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Bacteriological Assessment of Sliced Pineapple (*Ananas comosus*) Hawked in Ibadan North Local Government Area of Oyo State, Nigeria

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ABSTRACT

Background and Objective: Ready-to-eat fruits are commonly consumed without further processing, increasing the risk of bacterial contamination and food-borne infections. Sliced and hawked fruits, in particular, may be exposed to unhygienic handling and environmental contaminants. This study aimed to assess the bacteriological quality of ready-to-eat sliced/cut pineapple fruits sold in Ibadan North Local Government Area, Oyo State, and to identify the associated bacterial contaminants. **Materials and Methods:** A culture-dependent approach was employed for the isolation of bacteria from sliced pineapple samples collected from different vending locations. Total heterotrophic bacterial counts were determined using standard plate count techniques. Presumptive identification of bacterial isolates was carried out through biochemical characterization following conventional microbiological procedures. Data were analyzed using frequencies, percentages, and ANOVA at the 5% level. **Results:** The total heterotrophic count ranged from 1.0×10^4 to 1.0×10^7 CFU/mL, with the highest and lowest counts recorded in samples from Agbowo (Ag1) and Bodija (B1), respectively. A total of 44 bacterial isolates were identified, including *Bacillus* spp. (7), *Citrobacter* spp. (2), *Enterobacter* spp. (5), *Escherichia coli* (11), *Klebsiella* spp. (2), *Leminorella* spp. (1), *Morganella* spp. (1), *Pseudomonas* spp. (2), *Salmonella* spp. (5), and *Staphylococcus* spp. (8). *E. coli* showed the highest frequency of occurrence (25.0%), followed by *Staphylococcus* spp. (18.2%), while *Leminorella* spp. and *Morganella* spp. were least prevalent (2.2% each). **Conclusion:** The high bacterial loads and presence of potentially pathogenic bacteria indicate poor microbiological quality of the sliced pineapple fruits, rendering them unsafe for human consumption. The findings highlight the need for strict adherence to aseptic handling practices during fruit processing and vending. Future studies should incorporate molecular identification techniques and assess antimicrobial resistance patterns to strengthen food safety surveillance.

KEYWORDS

Pineapple, food safety, food-borne infection, total heterotrophic count, aseptic practices

INTRODUCTION

Microbiological assessment of foods is a process of estimating the numbers and types of microorganisms contaminating a particular food, which connotes the microbiological safety of the analysed food samples[1]. The microbiological risk assessment framework involves a structured and scientific approach to

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determining the complex issues relating to food hygiene and food borne diseases[2]. Fruits are the edible fleshy part of plants that bears the seeds, and endowed with a variety of flavours which might be sweet, sour or bitter. Fruits such as apricot, apple, banana, cantaloupe, berries, grapefruit, orange, pawpaw, cherry cashew, water melon, guava, pineapple are consumed in Nigeria because of their low cholesterol, fat, sodium, calories, and high levels of vitamins A, B6, C, E, K, and folate[3,4].

In recent times, the consumption of fruits has increased tremendously in both developing and under developed countries of the world[5], sequel to the enormous health benefits reported to be associated with them[6]. According to epidemiological surveys, individuals who consume fruit-rich diets show lower risks of developing cardiovascular diseases and associated chronic conditions such as cataracts, asthma, bronchitis and cancer[7]. In addition, fruits function in growth and repair of all body tissues, and also help to effectively fight against skin disorders, promote healthy hair growths, heal cuts, wounds, prevent diseases and disease conditions like stroke, high blood pressure, vitamin C and A deficiencies, diabetes, etc.[8]. Fruits are capable of providing these health benefits due to the possession of high amounts of bioactive compounds such as vitamins, minerals and many phytochemicals with antioxidant properties[9]. Despite the huge health benefits associated with the consumption of fruits, they have been reported as one of the major sources of transmission of food-borne diseases due to the fact that they are usually consumed raw[10]. The outbreak of salmonellosis has earlier been reported with the consumption of cut/sliced water melon and cantaloupe[11]. Additionally, foodborne diseases may be transmitted through contaminated fruits by bacteria, fungi and viruses[12]. In developing countries such as Nigeria, the contamination of fruits could emanate from washing of fruits with untreated waste water, the use of manure as fertilizers for boosting fruits yield, irrigation water, harvesting/processing equipment, improper storage, packaging, transportation, personal handling, soil and dust[13]. According to the previous reports, fruits and vegetables are crucial ingredients required for life's sustenance, hence their demand cannot be overemphasized[14].

Pineapple belongs the family *Bromeliaceae* which consists of about 2,000 species, mostly epiphytic and many strikingly ornamental[9]. It is reported that pineapple is adjudged as the third most important tropical fruit in the world after banana and citrus[10]. About 70% of pineapple produced in developing countries is consumed as fresh fruits, and many farmers in Nigeria depend on pineapple production as a means of sustenance. The enormous health benefits offered by pineapple include boosting the body's immune system, possession of trace elements such as manganese, vitamin C, A, thiamin (Vitamin B1), calcium, iron and water-soluble antioxidants[15]. Moving forward, the sales of sliced pineapples by local vendors constitute a profitable business because it is easily assessable and cheaper than the whole fruit. Therefore, this study was carried out to determine the bacteriological quality of sliced/cut pineapple hawked in different locations in Ibadan North Local Government Area (LGA), Oyo State, Nigeria.

MATERIALS AND METHODS

Collection of sliced pineapple samples: Four samples per location was collected from different pineapple vendors in Ibadan North LGA (Agbowo, Agodi, Bodija, Yemetu, Mokola and Sango) between July-August, 2025. All samples were collected inside zip lock bags, kept on ice packs, and immediately transported to the Microbiology Department of the University of Ibadan for analysis.

Isolation, morphological and biochemical characterization of bacteria isolated from sliced pineapple samples: Each pineapple sample was crushed in a sterile mortar with pestle, to extract the juice. Ten mL of the extracted juice was transferred into 90 mL of sterile distilled water, homogenized and serially diluted to a dilution factor of 10^{-10}. One mL of the dilution factors 10^{-3} and 10^{-6} was aseptically inoculated using the spread plate method into sterile Petri plates of Nutrient Agar (NA), MacConkey Agar (MAC), Eosin Methylene Blue Agar (EMB) and Mannitol Salt Agar (MSA). All the inoculated plates were incubated for 18-24 hrs at 37°C[16]. After incubation, the inoculated plates were examined for microbial growth, enumerated, Gram stained and subjected to various biochemical and sugar fermentation tests, which includes: starch hydrolysis, citrate, motility, catalase, indole, sucrose, fructose, galactose, maltose, glucose, etc., using the Bergey's Manual of Determinative Bacteriology (9th Edition) as a guide. Additionally, representative colonies were picked and streaked repeatedly to obtain pure cultures which were preserved on agar slants and kept at 4°C for future use[16].

Statistical analysis: The data obtained were analysed in frequency and percentages, while the ones from enumeration were analysed using Analysis of Variance (ANOVA) to separate significant means at 5% level.

RESULTS

The Total Heterotrophic Count (THC) of bacteria isolated from the sliced pineapple samples obtained from different points in Ibadan North LGA is presented in Table 1. It was documented that highest and lowest THC of 1.0×10^7 CFU/mL and 1.3×10^4 CFU/mL was recorded in Agbowo point 4 (Ag_4) and Bodija point 1 (B_1) respectively.

A total number of 44 bacterial isolates was obtained from all the sampled sliced pineapples (Table 2).

The frequency of occurrence of each bacterial species is reported in Table 3. It was observed that *Bacillus* sp. had the frequency occurrence of 0.0, 9.0, 0.0, 25.0, 13.3, 25.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu respectively, while *Citrobacter* sp. showed frequency occurrence of 0.0, 18.1, 0.0,

Table 1: Total heterotrophic count of bacteria isolated from vended sliced pineapples obtained from six selected points in Ibadan LGA, Oyo State

S/no	Sample codes/Locations	THC (CFU/mL)
	Agbowo	
1	Ag_1	1.8×10^{6a}
2	Ag_2	1.2×10^{5a}
3	Ag_3	5.2×10^{6b}
4	Ag_4	1.0×10^{7a}
	Sango	
5	S_1	5.2×10^{6a}
6	S_2	1.5×10^{5b}
7	S_3	2.7×10^{5c}
8	S_4	1.7×10^{4a}
	Bodija	
9	B_1	1.3×10^{4a}
10	B_2	1.1×10^{6a}
11	B_3	1.9×10^{5a}
12	B_4	7.2×10^{6b}
	Mokola	
13	M_1	1.8×10^{5a}
14	M_2	1.6×10^{6a}
15	M_3	2.1×10^{5b}
16	M_4	5.2×10^{6c}
	Agodi	
17	Ad_1	6.0×10^{6a}
18	Ad_2	7.7×10^{6b}
19	Ad_3	7.2×10^{6b}
20	Ad_4	1.7×10^{6c}
	Yemetu	
21	Y_1	1.8×10^{6a}
22	Y_2	1.5×10^{5a}
23	Y_3	5.7×10^{6b}
24	Y_4	4.0×10^{6c}

THC: Total heterotrophic count, Values with the different letters down the column are significantly different ($p = 0.05$), Ag1-Ag_2: Samples from Agbowo, S_1-S_4: Samples from Sango, B_1-B_4: Samples from Bodija, M_1-M_4: Samples from Mokola, Ad_1-Ad_4: Samples from Agodi and Y_1-Y_4: Samples from Yemetu

Table 2: Presumptive biochemical and sugar fermentation test results of bacteria isolated from vended pineapple samples

Sample code	Gram's reaction	KOH	Catalase motility	Citrate	SH	Oxidase	Indole	MR	VP	Sucrose	Fructose	Lactose	Galactose	Mannitol	Maltose	Glucose	Probable organism
Ag_1	-	+	+	-	+	-	-	-	+	-	+	-	+	-	+	+	*Citrobacter* sp.
Ag_2	-	+	+	-	-	-	-	-	+	-	-	-	-	-	+	+	*Salmonella* sp.
Ag_3	-	+	+	-	-	-	-	-	-	+	-	+	+	+	+	+	*Klebsiella* sp.
Ag_4	-	+	+	-	-	+	-	-	-	+	+	-	-	-	-	-	*Salmonella* sp.
Ag_5	+	-	+	+	-	+	-	-	-	-	+	+	+	+	+	-	*Staphylococcus* sp.
Ag_6	+	-	+	-	-	+	-	-	+	-	+	-	+	-	+	+	*Citrobacter* sp.
Ag_7	-	+	+	-	+	-	-	+	+	-	-	+	+	+	+	+	*Escherichia coli*
Ag_8	+	-	+	+	+	+	-	-	-	+	+	+	+	+	+	+	*Bacillus* sp.
Ag_9	-	+	+	-	+	-	-	+	+	-	+	-	+	+	+		*E. coli*
Ag_{10}	-	+	+	-	-	-	-	+	+	-	-	+	+	-	+	-	*E. coli*
Ag_{11}	-	+	+	-	-	+	-	-	-	-	+	-	-	+	-	-	*Leminorella* sp.
S_1	-	+	+	+	-	-	-	-	-	+	+	-	+	+	+	+	*Klebsiella* sp.
S_2	-	+	+	-	+	-	-	+	+	-	-	-	+	-	+	-	*E. coli*
S_3	-	+	+	-	-	-	-	-	-	+	+	-	-	-	+	+	*Enterobacter* sp.
S_4	-	+	+	+	-	-	-	-	+	-	+	+	+	+	+	+	*Staphylococcus* sp.
S_5	-	+	+	-	+	+	-	-	+	-	+	-	-	-	+	+	*Enterobacter* sp.
S_6	-	+	+	-	+	-	-	-	+	-	-	-	-	-	+	+	*Salmonella* sp.
S_7	+	-	+	+	+	+	-	-	-	+	+	+	-	-	+	+	*Bacillus* sp.
S_8	-	+	+	+	-	-	-	-	+	+	+	+	+	+	+	+	*Staphylococcus* sp.
S_9	-	+	+	-	+	-	-	+	+	-	-	-	+	-	+	-	*E. coli*
S_{10}	+	-	+	+	+	+	+	-	-	+	+	+	-	-	+	+	*Bacillus* sp.
S_{11}	-	+	+	-	+	-	+	-	-	-	-	-	-	+	+	-	*Pseudomonas* sp.
S_{12}	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+	+	*Salmonella* sp.
S_{13}	-	+	+	-	+	-	-	+	+	-	-	+	+	-	+	-	*E. coli*
S_{14}	-	+	+	+	-	-	-	-	+	-	+	+	+	+	+	+	*Staphylococcus* sp.
S_{15}	-	+	+	+	-	-	-	-	-	+	+	-	+	+	+	+	*E. coli*
B_2	-	+	+	-	+	-	-	+	+	-	-	-	+	+	+	-	*E. coli*
B_2	-	+	+	+	+	-	+	-	-	-	-	-	-	-	+	-	*Pseudomonas* sp.
B_3	+	-	+	+	-	-	-	-	+	+	+	-	+	+	+	+	*Staphylococcus* sp.
B_4	-	+	+	+	+	-	-	-	-	+	-	+	+	+	+	-	*Enterobacter* sp.
B_5	+	-	+	+	+	+	-	-	-	+	+	+	-	-	+	+	*Bacillus* sp.
M_1	+	-	+	+	+	+	-	-	-	+	+	+	-	-	+	+	*Bacillus* sp.
M_2	+	-	+	-	-	-	-	+	-	-	-	-	+	+	-	-	*Morganella* sp.

Table 2: Continue

Sample code	Gram's reaction	KOH	Catalase motility	Citrate	SH	Oxidase	Indole	MR	VP	Sucrose	Fructose	Lactose	Galactose	Mannitol	Maltose	Glucose	Probable organism
M_3	+	-	+	+	-	+	-	-	+	+	+	+	+	+	+	+	*Staphylococcus* sp.
M_4	-	+	+	-	+	+	-	+	+	-	-	-	+	-	+	-	*E. coli*
Ad_1	-	+	+	-	+	-	-	-	+	-	-	+	-	+	+	+	*Salmonella* sp.
Ad_2	-	+	+	+	+	-	-	-	-	+	-	+	+	+	+	-	*Enterobacter* sp.
Ad_3	+	-	+	+	-	+	-	-	+	+	+	+	+	+	+	+	*Staphylococcus* sp.
Ad_4	-	+	+	-	+	+	-	+	+	-	-	-	+	+	+	-	*E. coli*
Ad_5	+	-	+	+	+	+	+	-	-	+	+	+	-	+	+	+	*Bacillus* sp.
Y_1	-	+	+	-	+	+	-	+	+	-	+	-	+	-	+	-	*E. coli*
Y_2	+	-	+	+	-	-	-	-	+	+	+	+	+	+	+	+	*Staphylococcus* sp.
Y_3	-	+	+	+	+	-	-	-	-	+	-	+	+	+	+	-	*Enterobacter* sp.
Y_4	+	-	+	+	+	+	-	-	-	+	+	+	-	-	+	+	*Bacillus* sp.

SH: Starch hydrolysis, MR: Methyl red, VP: Voges proskauer, KOH: Potassium hydroxide, +: Positive reaction, -: Negative reaction, *Bacillus* and *Staphylococcus* were tested positive for Gram's reaction, catalase, citrate, oxidase, VP, fructose, lactose, maltose, galactose and mannitol, while *Citrobacter, E. coli, Klebsiella, Leminorella, Pseudomonas, Salmonella* and Enterobacter tested negative for Gram' reaction Ag_1-Ag_2: Samples from Agbowo, S_1-S_4: Samples from Sango, B_1-B_4: Samples from Bodija, M_1-M_4: Samples from Mokola, Ad_1-Ad_4: Samples from Agodi and Y_1-Y_4: Samples from Yemetu

Table 3: Frequency of occurrence of bacteria isolated from sliced/cut pineapples at different sampling locations

Bacteria	Agodi	Agbowo	Bodija	Mokola	Sango	Yemetu
Bacillus sp.	0.0	9.0	0.0	25.0	13.3	25.0
Citrobacter sp.	0.0	18.1	0.0	0.0	0.0	0.0
Enterobacter sp.	20.0	0.0	25.0	0.0	13.3	25.0
E. coli	0.0	18.1	25.0	25.0	26.7	25.0
Klebsiella sp.	20.0	9.0	0.0	0.0	6.7	0.0
Leminorella sp.	0.0	9.0	0.0	0.0	0.0	0.0
Morganella sp.	0.0	0.0	0.0	25.0	0.0	0.0
Pseudomonas sp.	0.0	0.0	25.0	0.0	6.7	0.0
Salmonella sp.	20.0	18.1	0.0	0.0	13.3	0.0
Staphylococcus sp.	20	9.0	25.0	25.0	20.0	25.0

Table 4: Overall percentage of occurrence of isolated bacteria species in the sliced pineapple samples

S/no	Bacteria	Frequency of occurrence (%)
1	*Bacillus* sp.	15.9
2	*Citrobacter* sp.	4.5
3	*Enterobacter* sp.	1.3
4	*E. coli*	25.0
5	*Klebsiella* sp.	4.5
6	*Lemionrella* sp.	2.2
7	*Morganella* sp.	2.2
8	*Pseudomonas* sp.	4.5
9	*Salmonella* sp.	11.4
10	*Staphylococcus* sp.	18.2

0.0, 0.0, 0.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu respectively. *Enterobacter* sp. demonstrated the frequency occurrence of 20.0, 0.0, 25.0, 0.0, 13.3, 25.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu respectively, while *E. coli* showed the frequency occurrence of 0.0, 18.1.0, 25.0, 25.0, 26.7, 25.0 in Agodi, Agbowo, Bodija, Mokola,Sango and Yemetu respectively. *Klebsiella* sp. recorded a frequceny occurrence of 0.0, 9.0, 0.0, 0.0, 6.7, 0.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu respectively. *Leminorella* sp. showed the frequency occurrence of 0.0, 9.0, 0.0, 0.0, 0.0, 0.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu respectively, while *Morganella* sp. exhibited a frequency occurrence of 0.0, 0.0, 0.0, 25.0, 0.0, 0.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu respectively. Furthermore, *Pseudomonas* sp. had the frequency occurrence of 0.0, 0.0, 25.0, 0.0, 6.7, 0.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu respectively, while *Salmonella* sp. recorded a frequency occurrence of 20.0, 18.1, 0.0, 0.0, 13.3, 0.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu respectively. Finally, *Staphylococcus* sp. demonstrated a frequency occurrence of 20.0, 9.0, 25.0, 25.0, 20.0, 25.0 in Agodi, Agbowo, Bodija, Mokola, Sango and Yemetu, respectively.

In addition, the overall percentage of occurrence is documented in Table 4. It was recorded that *E. coli* had the highest % of occurrence (25.0%), followed by *Staphylococcus* sp. (18.2%), while *Leminorella* sp. and *Morganella* sp. demonstrated the lowest percentages of occurrence (2.2%) respectively.

DISCUSSION

This study provides information on the isolation and biochemical identification of pathogenic bacteria recovered from sliced/cut pineapple samples hawked in some strategic selected areas in Ibadan North local government of Oyo State, Nigeria.

The sliced/cut pineapple samples worked upon in this study revealed that they were highly contaminated with different species of bacteria such as *Bacillus, Citrobacter*, *Enterobacter, E. coli, Klebsiella*, *Leminorella, Morganella*, *Pseudomonas*, *Salmonella* and *Staphylococcus*. All the identified documented bacteria sp. in this study have been previously reported to be isolated from fruits[15,17,18]. The observed low percentage of occurrence for *Pseudomonas*, *Enterobacter, Klebsiella*, and *Citrobacter* is in conformity with the findings[19], while the high percentage of occurrence for *E. coli* and *Staphylococcus* is in tandem with the documented submissions by[5,20]. According to literature reports, the survival of these bacteria in the sliced/cut pineapple samples might be due to their ability to utilise the nutrients present in the fruit for growth and metabolism, as well as their ability to adapt to prevailing conditions in the fruit matrix[3,13]. More so, the recorded high bacterial load might be due to exposure of the fruits to air during cutting or slicing by the fruit handlers, because air carries a lot of pathogens that may contaminate these fruits[12]. The contamination of cut/sliced fruits could emanate from atmospheric discharge from sneezing or coughing, as well as the methods of hawking and selling of the fruits, which may predispose them to contamination through ecological and environmental conditions[6,10,19]. The survival of these bacteria in the atmosphere depends on factors such as nature of microorganism, adaptation to changes in the physical environment (which includes ability to form resistant spores)[5]. Other researchers also mentioned that contamination of fruits might arise from sources such as contaminated water used in the cultivation of the fruits, harvesting, transportation, storage, time interval between storage and processing, contaminated soil, irrigation water, the environment, washing/rinsing water and handling by processors[3,8]. More so, bacteria borne by these fruits may proliferate rapidly over time depending on the storage conditions, especially the psychrophilic types[10]. Additionally, some of these bacteria species might also emanate as part of the natural micro flora population of the fruits. However, some of the fruit handlers might also be potential carriers of these bacteria due to one illness or the other of which during processing they can easily contaminate the sliced fruits[14]. This scenario therefore predisposes consumers of these hawked sliced fruits purchased susceptible to food borne illnesses caused by a wide variety of pathogenic contaminants. The presence of coliform bacteria such *E. coli* and *Enterobacter* sp. suggests that the sliced pineapple samples were fecally contaminated as a result of the water used for washing the utensils (such as knife, tray, tables, packing nylons, bucket for hawking), and hands of the handlers before and during processing the fruits[19]. Organisms (such as *E. coli, salmonella* and *Pseudomonas*) contaminating the cut/sliced fruits have been earlier reported to cause foodborne infections like gastroenteritis, diarrhoea, cholera and typhoid fever[20]. Cross-contamination of food during processing is a crucial factor to be reckoned with in food-borne illness cases[5]. The identification of *Pseudomonas* sp. as spoilage bacteria of vegetable, fruits and their products have been previously reported by Olu-Taiwo *et al*.[9]. Therefore, the high frequency of occurrence recorded for *Staphylococcus* in this work is in conformity with findings of Nura *et al*.[13], as its occurrence may be due to its natural presence on the hands and skins of healthy individuals because humans have been identified as primary reservoirs of *S. aureus*[12]. However, it can be inferred that contamination of cut/sliced fruits with *S. aureus* will easily occur when the hands of the handlers are not properly washed before engaging in fruit processing[9,11]. More so, sliced pineapple samples contaminated with *E. coli* above the recommended acceptable standard are not safe for human consumption[11,20]. Finally, the high level of contamination recorded by the analysed sliced pineapple samples has the potentials of constituting a huge threat to public health. Hence, appropriate governmental agencies which includes: National Agency for Food and Drug Administration and Control (NAFDAC), and Standard Organisation of Nigeria (SON) should be mandated to monitor and evaluate the microbiological safety of processed fruits hawked in Nigeria.

CONCLUSION

The findings from this study validate the fact that microbial contaminations of cut/sliced fruits through improper handling processes must be monitored and strict hygienic practices should be implemented. The high occurrence of pathogenic organisms recorded in this study points to the fact that, these fruits may become potential sources of food borne infections if adequate processing methods are not put in place. However, this study conducted only culture-dependent studies. Therefore, future studies should be directed towards molecular identification of the isolated organisms, their relatedness to one another, as well as the detection of virulent/toxigenic genes that might be present in the isolated organisms.

SIGNIFICANCE STATEMENT

This study was conducted to determine the level of contaminations caused by pathogenic bacteria associated with sliced pineapples hawked in the Ibadan North Local Government Area of Oyo State, Nigeria. The results obtained from this study will help to enlighten the consumers of the possible potential treat these fruits can cause, if they are not properly processed. Policy makers may also use the information documented in this study to implement laws that must be strictly followed, so as to ensure the maximum safety of the fruit consumers.

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