Microbiological Quality of Plantain *(Musa paradisiacal)*

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Abstract: This study on microorganisms associated with plantain sources was carried out in the Microbiological laboratory of Adekunle Ajasin University, Akungba-Akoko, Nigeria. Plantain *{Musa Paradisiacal)* is a rhizomatous nutritional perennial crop used as a source of starchy staple for millions of people in Nigeria. The total heterotrophic bacterial count for sample sources in cfu/mL ranged from 68 x 10^5; 78 x 10^5 while coliform count was 3 x 10 ;4 x 10 in wet sample and dry sample respectively. The morphological and biochemical characterization of the isolates encountered was determined. The eleven bacterial species obtained from dry flour are categorized into specific bacterial groups including two Gram negative organism such as *Escherichia coli* and *Klebsiella* spp., while the rest nine are Gram positive organisms including *Bacillus cereus* (3), *Bacillus globisporus* (3), *Bacillus circulans* (2) and *Entcrococcus* spp(l). In wet plantain sample sources, nine bacterial species were encountered. Only two are Gram negative *(E. coli)* while the rest seven isolates are Gram positive (including *Enterococcus* (2) one strain each of *Bacillus circulans. Bacillus insolitus, Bacillus alcalophilus* and *Lactobacillus fennentum).* The fungal species isolated during the study include *Aspergillus flavus, Aspergillus niger, Penicilliumchry sogenum, Saccharomyces cerevisae, Aspergillus fumigatus, Fusarium* spp., *Rhizopus stolonifer* and *Mucorspp.* This study shows the prevalence of fungi in plantain and the microbial quality of plantain both in wet and dry state when consumed.

Keywords: Food; Microorganisms; Mycoflora; Plantain; Quality

Introduction

Plantain (*Musa parasidiacal)* is a major staple food for most parts of Africa, as it contributes to the calories and sustenance of economies. Plantain (*Musa parasidiacal*) is the fourth most important food in the world today (after rice, wheat and maize). The plant grow in a wide range of environments and serves as a source of food, beverages, fermentable sugars, medicine, flavouring, silage, fragrance, toffees, fruit bars, brandy, rope, cordage, garlands, shelter, clothing and numerous ceremonial and religious uses (Kitume-Ngongo, 2002;Nelson *et al.,* 2006). Banana is closely related to plantain that originated from two wild botanical sources: *Musa acuminate* and *Musa balbisiana* Gold and Messiaen, 2000), that originated from Southeast Asia. This crop produced three different types namely banana which contains a low starch and high sugar content when ripe, true plantain which is starchy even when ripe and is only eaten when cooked. It possesses relatively different shape. While, third type known as cooking bananas, which I also starchy but commonly used for cooking (Hoss *et al.,* 2000)

Musa is one of the cheapest food crops to produce and the cost of production is less than most other staples(Gold and Messiaen, 2000). India, with rich bio-diversity of banana and plantain, is the largest producer and consumer of banana in the world with an estimated production of 16 million tonnes of bananas annually. In African context, there is large production of this crop in Cameroon whereby research shows that 1.5 million tonnes of plantains were produced during the year 2015. This source also stated that from 1.2 million tonne in 2010 to 1.5 million per year is produced in this country (Le Quotidien de l'economile, 2015).Similarly, according to Rossmanna (2012), In Uganda, the country with the second largest banana production in the world, bananas are the most important staple food. This shows the economic importance of this food source.

Plantain produces fruit throughout the year but is harvested between the harvests of other starchy staples such as cassava and yam. According to Pillay and Tenkouano, (2011), with current world population growth of 1.2%, the earth can expect to house 9-10 billion people by 2050. Increase in food production too is necessary to accommodate this numbers. Hence, easy growing, high calorie, nutritious foods such as bananas are the top solution to the imminent problem (Pillay and Tenkouano, 2011). Microorganism associated with production and processing of plantain to obtain some valuable end products includes *Bacillus subtilis, Staphylococcus aureus, Lactobacillus* spp., *Saccharomyces cerevisiae, Aspergillus flavus, Aspergillus niger, Fusarium* species and *Penicillum* species (Fajinmi *et al.,* 2011). Variable numbers of coliforms such as *Escherichia coli, Klebsiella pneumonia* and *Salmonella typhii,* which may arise from unhygienic water, materials and human contamination can also be present (Ohenhen *et al.,* 2013; Kouadio *et al.,* 2014).

Environmental factors that influence the growth of plantains include adequate rainfall and temperature (28 -32^{0}C) which are ideal for the growth of the crop. Temperatures below 18^{0}C and above 36^{0}C will adversely affect growth. Stormy winds can also cause considerable damage to plantain because of its

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week rooting systems (Li *et al.*, 1999). Soil is another major factor that affects plantains. Some nutrient components such as Nitrogen, Phosphorus, Potassium, Magnesium and Calcium are the most important element for plantains to avoid diseases conditions (Hoss *et al.*, 2000; Oloyede *et al.*, 2013).Plantains and Bananas can be affected by three major insect pests such as Plantain/Banana Root Weevil – *Cosmopolites sordidus;* Pseudostem Borer –*Lapaeumideslicus* (Lepidoptera; Castinidae) and Fruit Scarring Beetle – *Colapsishypochlora* (Coleoptera; Chrysomelidae). Many microbial agents are however involved in plantain infestation (Ruiz, *et al.*, 2009)..

In Guyana (South America), there are several varieties of plantains grown but farmers as well as consumers show a definite preference for the 'Creole plantain'. It is also boiled in coconut milk as a component in 'metagee' or it can be thinly sliced and fried into "plantain chips"(Gold and Messiaen, 2000). In the southern United States, particularly in Texas, Louisiana and Florida, plantains are most often grilled. In Nigeria, plantain is eaten boiled, fried or roasted; roasted plantain, called *boli* is usually eaten with palm oil or groundnut(Gold and Messiaen, 2000). Steam-cooked plantains are considered a nutritious food for infants and the elderly. SriLanka's ash plantains called *alukesel* are generally used for cooking. On some occasions, they are used in Ayurvedic medicine. Plantain flower also called as kesel mala (or kehelmala or keselmuwa) can also be used in this regard (Lebeda *et al.*, 2001).

Other forms of preparations of plantain are **Yo-yo** (Venezuela),***Mofongo*** (Puerto Rico),***Fufu de platano*** (Cuba), ***Chifles*** (Spanish term used in Peru, Colombia and Ecuador for fried green plantains), ***Alcapurria*** (Puerto Rican), ***Pionono***s (A popular Caribbean dish which originated in Puerto Rico), ***Pastelon de amarillos*** (Dominican Republic) and ***Mangú*** (A traditional mangú from the Dominica republic) (Lebeda *et al.*, 2001). Similarly, we have ***Dodo***which is plantain is popular in West Africa, especially Cameroon, Bénin, Ghana and Nigeria. ***Boli*** is also the term used for roasted plantain in Nigeria. ***Matooke,*** *Matooke* or *Matoke* is a plantain dish common in Uganda, Tanzania, Rwanda and eastern Congo. ***Ethakkaappam***, *pazham* (banana) *boli* or *pazhampori* are terms used for fried plantain in Kerala. The plantain is generally modified for consumption in various parts of the world (Jalal *et al.*, 1992; Ohenhen *et al.*, 2013).

The low fat content of plantain, coupled with its high starch content, makes it a possible food for geriatric patients. It may also be a possible food alternative for people suffering from gastric ulcer, coeliac disease and in the relief of colitis. Plantain contains very little beta-carotene. The vitamin C content of plantain is very similar to those of sweet potato, cassava and potato, but the concentration may vary with the crop, maturity at harvest, soil, and farming conditions (Kitume-Ngongo, 2002). Plantain and banana allergy are reported in some human beings. Patients with allergy to plantains and banana report adverse reactions immediately after consumption, that is, up to one hour after ingestion. Symptoms are characteristics of food allergy: from mild reactions, such as itching and mild swelling of the lips, tongue, palate and throat, followed by a rapid resolution of symptoms, to itching rush and hives in the skin or mucous swelling, stomach complaints, hay fever, constriction of the throat and asthma, or anaphylactic shock, a generalized serious reaction with a large drop in blood pressure (Kitume-Ngongo, 2002).This study evaluates the microbiological quality of plantain.

Materials and Methods

Sample Collection and Preparation

The plantain used for this study were purchased from Akungba-Akoko market, Ondo State, Nigeria and conveyed in a clean polythene bag to the *Microbiology Laboratory in Adekunle Ajasin* University, Akungba-Akoko, Nigeria, for microbiological analysis. They were washed thoroughly with tap water to remove adhering substances. Using a clean knife, 10pieces of the unripe plantain were peeled and sliced into tray (Amande and Adebayo-Tayo, 2012). It was then sundried for 12days and grinded into powder form with the use of house-hold blender that was thoroughly washed and swab with ethanol for adequate sterilization. The other set of wet fruit sample was not dried. About one gram of the appropriate sample source was measured and ten-fold dilution was carried out up to 10^{10}dilutions. One(1)ml of the diluted sample was pipette from the dilutions 10^{-5} and 10^{-6}respectively and was dispensed into sterile Petri-dishes followed by the addition of the media that was cooled to about 45^{0}C then swirled briefly and allow to set, after which it was incubated at 37^{0}C for 24hours to 48hours. Estimation of total heterotrophic viable bacterial count and coliform count was made from this pour plate technique. Each discrete colony was subcultured for their morphological and cultural characteristics.

Isolation of fungi

Direct Plating Method: From the dried plantain chips, ten slices examined randomly for external mouldiness. They were surfaced sterilized with ethanol and later washed with sterile distilled water. Using a sterile blade, the surface of the dried plantain were scrapped and were aseptically plated on Potato Dextrose Agar (PDA) plate and incubated at room temperature for 5-7 days as described by Amusa *et al.*, (2001). The fungi cultures were further subcultured until pure colonies were obtained by successive hyphae tip transfer (Egbebi *et al.*, 2007; Fagbohun *et al.*, 2010). The cultures were examined under the microscope for fruiting bodies, hyphae to determine the common fungi present.

Dilution Plating Method: This method was used to determine the type of fungi present in the stored dried

and wet plantain chips. About one gram of the sample was sterilized with ethanol and grinded with 10ml of sterile distilled water. This was thoroughly mixed together. The sample was serially diluted and 1ml each of aliquots of 10^{-3} and 10^{-5} were added to molten PDA plates.

The plates were swirled gently to obtain through mixing and were allowed to solidify and incubated at 25^{0}C for 5-7 days. The fungal colonies were counted every 24hours. Successive hyphae tip were transferred until pure cultures of each of fungus was obtained.

Identifications of isolates.

The isolates were identified by standard microbiological method. This includes the Gram stain and various types of biochemical tests performed on isolates cultured for about 24hours during the study.

Identification of Mycoflora

Fungal isolates were incubated using potato dextrose agar medium for about 96 hours. The associated fungi were identified by their cultural and morphological features (Kelley *et al.*, 2003). The isolates were examined under bright daylight that enhances clarity of cultural appearance including the color of the culture and further examinations were carried out. Microscopic studies of each fungi type was done by making a drop of Lactophenol cotton blue on a glass slide. Then mounting a bit of each colony on to the drop of Lactophenol cotton blue on the slide then thinned out with inoculating needles and examined under the microscope. Fragments of the sporing surface of the initial culture was taken midway or between the centre and the edge of the colony. This was teased out in a drop of alcohol on sterilized glass slide using a botany needle. The fragments were stained by adding a drop of Lactophenol cotton blue. A cover slip was applied and preparation was examined under x10 and x40 objective lens of the microscope. (Egbebi *et al.*, 2007 and Fagbohun *et al.*, 2010).

Results

Microbiological quality of plantain (*Musa Paradisiaca*) was determined during this study. The result shows that the bacterial population in cfu/mL ranged from 68 x 10^5; 78 x 10^5 while coliform count was3 x 10^5;4 x 10^5 in wet samples and dry sample respectively (Table 1). Various forms of plantain microflora and other microbial groups were encountered during the study. The morphological and biochemical characterization of the isolates encountered was determined. Table 2 shows that eleven isolates were obtained from dry flour and they are categorized into specific bacterial groups including two Gram negative organism such as *E.coli* and *Klebsiella* spp., while the rest nine were Gram positive organisms including three *Bacillus cereus*, three *Bacillus globisporus*, two *Bacillus circulans* and one *Enterococcus* spp.). In wet plantain sample sources, nine bacterial species were encountered (Table 3). Only two are Gram negative (*E. coli*) while the rest seven isolates are Gram positive (including two *Enterococcus*, *Bacillus circulans*, *Bacillus insolitus*, *Bacillus alcalophilus* and *Lactobacillus fermentum*).

The fungal species isolated during the study include *Aspergillus flavus, Aspergillus niger, Penicillium chrysogenum, Saccharomyces cerevisae, Rhizopus stolonifer, Mucor* spp. Table 4 shows Fungal species isolated from wet plantain which include *Aspergillus flavus, Fusarium* spp,, *Mucor*spp., *Penicillium chrysogenum.* In Table 5, the fungal species isolated from oven dried plantain were determined and this include *Aspergillus fumigatus, Aspergillus niger, Rhizopus stolonifer, Saccharomyces cerevisae, Fusarium* spp. Table 6 shows the fungal species isolated from sun-dried plantain which include *Penicillium chrysogenum, Aspergillus niger, Saccharomyces cerevisae, Rhizopus stolonifer* and *Aspergillus flavus.*

TABLE 1: Total Viable Bacteria Counts of Plantain Sample at 24hours.

Plantain Sample	Total count		Coliform count	
	10^{-5} cfu/ml	10^{-6} cfu/ml	10^{-5} cfu/ml	10^{-6} cfu/ml
Dry Sample	78 x 10^5	41 x 10^6	4 x 10^5	0.5 x 10^6
Wet Sample	68 x 10^5	NVG	3 X 10^5	NVG

LEGEND: NVG = No Visible Growth

Table 2: Biochemical Reactions of Isolates found on Dry Plantain Sample.

S/no	Sample code	Morphology on NA	Gram reaction	Morphology	Citrate test	Catalase test	Starch hydrolysis	motility	H_2S	Lactose	Sucrose	Glucose	Maltose	Indole	Oxidase	Probable organism
1	PSD1	Swam, creamy, opaque,serrated edge, raised.	+ in cluster	SR	+	+	+	-	+	a	ag	a	a g	-	-	*B.cereus*
2	PSD2	Swam, creamy, opaque,serrated edge, raised.	+in cluster	SR	+	+	+	-	+	a	ag	a	a g	-	-	*B.cereus*
3	PSD3	Swam, creamy, stellate,translucent, edge, raised.	-	LR	+	-	-	-	+	a	a	a	a	-	-	*Klebsiella* spp.
4	PSD4	Swam, creamy, opaque,smooth edge, flat.	+ in cluster	LR	-	+	+	-	+	a	ag	a	a g	-	-	*B.circulans*
5	PSD5	Swam, creamy, translucent,smooth edge, raised.	+	LR	-	+	+	-	+	ag	ag	a	a	-	+	*B.globisporus*
6	PSD6	Swam, creamy, translucent,smooth edge, raised.	+	LR	-	+	+	-	+	ag	ag	a	a	-	+	*B.globisporus*
7	PSD7	Swam, creamy, opaque,serrated edge, flat	+ in cluster	SR	+	+	+	-	+	a	ag	a	a g	-	-	*B.cereus*
8	PSD8	Swam, creamy, translucent, smooth edge, raised.	+ in cluster	LR	-	+	+	-	+	ag	ag	a	a	-	+	*B.globisporus*
9	PSD9	Swam, creamy, opaque,Smooth edge, flat.	+	LR	-	+	+	-	+	a	ag	a	a g	-	-	*B.circulans*
10	De1	Swam, pink, flat, smooth edge on EMB	+	CC	+	+	-	-	-	a	a	a	a	-	+	*Enterococcus* spp.
11	De2	Swam, pink, flat, smooth edge on EMB	-	SR	-	+	+	-	-	ag	ag	ag	a g	+	+	*E.coli*

LEGEND:a= Acid production, ag= Acid and gas, SS=Short rod, LR= Long rod, CC= Cocci in cluster, + = Positive, - = Negative, PSD= Plantain sample dried and cultured on Nutrient Agar, De= Dry sample on Eosine Methylene-blue Agar (EMB).

Table 3: Biochemical Reactions of Isolates found on Wet Plantain Sample.

S/no	Sample code	Morphology on NA	Gram reaction	Morphology	Citrate test	Catalase test	Starch hydrolysis	motility	H_2S	Lactose	Sucrose	Glucose	Maltose	Indole	Oxidase	Probable organism
1	Wna1	Swam, creamy, opaque, smooth edge, flat	+	SR	-	+	-	-	-	-	-	-	-	-	+	*B. insolitus*
2	Wna2	Swam, creamy, opaque, smooth edge, flat	+	SR	-	+	+	-	-	ag	ag	-	ag	-	-	*B.alcalophilus*
3	Wna3	Swam, creamy, opaque, smooth edge, flat	+	LR	-	-	-	-	-	ag	ag	ag	ag	-	-	*L. fermentum*
4	Wna4	Swam, creamy, opaque, smooth edge, flat	+	LR	-	-	-	-	-	ag	ag	ag	ag	-	-	*L. fermentum*
5	Wna5	Swam, creamy, opaque, smooth edge, flat	+	LR	-	+	+	-	+	a	ag	a	ag	-	-	*B. circulans*
6	We1	Swam, pink, smooth edge, flat on EMB	-	SR	-	+	+	-	-	ag	ag	ag	ag	+	-	*E.coli*

7	We2	Swam, pink, smooth edge, raised on EMB	+	CC	+	+	-	-	-	a	a	a	a	-	+	*Enterococcuss* pp.
8	We3	Swam, pink, smooth edge, raised.	+	CC	+	+	-	-	-	a	a	a	a	-	+	*Enterococcus* spp.
9	We4	Swam, pink, smooth edge, flat on EMB	-	SR	-	+	+	-	-	ag	ag	ag	ag	+	-	*E.coli*

LEGEND: a= Acid production, ag= Acid and gas, SS=Short rod, LR= Long rod, CC= Cocci in cluster, + = Positive, - = Negative, C= Clustered Wna= Wet sample on Nutrient Agar, We= Wet sample on Eosine Methylene Blue Agar (EMB).CE= Curve Edge.De= Dry sample on Eosine Methylene blue Agar (EMB).
PSD=Plantain sample dried and cultured on Nutrient Agar.LR= Long rod, NVG = No Visible Growth
I: Intermediate, R: Resistance, S: Sensitive, S= Scattered

Table 4: Fungi isolated from wet plantain.

Cultural Characteristics	Microscopic observation	Suspected organisms
Army green mycelia growth was seen in colonies on the growth medium.	Conidiosphores upright, bearing phialides at the apex.	*Aspergillus flavus*
White and fluffy mycelia growth spread through the entire growth medium.	Conidiosphores richly branched, bearing phialides which proliferate.	*Fusarium* spp.
Brownish mycelia spread through the plate; it is fast growing.	Conidiosphores arising from long, broad thick smooth wall and mostly brownish.	*Aspergillus niger*
Greyish mucoured on plate.	Round sporangia	*Mucor* spp.
Green on plate.	Conidiosphores richly branched, bearing phialides which proliferate. long, broad thick smooth wall and mostly brownish	*Penicillium chrysogenum*

Table 5: Fungi isolated from oven dried plantain

Cultural Characteristics	Microscopic observation	Suspected organisms
Grey-Brown colour. Colonies are fast growing.	Unbran chedsporangiosphores with rhizoides	*Rhizopus stolonifer*
Powdery, white at first then turned greenish.	Cover entire vesicle, form "radiate" head.	*Aspergillus fumigatus*
Creaming with lots of tiny colonies.	Hyphal growth is not extensive.	*Saccharomyces cerevisiae*
White and fluffy.	Conidiosphores richly branched, bearing phialides which proliferate.	*Fusarium* spp.
Brownish mycelia spread throughout the plate	Conidiosphores arising from long, broad thick smooth wall and mostly brownish.	*Aspergillus niger*

Table 6: Fungal isolated from sundried plantain chips

Cultural Characteristics	Microscopic observation	Suspected organisms
Started growing by appearing creamy in tiny colonies, turned yellow-green in 3 days.	Conidiosphores upright, bearing phialides at the apex.	*Aspergillus flavus*
Grey-Brown with black pigment, colonies are very fast growing.	Sporangiophores with rhizoides, and connected by a stolom	*Rhizopus stolonifer*
Creaming with lots of tiny colonies.	Hyphal growth is not extensive.	*Saccharomyces cerevisiae*
Deep green	Conidiosphores richly branched, bearing phialides which proliferate.long, broad thick smooth wall and mostly brownish	*Penicillium chrysogenum*
Brownish mycelia spread throughout the plate	Conidiosphores arising from long, broad thick smooth wall and mostly brownish.	*Aspergillus niger*

Discussion

This study shows the microorganisms associated with plantain sources in Akungba-Akoko, Nigeria. The results from the Table 1 shows that the total bacterial countof 68 x 10^{-5}cfu/mLand 78 x 10^{-5}cfu/mL for both the wet and the dry samples respectively. Similarly, the coliform count was 4 x 10^{5}cfu/mL and 3 x 10^{5}cfu/mL for the two set of samples

respectively was high. This is because the presence of these coliforms may be indicative of faecal contamination. The wet sample at dilution 10^{-6} had no visible growth both on the Nutrient agar and on the Eosine Methylene-Blue agar while the dry sample which is more or less a preserved form shows a reduction in the population in dilution 10^{-6} ($0.5x10^{6}$cfu/ml) compared to the dilution 10^{-5} ($4x10^{5}$cfu/ml). This correlates with the study of Fagbohun *et al.*, (2010) who demonstrated the increase in some microbial count during storage of plantain.

The result for the Table 2 which shows the morphological characteristics of the isolates found on dry plantain sample, eleven isolates was obtained and their reactions to the Gram reagents shows that there are two Gram negative (*E.coli* and *Klebsiella* spp.) organism while the rest nine are Gram positive (three *Bacillus cereus*, three *Bacillus globisporus*, two *Bacillus circulans* and one *Enterococcus spp.* suspected).Table 3 shows the morphological and biochemical characteristics of isolates found on wet plantain sample. The test performed include Citrate, Catalase, Starch hydrolysis, Motility, Lactose, Sucrose, Glucose, Maltose and their respective gas, Indole and Oxidase test, as this enhanced the proper identification of the isolated organisms. Out of the nine organisms isolated only two are negative to Gram reactions (two *E. coli*) while the rest seven isolates are Gram positive (two *Enterococcus*, *Bacillus circulans*, *Bacillus insolitus*, *Bacillus alcalophilus* and *Lactobacillus fermentum*. This corroborates with the study of Fajinmi *et al.*, (2011) who reported the influence of storage conditions on microbial loads of some Musa species.

In Tables 4, 5 and 6, the cultural and microscopic characteristics of fungal species isolated were determined for identification purposes. A total of eight fungal species were isolated from the plantain (wet and dry) in this context. The fungal species isolated and identified include *Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Mucor* spp., *Penicillium chrysogenum, Fusarium* spp., *Rhizopus stolonifer* and *Saccharomyces cerevisae*. This study shows that *Aspergillus niger, Aspergillus flavus, Fusarium* spp., *Mucor* spp., *Penicillium chrysogenum* were found in the wet plantain. Most of these fungi are known to be surface contaminant of most agricultural product that induces decay, also most of the fungi isolates are those capable of growing inside the chips in correlation with the Aspergillus *flavus* is a fungus which is also a common mold in the environment and can cause storage problems in stored grains (Amaike and Keller, 2011). It can also be a human pathogen and many strains produce significant quantities of aflatoxin, a carcinogenic and actually toxic compound.

Aspergillus niger which is also one of the fungus identified in this laboratory work is one of the most common specie of the genus *Aspergillus*. It is a major cause of various crop diseases. Some strains of *Aspergillus niger* have been reported to produce potent mycotoxins called ochratoxins. *Penicillium* infections results in keratitis, endophtalmitis, otomycosis, necrotizing esophagitis, pneumonia, endocarditis, peritonitis, urinary tract infections, mucocutaneous, genitourinary, gastrointestinal, pulmonary and disseminated infections as the clinical features (Kontogiorgi *et al.*, 2007). *Rhizopus* is another fungal species encountered in this study. It was reported by Kontogiorgi *et al.* (2007) to causerhinocerebral Mucor mycosis, mucocutaneous, genitourinary, gastrointestinal, pulmonary and disseminated infections. It is also responsible for the damage of blood vessels and nerves. Rhizopus and some fungal infections can be prevented by avoiding contact with contaminated object as well as maintaining a proper hygiene (Welsh and Kaplan, 1998; Oluwafemi *et al.*, 2013). Chemical approach can also be used to control the emergence of these fungal aetiologic agents (Díaz-Rivera, 2004; Ceballos *et al.*, 2012).

Conclusion and Recommendation

The study shows decrease in the number of colonies with increase in the dilution ratio.It resulted to the reduction of the number of propagules present in the inoculum which goes to extinction at 10^{-6}diluent source. This is in consistence with the study of Kitume-Ngongo (2002) that shows that the population of microorganisms decreases with increase in the dilution factor. Various group of bacterial species obtained from these sources including *L. fermentum* can actively utilize sugar in the plantain for their survival and *Bacillus cereus* is a spoilage organism responsible for the spoilage of the plantain flour while the presence of the rest species of *Bacillus* is due to the presence of proteins and versatility of Bacillus species to thrive well in diversified environment or form part of natural micro floral of plantain (Lebeda *et al.*,2001). The two Gram negative organisms isolated and identified as *Escherichia coli* and *Klebsiella* spp. signifies faecal contamination from either human, birds or other domestic animals during the processing of the flour and so a more hygienic condition is required for the production of the *Enterobacteriaceae* free flour.

Plantains are of great economic importance, and in order to maintain quality, they should be stored under proper-controlled conditions to prevent them from fungal deterioration. The present study shows the nature of bacterial and fungal species associated with plantain. This can enhance the quality of this crop for human consumption. The presence of various species of fungi in this crop can result in the synthesis of toxins such as aflatoxins, fumonisins, and ergot alkaloids thereby posing threat to immune copromised individual. Hence, proper storage of plantain against contamination to meet the international standards of good manufacturing process will facilitate sustainable economic growth and food safety

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