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Effect of post-harvest handling on the bacteria quality of selected fruits and vegetables sold in two markets at Abuja, Nigeria.

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Abstract: *The effects of postharvest handlings on the bacterial quality of some selected fruits and leafy vegetables sold in two markets in Abuja, Nigeria, were investigated. Carrot, guava, oranges, cucumber, garden egg, banana, plantain, cabbage, spinach, and Oha leaves were obtained from Karu and Nyanyan in markets in the Federal Capital Territorial Abuja, Nigeria. The study was carried out in 2012. Seven different types of fruits and three types of leafy vegetables were used in this study. The samples were all collected from fruit vendors in two different markets. The study was carried out in the rainy season and dry season. The fruits and vegetables were stored on three (3) different days (Day 1, Day 4 and Day 7). Significant (p< 0.05) differences were recorded between the two seasons. Banana had the highest bacteria load of 8.2 in the dry season; while Cabbage and Oha vegetable had 7.1 and 7.1 each in the raining season, Guava and cucumber showed the lowest bacteria load of 6.5 and 5.5 respectively in the both seasons. The results obtained from the investigations showed that bacteria load was higher on the fruits and vegetables during the dry season than in the raining season. The results shows that fruits and vegetables when eaten without proper washing can transmit some pathogens to consumers, hence more caution should be taken by consumers during the dry season.*
Key Words: *Bacteria quality, Escherichia coli, Pterocarpus soyauxii,*

I. Introduction

Fruits and vegetables are an extraordinary dietary source of nutrients, (minerals and vitamins) and fibre for health and wellbeing of human beings. Well balanced diets, rich in fruits and vegetables, are especially valuable for their ability to supply vitamins A and C which are known to reduce the risk of several diseases **(**Kalia and Gupta, 2006). Fruits and vegetables are widely exposed to microbial contamination through contact with the soil when growing, though unclean water and improper handling at harvest or during postharvest processes are other sources of contamination. They therefore, harbor diverse microorganisms including those that are plant and human related (Nguyen and Carlin, 1994). Differences in microbial profiles of various fruits and vegetables can largely be caused by such factors as resident micro-flora and fauna of the soil, manures used as sources of nutrients, sewage or irrigation water, transportation and type of handling by retailers (Ray and Bhunia, 2007). According to (Olayemi 2007), developing countries such as Nigeria, with continuous use of untreated waste water for irrigation and manure as fertilizers for the production of fruits and vegetables are a major contributing factor to contamination.

The postharvest sector includes all points in the value chain from production in the field to when the food is placed on the plate for consumption. Several losses may occur along the production Chain all to point of sales of the produce. They can be caused by a wide variety of factors, ranging from growing conditions to handling at retail levels. Not only are losses clearly a waste of food, but can also represent a similar waste of human effort, farm inputs, livelihoods, material investments and scarce resources such as water and money.

Despite the nutritional and health benefits of fruits and vegetables to man, outbreaks of infections associated with the consumption of fresh or minimally processed fruits and vegetables have increased in recent years (Beuchat, 2002). Enteric pathogens such as Escherichia coli and Salmonella are among the greatest concerns during food-related disease outbreaks, Buck, et. al., (2003). Several cases of typhoid fever outbreak have been associated with eating contaminated vegetables grown in/or fertilized with contaminated soil or sewage. These increases in fruits and vegetable-borne infections cannot be unconnected with increased consumption of contaminated fruits and vegetables outside the home as most people spend long hours outside (Kadar, 2005).

In Nigeria for instance, street vending of handy ready-to-eat sliced fruits and vegetables have recently become very common and the marketing of such fruits and vegetables is thriving. These agricultural produce (fruits and vegetables) carry microbial flora while passing from the farm to the table. These produce are exposed to potential microbial contamination at every step beginning from cultivation, harvesting, transportation, packaging, storage and the final sells to the consumers (Tournas, 2005)

Bacteriologically safe fruits and vegetables are essential to maximize the health benefits promised by adequate consumption of these produce. Proper washing of fruits and vegetables is essential for decontamination. Water supplemented with varying concentrations of organic acids, such as acetic, citric and ascorbic acids have been shown to reduce microbial load on fruits and vegetables. Beuchat (1998) revealed that a vinegar dip resulted in a 3 to 6 log10 decrease in the number of aerobic bacteria on leaves of parsley, depending on the concentration of the vinegar used and microbial incubation time. In this study an attempt was undertaken to determine the effects of postharvest handling of some selected fruits and vegetables sold in the Karu and Nyanyan market at Federal Capital Territory – FCT, Abuja, Nigeria.

Statement of the problem

Abuja is the administrative capital of Nigerian. It is located in the geographical centre of related Nigeria. Abuja is a planned city, built in the 1980s. It became Nigeria's official capital on 12 December 1991, leaving Lagos as the business capital. At the 2006 census, the city of Abuja had a population of 776,298.

In Abuja, fruits and vegetables are greatly consumed by people of all class; therefore the regular outbreak of infections associated with the consumption of fresh or minimally processed fruits and vegetables had caused the death of so many consumers in Abuja. Based on this, the study will look at the effects of postharvest handling on the bacterial quality of these fruits and vegetables within Nyanyan and, Karu site area of Federal Capital Teritory (FCT).

The aim of this study was to determine the effects of postharvest handling on the quality of fruits and vegetables sold in the Abuja (FCT) markets. The specific objectives were

i. To determine the bacterial load of some selected fruits and leafy vegetables at different storage periods.
ii. To identify the types of bacteria present in the selected fruits and leafy vegetables.
iii. To determine the overall quality of produce at different stages and precautionary measures that can be adopted in reducing the postharvest handling effects and the bacterial load on the these produce.

II. Materials Methods

Materials

Seven fruits carrot (Daucus carota), Guava (Psidium guajava), oranges (Citrus sinensis), cucumber (Cucumis sativus), Garden eggs (Solanum melongena), Banana (Musa acuminate), plantain (Musa paradisiaca), were used for the study, while Cabbage (Brassica oleraceavar), Spinach (Amarathus caudatus. L.) and Oha leaves (Pterocarpus soyauxii) were leaves selected for the study.

The samples were all collected from fruit and vegetable vendors at the Karu and Nyanyan markets in Abuja. The specimens were carefully stored in polythene bags that had been disinfected with acetic acid. They were transported in a car from Abuja to the Microbiology laboratory of the National Cereals Research Institute, Badeggi, Niger State for laboratory analysis.

Preparation of Media

Nutrient agar, Mac Conkey Agar, plate count agar, Eosin methylene blue and Xylose deoxycholate Iysine agar, peptone water, were prepared according to Manufacturer's instructions, and sterilized by autoclaving at 121°C for 15 min after which the media were allowed to cool to 45-50^{o}C before inoculating them with sample material.

The method used for the recording of the bacteria load count was the serial dilution method. The plates that had been inoculated were placed in the incubator (that had been pre-set at a temperature of (37^{o}C) for 24hours

Inoculation of Samples

The samples on arrival at the laboratory were immediately inoculated using the swap and rinsed method as described by Manheimer and Ybanez (1998).

Sterile cotton swaps were used and the organisms dislodged from the fiber into a conical flask containing 25mls that had previously been auto cleaved with a BPW. A 10 fold serial dilution was carried out by pipeting 1ml of the diluents into 9mls of BPW in test tubes and 1ml of the 10^{6}dilution was plated in 15mls previously autoclaved plate count Agar, and the plates rotated gently to allow for thorough mixture, and then also allowed to rest on the working bench to solidify as described by Eckert, **(**1979).

They were then put in the incubator and incubated inverted in a Gelan camp incubator at 36^{o}C for 24 – 36 hrs. The organisms in the diluents were enumerated by a suitable method **-**APC. Any culture media may be used to test specifically for any group of organisms. The dilutant was surface plated using plate count agar or selective media **(**Eckert, 1979)

Enumeration of Colonies
Following incubation, all colonies on dishes containing 30 – 300 colonies were counted and the results per dilution were also counted.
When the plates examined contained no colonies, the result is expressed as less than 1x 10^1 bacteria per gram. (Bachoon, et al, 2008)

Identification of Microorganisms
Pure Cultures
Each growing colony was sub-cultured into prepared plates of nutrient agar set at 45^0C, by streaking across the plates with wire loop and subsequently flaming it for sterility before picking subsequent colonies for streaking. The streaked plates were incubated in an incubator at 36^0C for 24 hrs. The growing colonies on nutrient agar after 24 hrs were streaked into three selective media for identification and the results are shown on plates 1 and 2.

Types of Differential Media
MacConkey Agar (MAC) is a selective and differential medium designed to isolate and differentiate enterics based on their ability to ferment lactose.
Organisms that ferment lactose and thereby produce an acidic environment will appear pink because of the neutral red turning red.Non-fermenters will produce normally-colored or colorless colonies. Klebsiella pneumoniae ferments lactose and produces pink colonies on MacConkey Agar (Bachoom, 2008)

Eosin Methylene Blue
Differential microbiological medium, which slightly inhibits the growth of Gram-positive bacteria and provides a color indicator distinguishing between organisms that ferment lactose (e.g., E. coli) and those that do not ferment lactose(e.g Salmonella and Shigella). Organisms that ferment lactose display "nucleated colonies" **--** colonies with dark centers. (ZajcSatler and Gragas, 1977)**.**
- Lactose fermentation produces acids, which lower the pH. This encourages dye absorption by the colonies, which are now colored purple-black.
- Lactose non-fermenters may increase the pH by domination of proteins. This ensures that the dye is not absorbed. The colonies will be colorless.

Xylose Lysine Deoxycholate Agar (XLD agar) is a selective growth medium used in the isolation of Salmonella and Shigella species from clinical samples and from food (Zajc-Satler and Gragas 1977) .Most gut bacteria, including Salmonella, can ferment sugar xylose to produce acid; Shigella colonies cannot do this and therefore remain red. Salmonellae metabolise thiosulfate to produce hydrogen sulphide, which leads to the formation of colonies with black centres and allows them to be differentiated from the similarly coloured Shigella colonies.
- Shigella species: red colonies.
- Coliforms: yellow to orange colonies.
- Pseudomonas aeruginosa: pink, flat, rough colonies. This type of colony can be easily mistaken for Salmonella due to the color similarities. The Bergey's manual of Determinative Microbiology (1918) was used to further identify the observed microorganisms.

Carbohydrate Fermentation
One tube of each of the carbohydrate media was incubated at 35 – 37^oC -and examine for acid and gas production. This was examined by inoculating nutrient broth tube containing 0.5% glucose, 0.01% phenol red with cultures of unknown bacteria, and one tube was left not incubated as control. It was incubated at 35^oC to 37^oC for 2-5 days. Then the acid production was shown by change in phenol red indicator to yellow while gas production was shown by medium displacement in the Durham tube.

Gram Staining Method;
- This method was used to differentiate the bacteria that may be gram positive or gram negative.
- Flood heat – slide with methyl violet solution was fixed and allowed to remain for 5 min. Washed with water and then Flooded with iodine solution and allowed to drain for 2 minutes and decolorized with acetone and washed gently in running water. It was then counter stained with Safranin or basic Fuchsin for further 30 sec to 1 min. It was then washed, blotted and dried.

Data Analysis
Data collected from the study were subjected to analysis of variance (ANOVA) using completely randomized design (CRD) replicated three times. Means were separated using Duncan Multiple Range Test (DMRT).

III. Results and Discussion

Bacteria Load of fresh fruits and vegetables

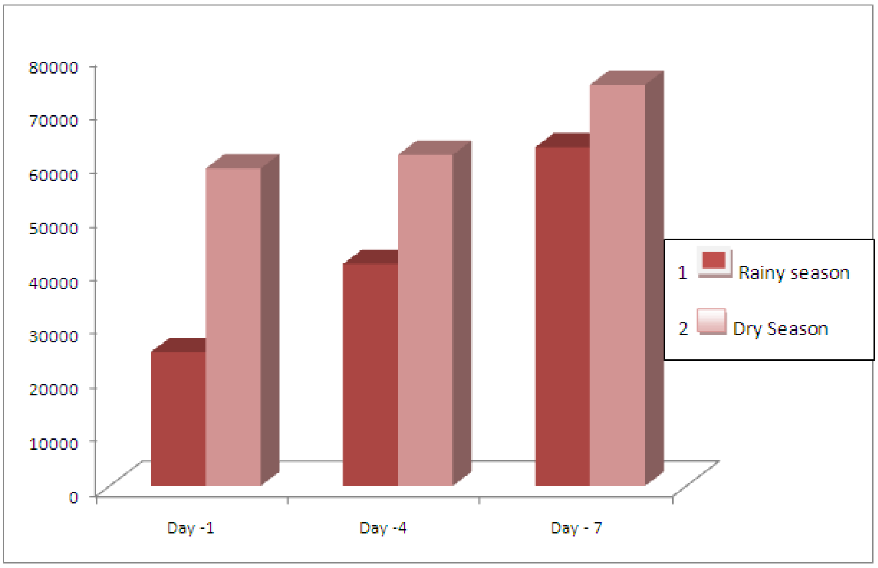
The bacterial load of selected fresh fruits and vegetables on the first day of storage are presented on Table 4.1. The bacteria loads of the fruits and vegetables were generally similar in value on the first day of storage. Significantly, higher value was recorded for spinach vegetable, orange and garden egg fruits in the rainy season. Higher values of bacterial load were recorded among the fruits and vegetables that were stored for the first day in the dry season. There were some similarities in the bacterial load of fruits such as guava and garden eggs, banana and plantain in the dry season. Furthermore, the interaction between the bacterial load of the fruits and leafy vegetables recorded some significant different in both rainy and dry season. While the leafy vegetables shows some similarities in their bacteria load in the raining season.

The bacterial load of selected fresh fruits and vegetables at 4 days of storage both in the rainy and dry season **(**Table 2). The bacterial load was higher in the dry season than in the rainy season on the fourth day of storage. All the samples analyzed were contaminated with bacteria. In the rainy season analysis, there were no significant difference in the bacterial content of the fruits and leafy vegetables. Apart from the bacterial load being higher in the dry season, there were no significant difference among the fruits and leafy vegetable in the dry season on the fourth day of the storage. Among fruits, guava and garden egg showed similarities in their bacterial load during the dry season.

Th**e** differences in bacteria load of fruits and vegetables after 7 days of storage is shown in Table 3. In each of the seasons (rainy and dry season) the bacteria load of each of the fruits and vegetables varied in the values. The bacteria load of fruits and vegetables were much higher in the dry season compared to that of rainy season. The fruits recorded significant different in their bacterial load during the dry season. While among the leafy vegetables in the dry season storage cabbage recorded the highest bacteria load, and the spinach had the second highest among the leafy vegetables. This is an indications that bacterial load were higher on the leafy vegetables than the fruits after 7 days of storage. Among the fruits, banana recorded the highest bacteria load followed by plantain on the seventh day of storage in the dry season. The interaction in the bacterial content of fruit and leafy vegetables recorded in the rainy season shows that there was no significant difference in their bacterial load.

Differences in the bacteria load of the two seasons

The result of the analysis of the rainy and dry season samples is presented in this section. The result shows that bacteria load was higher in the dry season than in the raining season. (This is represented in the figure 1. below). Significant ($p<0.05$) differences were recorded between the two seasons. Banana had the highest bacteria load of 8.2 in the dry season as against 7.0 in the raining season. This was followed by that of cabbage with bacteria load of 7.1 in the rainy season and 8.1 (dry season) respectively. Guava and cucumber showed the lowest bacteria load in both raining and dry season 5.5 and 6.5 respectively. Based on all the results obtained from the two seasons, analytically shows that bacteria load was higher on the fruits and vegetables during the dry season than in the raining season. This may be due to the fact that the dry season favored the growth of bacteria more than the rainy season.



Days of storage

Figure 1. Seasonal variations in microbial load of fruits and vegetables.

Effect of bacteria on the texture of fruits and vegetables

The texture of the fruits was firm and strong at first day of exposure from the market. At the time of collection from the vendor, the fruit were fresh and firm in texture. Even at fourth day of exposure, the fruits were still firm. guava, banana, garden egg had however, began to show changes in their colours as a result of ripeness advancing to spoilage. This may not be unconnected with microbial activities taking place in the fruits because of the high moisture content of the produce and also the environment being conducive for their multiplication.

The fruits that were exposed for 7 days show changes in both texture and colour. At this time both the fruits and vegetables had started showing serious textural deterioration. The microbial load of fruits and vegetables was also higher at this period compared to that of 4 days and 1 day (see Figure 3). This could be because the fruits and vegetables had started having softer skin tissue that was more susceptible to bacterial attack and other spoilage microorganism.

Deterioration in the fruits and vegetables

Deterioration of fruits and vegetables was more prominent among dry season samples from Nyanyan and Karu markets in Federal Capital Teritary compared to that of the rainy season, because the bacteria load was also higher in the dry season samples compared to the rainy season. The reason for the higher bacterial load in the dry season could be as a result of use of (i) waste sewage water used in growing the crops in the field, (ii) manure used to fertilize the soil, (iii) the hygienic conditions of the area were the vegetables had being produced and (iv) how the crops were washed after harvest. If any water was used in washing the produce (contaminated or dirty water), cut fruits and vegetable surfaces may often become inoculating sites for microorganisms. Beuchat and Ryu ,(1997) showed how the presence of many pathogens in the soil may have been washed in the water from the point of entry for microorganisms into the produce and how it can be thought that from historical applications or the environmental presence of fasces or untreated sewage can be the source of the inoculation of these microorganisms. Benjamin (2005) also speculated that pathogens existing in the soil or water can be the source of both pre and post-harvest contamination.

Deterioration of most fruits and vegetables usually occur during transportation and storage. Contamination may have taken place during harvesting, handling, transportation and improper handling of farm produce. The combined activity of microorganisms, environmental conditions and temperature may encourage the growth and spread of spoilage microorganisms thereby hastening deterioration of raw fruits and vegetables. Other physical factors i.e, action of enzymes contained in the fruits and vegetables, moisture content of the fruits and vegetables, temperature around the selling markets or storage stalls and the packaging processes can all encourage these spoilage microorganisms and their activity on the fruits or vegetables. Other factors for deterioration among fruits and vegetables especially in storage is the use of already contaminated containers, use of already contaminated dressing materials, possible contact with decayed products, As flies are not far removed from decaying material, so also infestation can also not be excluded from raw fruits and vegetables that are not hygienically kept.

Aroma of the fruits and vegetables

The aroma of the fruits and vegetables was very good up until the 4th day of storage before it started deteriorating. This may be because some fruits such as bananas, guava, and plantain were just beginning to ripen. By the seventh day the entire fruits and vegetables had lost their sweet aroma, thereby giving way to a strong astringent odour. The sweet fruit aroma had deteriorated to that of an offensive smell of rotten fruits and vegetables by the seventh day of storage, (except for oranges, unripe plantain, garden eggs and Oha vegetable leaves that still retained their aroma -but changed in colours.

Types of organisms isolated from the sample.

Below are the types of micro-organisms isolated from the samples. More micro-organism were observed in the fruits compared to the vegetable leaves. The trend of the number or micro-organisms did not differ between the sampling seasons.

Table 3. Types of organisms isolated from the samples.

FRUITS/VEGETABLES	BACTERIA
VEGETABLES	
Cabbage	Salmonella typhae
	P. aeruginosa
Oha leafy	P.aeruginosa
	E. coli
Spinach	E. coli
	S. typhae

FRUITS	
Orange	Pseudomonas
Garden egg	P. aeruginosa
	E .coli
Banana	S. typhae
	E. coli
Plantain	P. aeruginosa
	S. dysenteriae
Cucumber	E. coli
	S. dyssenteriae
Carrot	E. coli
	Pseudomonas
	Aeruginosa
Guava	Shigella
	Dysenteriae

IV. Discussion

The micro-organisms present in fruits and vegetables are a direct reflection of the sanitary quality of the cultivation processes – water for irrigation; time and methods of harvesting and types or means of transportation of produce; storage environment and finally processing of the produce (Beuchat, 1996; Ray, and Bhunia, 2007; Amoan, Drechsel, Abaidoo and Abraham, 2009).

The types of bacteria isolated in this study are in agreement with previous reports for fruits and vegetables in Nigeria and other parts of the world (Adebolu and Ifesan, 2001). The high microbial contamination observed in the fruits and vegetables may also be a reflection of the storage conditions in the markets. It is important to know that bacteria on the produce may multiply over time depending on the storage conditions especially produce that are soft in nature (Montville and Mathews, 2008). Some of the bacteria isolated in this study may be part of the natural flora of the fruits and vegetables or contaminants from the soil, inoculation through irrigation water, through the environment, while in transportation, inoculation during washing/rinsing of the produce or during handling by poor uneducated processers (Ofor et al., 2009). Pseudomonas spp. and Bacillus spp. are part of the natural flora and are among the most common vegetable spoilage bacteria.

The rise in the bacteria load of fruits and vegetables based on the different stages of storage period would have been so due to the fact that, as soon as fruits and vegetables were cut from their natural supply of nutrients, their quality began to diminish due to a natural decomposition that started as soon as biological cycle was interrupted by harvesting. If the fruits and vegetables are not treated after harvesting, the bacteria load will increase as the physiological and biological process of the fruits and vegetables would have started breaking down. There were significant differences in the bacteria load of fruits and leafy vegetables and at different stages and seasons.

The leafy vegetables had the highest bacteria load and deterioration rate compared to that of fruits. This may be because the surface area of vegetables is more than that of fruits (Odemeru, et. al., 1997). The workers have stated that the overall exposure of the plant products to the environment provided many opportunities for the contamination of several micro-organisms.

Some of the fruits like carrot, guava, Garden eggs showed low bacteria count when compared with the leafy vegetables. This probably could be due to their hard skin surface that makes it difficult for bacteria to stick on it immediately they are handled during harvesting and after harvesting. Babic, et al., (1996) had stated that fruits contain vitamins and other organic compounds just as vegetables The rapid growth of bacteria on vegetables can be attributed to the adhering properties of most bacteria on vegetable leaves, since bacteria can easily grow and adjust to their surrounding environment.(Francis, 1999).

Francis et al (1999) have shown that the higher the water content of vegetables, the greater will be the growth of spoilage bacteria leading to the spoilage of the leaves. Among the leafy vegetables, spinach had the highest number of bacteria load on the first day in the rainy season, due to probably the fact that the vegetable part was fresh and of high water content. Oha leaves were lower than spinach with bacteria load of 2.8 and cabbage recorded 2.7 respectively. This also could be attributed to the variation in the amount of water content between the vegetables. In the area of deterioration, Oha vegetable leaf stayed longer in storage than the spinach. Oha leaves at day 4 and 7 were still greenish while the leaves of spinach were already brownish and fairly dried. This could be as a result of the higher proportion of water content of Oha vegetable leaves.

The variation among the seven types of fruits used in this study may be because of its exposure at uncontrollable environmental conditions of the open market. After being exposed to the environmental conditions for a period of seven days, some of the fruits such as bananas, guavas, and cucumbers were already very soft and was beginning to rot. Other fruit and vegetable like garden eggs, plantain and oranges were still firm in texture even though the oranges and garden eggs had changed skin colour going from green to yellowish/green colour. The deterioration rate was slower in the oranges and garden eggs respectively.

Comparing the bacteria load of the two fruits (guava and garden eggs), deterioration rate was higher in guava than in garden eggs. This could be due to the hard skin (cutaneous) cover of garden eggs that makes it difficult for bacteria to adhere to immediately it is harvested (Odumeru et. al., 1997) said that the protective cover of fruits and the possession by some pH values below which many organisms cannot grow, are important factors in the microbiology of these fruits within the growth range of a large number of bacteria, and are also known as common agent of vegetable and fruits spoilage. Francis et. al., (1999) also stated that the higher the water content of fruits, the higher the growth and expansion of the bacteria causing spoilage.

Furthermore, the current study revealed that bacteria strived higher in fruits and vegetables on dry season than the raining season.

V. Conclusion

This study confirms the presence of bacteria load on fruits and leafy vegetables sold in Federal Capital Tertiary, Abuja and its environs. It also confirms that the source of the microorganism is not limited to any particular location and season but that these bacteria can be found in all the fruits and vegetables and at any seasons (Rainy or Dry season) All the fruits sampled in the rainy and the dry seasons in the cause of this study and at different storage periods were found to be contaminated. The bacteria load observed in the rainy season was lower compared to those of the dry season. The isolated organisms bring to mind the health hazards attributable to raw fruits and vegetables consumed by people in and around Abuja, with more emphasis to those consumed during the dry season.

Fruits and Vegetables when eaten raw, can also transmit pathogens to the consumers, hence caution should be taken by consumers of fruits and vegetables such as garden eggs, guava, bananas, oranges, cucumbers, and cabbages in and around the Federal Capital Tertiary. Vegetable farmers should also be mindful on the use of unhygienic water used to irrigate their fields. In a similar manner fruits and vegetables should be properly washed in clean or iodized water after harvesting before sending them to the markets. Also, fruits vendors in Abuja (Karu and Nyanyan) markets should be advice to keep fruits and leafy vegetables in well ventilated places in order to reduce the incidence of bacteria infestation.

Based on the result of this study, consumers of fruits and leafy vegetables in and around Abuja are advised to pay proper attention to the washing of fruits and vegetables with clean water or iodized water before they are consumed. And more emphasis should be paid to the fruits and vegetables consumed in the dry season.

VI. Recommendations

This study was basically on examination of the bacteria load of fruits and leafy vegetables sold in Abuja and the factors that contribute to the levels of high or low bacteria load.
Based on the findings of this study, the following recommendations were made.

- Fruits and vegetables farmers should be sensitized on the use of hygienic water for irrigation and washing of fruits and vegetables after harvest.
- Consumer of fruits and vegetables in and around the Abuja should always wash them thoroughly with iodized water before consumption to avoid bacterial contamination.
- If fruits and vegetables can be stored in the refrigerators by fruits vendor in Abuja markets, especially in the dry season that will help to prevent the spread of bacteria among consumers.
- Alternatively, fruits and vegetables vendors in Abuja should be educated on the use of Evaporative coolant structure (ECS) such as Pot- in- pot, Tin- in-tin, Tin- in-block, and Block –in-block for storage of fruits and vegetables. These storage systems were locally design to store fruits and vegetables in areas where there is no electricity or in areas with erratic supply of power like Nigeria.

Some areas that may need further study in continuation of the work are as follows;

- The effect of nutritional content on the bacterial load of fruits and vegetables should be studied.
- Effect of fibre content of fruits and vegetables on the level of attack of microorganisms, and
- Determination of crop varieties that were mostly attacked by these microorganisms.

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Plate I: Colour change in (EMB) due to activities of lactose fermenters and non- fermenter

Plate II : Red Shigella colonies on XLD Agar

Table 1: Bacterial load of selected fresh fruits and vegetables for first day of storage

Fruit /Vegetable	Rainy Season (CFu/g)	Dry Season (CFu/g)
Fruit		
Carrot	1.9^{dc}	7.7^{a}
Guava	$2.0b^{dc}$	6.5^{c}
Orange	3.0^{ba}	4.0^{g}
Cucumber	2.2^{bdc}	3.5^{h}
Garden egg	3.1^{a}	**6.5^{c}**
Banana	2.3^{dc}	7.0^{b}
Plantain	1.0^{d}	6.1^{d}
Leafy Vegetable	4.3^{ba}	6.0^{e}
Oha vegetable		
Cabbage	$2.7b^{ac}$	6.1^{d}
Spinach	3.5^{a}	5.0^{f}
±SEM	**0.1**	**0.2**

Means followed by the same letter(s) in a column are not significantly different at p =0.05 using Duncan Multiple Range Test (DMRT).

Table 2: Bacterial load of selected fruits and vegetables after 4 days of storage

Fruit /Vegetable	Rainy Season (CFu/g)	Dry Season (CFu/g)
Fruit		
Carrot	4.1^{b}	4.7^{c}
Guava	3.2^{d}	7.5^{a}
Orange	4.2^{b}	6.0^{b}
Cucumber	5.0^{a}	4.5^{c}
Garden egg	4.7^{b}	7.5^{a}
Banana	4.2^{b}	6.0^{b}
Plantain	3.3^{dc}	6.1^{b}
Leafy Vegetable		
Oha vegetable	4.5^{b}	7.0^{a}
Cabbage	3.8^{c}	6.1^{b}
Spinach	4.3^{b}	6.0^{b}
±SEM	**0.1**	**0.2**

Mean followed by the same letter in a column are not significantly different at p+0.05 using Duncan Multiple Range Test DMRT.

Table 4.3: Bacterial load of selected fruits and vegetables after 7 days of storage

Fruit /Vegetable	Rainy Season (CFu/g)	Dry Season (CFu/g)
Fruit		
Carrot	5.7[d]	7.7[b]
Guava	6.5[b]	6.5[d]
Orange	7.0[a]	7.0[c]
Cucumber	5.5[d]	6.5[e]
Garden egg	6.5[b]	7.5[c]
Banana	7.0[a]	8.2[a]
Plantain	6.3[cb]	8.1[a]
Leafy Vegetable		
Oha vegetable	7.1[a]	7.0[c]
Cabbage	7.1[a]	8.1[a]
Spinach	6.0[c]	8.0[a]
SE±	**0.1**	**0.2**

Mean followed by the same letter in a column are not significantly different at p+0.05 using Duncan Multiple Range Test DMRT.