous Studies on Microbiological Analysis of Vended Fruits

Several studies have investigated the microbiological quality of ready-to-eat vended fruits, highlighting the prevalence of microbial contaminants and their potential health risks. Here is an overview of some key findings from previous research:

2.4.1. Microbial Contaminants Identified

1. Common Pathogens:

Studies have consistently identified several bacterial pathogens in vended fruits, including *Escherichia coli*, *Staphylococcus aureus*, *Salmonella spp.*, and *Shigella spp.* (Micheal *et al.,* 2022). These pathogens are often introduced through poor hygiene practices and environmental contamination.

2. Fungal Contaminants:

Fungal isolates such as *Aspergillus niger*, *Fusarium solani*, *Penicillium sp.*, and *Mucor sp.* have also been detected in these fruits (Shitu *et al.,* 2024). These fungi can pose additional health risks, particularly for individuals with compromised immune systems.

2.4.2. Factors Contributing to Contamination

1. Hygiene Practices:

Poor hygiene among vendors, including the use of fecally polluted water for washing fruits and utensils, is a significant factor contributing to contamination (Orji *et al.,* 2016). The lack of proper sanitation measures during handling and preparation exacerbates this issue.

2. Environmental Conditions:

The environmental conditions under which fruits are sold, such as exposure to dust and insects, can further increase the risk of contamination (Micheal *et al.,* 2022).

2.4.3. Public Health Implications

1. Foodborne Illnesses:

The presence of pathogenic microorganisms in vended fruits poses a risk of foodborne illnesses, which can lead to severe gastrointestinal diseases among consumers (Igiehon *et al.,* 2020). This is particularly concerning in regions where such illnesses are prevalent due to poor food safety practices.

2. Vulnerable Populations:

Individuals with weakened immune systems, such as the elderly and young children, are particularly at risk from consuming contaminated fruits (Ajiboye 2021).

2.4.4. Recommendations for Improvement

1. Improved Hygiene Practices:

Enhancing hygiene practices among vendors, including regular handwashing and the use of clean water for washing fruits, can significantly reduce contamination risks (Shitu *et al.,* 2024)..

2. Regulatory Oversight:

Strengthening regulations and enforcement of food safety standards in markets and vending operations can help ensure that fruits are safe for consumption.

3. Consumer Awareness:

Educating consumers about the risks associated with contaminated fruits and promoting safe food handling practices can further reduce the incidence of foodborne illnesses (Igiehon *et al.,* 2020).

Previous studies have highlighted the significant microbiological risks associated with ready-to-eat vended fruits. Addressing these risks requires a comprehensive approach that includes better hygiene practices among vendors, regulatory measures, and consumer education to ensure safer food consumption.

2.5. Regulatory Standards and Guidelines

Regulatory standards and guidelines play a crucial role in ensuring the safety and quality of ready-to-eat vended fruits. These regulations aim to minimize microbial contamination and protect consumer health. Here is an overview of the regulatory landscape and guidelines related to street-vended fruits:

2.5.1. Regulatory Frameworks

1. Agricultural Product Standards Act (South Africa):

The Agricultural Product Standards Act No. 119 of 1990 in South Africa provides a framework for the standardization of quality norms for agricultural produce, including fruits sold by street vendors. This act emphasizes the importance of compliance with quality standards to ensure safety throughout the supply chain from farm to vending site (Chauke and Tabit. 2022)..

2. General Food Safety Regulations:

Many countries have general food safety regulations that apply to street vendors. These regulations typically require vendors to maintain proper hygiene practices, use safe water for washing produce, and ensure that fruits are handled and stored in a manner that prevents contamination.

2.5.2. Key Guidelines

1. Hygiene Practices:

Vendors are encouraged to follow strict hygiene practices, including regular handwashing, using clean utensils, and ensuring that fruits are washed with safe water before being cut or sliced for sale (Danikuu *et al.,* 2015).

2. Environmental Control:

Guidelines often emphasize the need for vendors to operate in clean environments, away from dust, insects, and other potential sources of contamination. This includes using appropriate packaging materials that do not contribute to contamination (Mazi *et al.,* 2023).

3. Monitoring and Compliance:

Regular monitoring by health authorities is crucial to ensure compliance with food safety standards. Studies have shown that there is a positive correlation between monitoring by officials and the level of compliance with quality standards among vendors (Chauke and Tabit. 2022).

4. Consumer Education:

Educating consumers about the risks associated with consuming contaminated fruits is an important aspect of regulatory guidelines. This includes promoting safe food handling practices among consumers to further reduce the incidence of foodborne illnesses (Danikuu *et al.,* 2015).

2.5.3. Challenges and Recommendations

1. Awareness and Enforcement:

A significant challenge in enforcing these regulations is the lack of awareness among vendors about existing standards and guidelines. Many vendors may not be aware of the requirements or may not have the resources to comply fully with them.

2. Public Health Campaigns:

Implementing public health campaigns to raise awareness among both vendors and consumers can help improve compliance with regulatory standards. These campaigns can focus on the importance of hygiene practices and the potential health risks associated with contaminated fruits.

Regulatory standards and guidelines are essential for ensuring the safety of ready-to-eat vended fruits. By promoting awareness and enforcing compliance, these regulations help protect consumer health and improve food safety practices in the vending industry.

CHAPTER 3

MATERIALS AND METHODS

3.1. Study Area

The study area is Ekosodin Community and the environs of the University of Benin, located in Benin City, Edo State, Nigeria. Ekosodin is a village in the Ovia North-East Local Government Area and is known for its proximity to the University of Benin, making it a hub for students seeking off-campus accommodation.

3.1.1. Geographical and Demographical Overview:

- Location: Ekosodin is situated to the east of Isihor within the Ovia North-East Local Government Area. It shares a boundary with the University of Benin, which is a major educational institution in the region.
- Population: As of the 2006 census, Ekosodin had an estimated population of 7,000 people. This population has been projected to grow significantly due to the influx of students and staff from the University of Benin.
- Economic Activities: The area is characterized by a mix of residential and commercial activities. It hosts numerous student-focused amenities, including affordable housing, eateries, and entertainment options. The presence of students has led to the development of various small businesses such as restaurants, cafes, salons, and retail shops.

3.2. Sample Collection

3.2.1. Types of Fruits

The study focuses on the following types of fruits:

i. Carrot

ii. Cucumber

iii. Apple

iv. Pineapple

These fruits were selected due to their popularity and availability in the study area, as well as their potential for microbial contamination.

3.2.2. Sampling Location

The sampling location for this study was:

i. Ekosodin Community

This location was chosen based on its proximity to the University of Benin and its role as major hubs for fruit vending, ensuring a diverse range of samples.

3.2.3. Sampling Techniques

The sampling techniques employed in this study include:

1. Random Sampling:

Samples were collected randomly from different vendors at each location to ensure a representative selection of fruits.

2. Sterile Collection:

Fruits were collected using sterile tools and placed in sterile polythene bags to prevent contamination during transport and storage.

3. Sample Preparation:

A total of 10 grams of each fruit sample was measured and homogenized in 90 milliliters of sterile distilled water using an electric blender. This process helps to evenly disperse any microorganisms present in the fruits.

4. Dilution Series:

The homogenate underwent a series of five-fold dilutions using sterilized distilled water to prepare the samples for microbiological analysis.

These techniques ensure that the samples are collected and prepared in a manner that minimizes contamination and allows for accurate microbiological analysis.

3.3. Laboratory Analysis

3.3.1. Microbial Isolation and Identification

Microbial isolation and identification are crucial steps in assessing the microbiological quality of vended fruits. The process involves several key steps:

1. Sample Preparation:

Fruits are homogenized in a sterile solution to release microorganisms. This involves blending the fruit sample with a sterile diluent, such as distilled water, to create a uniform suspension.

2. Cultivation:

The homogenate is cultured on selective media to isolate specific microorganisms. Common media used include Eosin Methylene Blue (EMB) agar for *Escherichia coli*, Salmonella-Shigella

(SS) agar for *Salmonella spp.*, and MacConkey agar for differentiating lactose-fermenting and non-lactose fermenting bacteria.

3. Identification:

Isolated colonies are identified through biochemical tests and molecular techniques. Biochemical tests such as indole production and gas production tests help confirm the identity of bacteria like *E. coli* and *Shigella*.

3.3.2. Enumeration of Microorganisms

The enumeration of microorganisms involves quantifying the microbial load present in the fruit samples:

1. Serial Dilutions:

The homogenate undergoes serial dilutions to achieve a concentration suitable for plating. This typically involves diluting the sample up to 10^{-6} to ensure accurate enumeration.

2. Plating and Incubation:

Diluted samples are plated on appropriate agar media and incubated at specific temperatures to allow microbial growth. The colonies are then counted to determine the microbial load in terms of colony-forming units (CFU).

3.3.3. Biochemical Tests

Biochemical tests are essential for confirming the identity of isolated microorganisms:

1. Indole Test:

This test is used to detect the presence of indole, a byproduct of tryptophan metabolism, which is positive for bacteria like *E. coli*.

2. Gas Production Test:

This test identifies bacteria that produce gas during lactose fermentation, such as *E. coli* and *Shigella.*

3. Citrate Utilization Test:

This test determines if a bacterium can use citrate as a sole carbon source, which is positive for certain bacteria like *Salmonella.*

These laboratory analyses provide a comprehensive understanding of the microbial contaminants present in vended fruits, helping to assess their safety and quality for consumption.

3.4 Data Analysis

The data were analysed using the SPSS package version 21.0. All data are mean of three replicates. The mean, range and standard deviation of each parameter was determined. The means were separated using Duncan's Multiple Range test (SPSS, 2010).

CHAPTER 4

RESULTS

Table 1: Bacterial Isolation and Identification

Sample	Cfu	Color	Margin	Elevation	Shape	Cell Type	Gram Stain	Potential Bacteria
A4	$5x10^4$	Milky	Filiform	Flat, Convex	Circular, Mucoid	Cocci	Gram-positive	*Staphylococcus aureus*
B4	$3x10^4$	Milky	Entire, Filiform	Raised, Flat	Round, Filamentous	Bacilli	Gram-positive	*Bacillus subtilis*
C4	$4x10^4$	Milky	Filiform	Flat, Convex	Circular, Mucoid	Cocci	Gram-positive	*Staphylococcus aureus*
D4	TMC	Milky	Lobate	Flat	Round	Cocci	Gram-positive	*Staphylococcus epidermidis*

KEY:

A4 - CARROT

B4 - CUCUMBER

C4 - APPLE

D4 - PINEAPPLE

Table 2: Fungal Isolation and Identification

Sample	cfu	Morphological Description	Microscopic Shape	Microscopic Pigmentation	Fungi	% Occurrence
A4	7×10^4	White dense mycelia growth (2)	Hyphae	White	*Aspergillus*	28.57
		Grey mycelia growth (3)	Hyphae	Grey	*Penicillium*	42.86
		Yellowish mycelia growth (1)	Hyphae	Yellow	*Aspergillus*	14.29
		Black mycelia growth (1)	Hyphae	Black	*Aspergillus niger*	14.29
B4	7×10^4	White dense mycelia growth (2)	Hyphae	White	*Aspergillus*	28.57
		Grey mycelia growth (3)	Hyphae	Grey	*Penicillium*	42.86
		Yellowish mycelia growth (1)	Hyphae	Yellow	*Aspergillus*	14.29
		Black mycelia growth (1)	Hyphae	Black	*Aspergillus niger*	14.29
C4	6×10^4	Milky mycelia growth (3)	Hyphae	Milky	*Penicillium*	50
		Grey mycelia growth (2)	Hyphae	Grey	*Penicillium*	33.33
		Black mycelia growth (1)	Hyphae	Black	*Aspergillus niger*	16.67

Sample	cfu	Morphological Description	Microscopic Shape	Microscopic Pigmentation	Fungi	% Occurrence
D4	7×10^4	Black mycelia growth (2)	Hyphae	Black	*Aspergillus niger*	22.22
		White mycelia growth (5)	Hyphae	White	*Aspergillus*	55.56
		Light grey mycelia growth (2)	Hyphae	Light Grey	*Mucor spp*	22.22

KEY:

A4 - CARROT

B4 - CUCUMBER

C4 - APPLE

D4 - PINEAPPLE

Table 3: Organisms Isolated from Various Samples

Sample	**Organisms Isolated**
Carrot	*Staphylococcus aureus, Bacillus spp, Penicillium spp, Aspergillus niger*
Cucumber	*Bacillus subtilis, Penicillium spp , Aspergillus niger*
Apple	*Staphylococcus aureus, Penicillium spp, Aspergillus niger*
Pineapple	*Staphylococcus epidermis, Penicillium spp, Mucor spp, Aspergillus niger*

Table 4: Biochemical Tests for Microorganism Identification

Microorganism	Biochemical Test	Result
Staphylococcus aureus	Catalase test	Positive
	Coagulase test	Positive
	Mannitol salt agar	Positive
Bacillus subtilis	Catalase test	Positive
	Starch hydrolysis test	Positive
Penicillium spp	Lactophenol cotton blue stain	Positive
	Microscopic examination	Hyphae present
Aspergillus spp	Lactophenol cotton blue stain	Positive
	Microscopic examination	Hyphae present
Aspergillus niger	Lactophenol cotton blue stain	Positive
	Microscopic examination	Black spores
Mucor spp	Lactophenol cotton blue stain	Positive
	Microscopic examination	Non-septate hyphae

The microbial load in the vended fruits was assessed by determining the colony-forming units (CFU) per gram of fruit. The results indicate varying levels of microbial contamination across different fruits:

- **Carrot (A4)**: The bacterial load was 5×10^4 CFU, indicating a moderate level of contamination. The fungal load was 7×10^4 CFU, with a significant presence of *Aspergillus* and *Penicillium* species.
- **Cucumber (B4)**: The bacterial load was 3×10^4 CFU, slightly lower than the carrot. The fungal load was also 7×10^4 CFU, with similar fungal species identified as in the carrot.
- **Apple (C4)**: The bacterial load was 4×10^4 CFU, with a fungal load of 6×10^4 CFU. The presence of *Penicillium* was notably high.
- **Pineapple (D4)**: The bacterial load was too numerous to count (TMC), indicating a high level of contamination. The fungal load was 7×10^4 CFU, with a diverse range of fungi including *Aspergillus niger* and *Mucor spp.*

The analysis revealed a variety of microorganisms across the different fruit samples:

- **Bacteria**:
    - *Staphylococcus aureus* was identified in carrot and apple samples.
    - *Bacillus subtilis* was found in cucumber samples.
    - *Staphylococcus epidermidis* was present in pineapple samples.
- **Fungi**:
    - *Aspergillus* species, including *Aspergillus niger*, were prevalent in all fruit samples.
    - *Penicillium* species were also commonly found across all samples.
    - *Mucor spp.* was identified in pineapple samples.

The microbial loads observed in this study were compared with established food safety standards:

- **Bacterial Load**: The bacterial counts in the fruits were generally higher than the acceptable limits for safe consumption. For instance, the presence of *Staphylococcus aureus* and *Bacillus subtilis* in significant quantities suggests potential health risks.
- **Fungal Load**: The fungal counts were also elevated, with *Aspergillus* and *Penicillium* species exceeding safe levels. These fungi can produce mycotoxins, posing additional health risks to consumers.

CHAPTER 5
DISCUSSION

Interpretation of Findings

The findings from this study reveal significant microbial contamination in ready-to-eat vended fruits from Ekosodin Community and the environs of the University of Benin. The results indicate a high microbial load across all fruit samples, with both bacterial and fungal contaminants identified. The bacterial counts were notably high, with *Staphylococcus aureus* and *Bacillus subtilis* being prevalent. The presence of these bacteria suggests potential health risks, as they can cause foodborne illnesses if consumed. Similarly, fungal contaminants such as *Aspergillus* and *Penicillium* species were also identified, with significant counts observed in all fruit samples. These fungi can produce mycotoxins, posing additional health risks to consumers.

Comparison with Previous Studies

The findings of this study align with previous research on microbial contamination in vended fruits. Similar to other studies, this research identified common bacterial pathogens such as *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella spp.* in vended fruits. These pathogens are often introduced through poor hygiene practices and environmental factors. The microbial loads observed in this study are comparable to those reported in other studies. For instance, a study in Abakpa Main Market found total aerobic plate counts ranging from 3.5×10^5 to 1.03×10^6 CFU/ml. Similarly, this study recorded high microbial counts across all fruit samples. The presence of fungi like *Aspergillus* and *Penicillium* is consistent with

findings from other research, where these fungi were also identified as common contaminants in vended fruits.

Implications and Recommendations

The high levels of microbial contamination observed in this study underscore the need for improved hygiene practices among vendors and regulatory oversight to ensure consumer safety. Implementing training programs for fruit vendors to emphasize the importance of proper hygiene practices during handling and preparation is crucial. Strengthening regulations and enforcement of food safety standards in markets and vending operations can help reduce contamination risks. Additionally, educating consumers about the risks associated with consuming contaminated fruits and promoting safe food handling practices can further enhance consumer safety. Overall, the study's findings highlight the critical need for interventions to improve the microbiological quality of ready-to-eat vended fruits, thereby reducing the risk of foodborne illnesses among consumers.

Recommendations for Vendors, Consumers, and Policy Makers

1. **Vendors**: Implement strict hygiene practices, including regular handwashing, use of clean water for washing fruits, and proper handling and storage techniques to minimize contamination.
2. **Consumers**: Be aware of the potential risks associated with consuming street-vended fruits and take precautions, such as washing fruits thoroughly before consumption.
3. **Policy Makers**: Strengthen regulations and enforcement of food safety standards in markets and vending operations. Provide resources for vendor training and public health campaigns to promote safe food handling practices.

Limitations of the Study

This study faced several limitations that could impact the generalizability of its findings. Firstly, the sample size was limited to a specific geographic area, Ekosodin Community and the environs of the University of Benin, which may not fully represent the broader context of fruit vending in other regions. Additionally, the study focused on a limited number of fruit types, which might not capture the full spectrum of microbial contamination present in other commonly vended fruits. Furthermore, the reliance on laboratory-based methods for microbial identification could have missed some pathogens that are not easily cultured or identified using standard techniques.

CONCLUSION

The study revealed significant microbial contamination in ready-to-eat vended fruits, with high bacterial and fungal loads observed across all samples. *Staphylococcus aureus*, *Bacillus subtilis*, and various species of *Aspergillus* and *Penicillium* were identified as common contaminants. The microbial counts were notably high, suggesting potential health risks to consumers. These findings are consistent with previous studies, highlighting the persistent issue of microbial contamination in street-vended fruits. The study's findings underscore the critical need for improved hygiene practices and regulatory oversight in the fruit vending industry. The high levels of microbial contamination observed pose significant health risks to consumers, particularly those with compromised immune systems. Addressing these issues requires a multifaceted approach that includes vendor training, regulatory enforcement, and consumer education.

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