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Assessment of Post-Harvest Losses and Fungal Organisms Associated with Some Fruits Sold in Owerri, Imo State, Nigeria.

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Abstract

The investigation was conducted in the Laboratory of Department of Crop Science and Technology, Federal University of Technology Owerri, Imo State, Nigeria, to determine the post-harvest losses of pawpaw, pineapple and tomatoes sold in Owerri area of Imo State Nigeria. Twenty respondents were randomly selected. Data were collected by the aid of questionnaire forms, oral interview and personal observations by the researcher. The design $^{w\,1as}$ completely randomized design (CRD), and statistically analyzed using SAS, (1998). Result showed that the percentage moisture content of pawpaw was highest (32.70%), followed by pineapple (31.30%), while tomato was lowest (29.07%). The percentage ascorbic acid content of tomato was highest (68.34%), followed by pineapple (23.74%), while pawpaw recorded the lowest (7.93%). Pawpaw however, recorded highest nitrogen content (0.013%) while tomatoes and pineapple had similar but lower nitrogen content (0.01%). Tomatoes and pawpaw recorded similar but low percentage occurrence of scab (18.87%), when pineapple was highest (62.26%). Pawpaw had the highest percentage occurrence of mould (45.95%) when pineapple and tomato recorded similar but low occurrence of mould (27.03%). Pawpaw recorded highest percentage occurrence of rot (42.86%), while pineapple was lowest (25.40%). Physiological damage was more evident in tomatoes (57.45%) while pineapple was lowest (14.09%). Twenty six percent of the traders that store tomatoes use well perforated cellophane bags, while 16% use platforms exposed to night dew falls. 37% of the traders store the pineapple in refrigerators, while lowest percentage 16%,

store using wooden boxes. 42% store pawpaw by placing them on the bare floor. 32% store in well aerated stores, while 26% use refrigerators, 26% of the traders recorded losses by spoilage, 21% by crushing, 16% by pests and diseases attack while 11% by numerical loss. The micro-organisms identified were *Aspergillus niger*, Mould, *Rhizopus stolonifer* and *Penicillum* spp, with *Aspergillus niger* occurring highest in all the fruits investigated.

Keywords: Assessment, Post-harvest, Losses, Microorganisms, Fruits, Owerri, Nigeria.

1.0 Introduction

Fruits and Vegetables are horticultural food crops in which the edible parts contain high level of moisture, vitamins, minerals and fiber, which can be consumed raw or cooked. The commonly grown vegetables in Nigeria and in Imo State in particular can be classified into various groups. They are leafy vegetables, fruit vegetables, seed vegetables and root vegetables (FAO, 2002).

Due to the perishable nature of vegetables shortly after harvest, there is need to ensure adequate preservation and storage to enable stable supplies in the market (Nwufo, *et al*., 1992).

Pineapple, pawpaw and tomato have been described as high perishable crops. The most important characteristics which affect their shelf-life are high moisture content (50-95%), high rate of respiration and other metabolic activities (Gagandeep, 2015). Other factors contributing to loss are their general soft texture, lack of protective covers and large size as compared to grains (FAO, 1989). Consequently, these factors make it possible for these crops to be easily damaged because they deteriorate very fast. A major problem in handling these crops is that they are preferred fresh by the consumers and as such, efforts should be made to keep them as fresh as possible as they were at harvest. Being highly delicate crops, changes in the appearance, feel and texture are readily discernible by the buyer and these result in market losses. Furthermore, as a result of their high moisture content, any changes in the environmental condition affect the quantity of the crops.

Immaturity, or over maturity, mechanical damage, tissue breakdown, crushing, poor ventilation, rottening, decay or spoilage, browning, insect damage, wilting, weight loss and high temperature during cooking are responsible for post-harvest losses. In addition to the above, poor packaging and rough handling during transportation promote market losses (Rice, *et. al,* 1990).

Cultivated papaya, (*Carica papaya* L.) is also known as pawpaw, is a fast growing tree-like herbaceous plant in the family *Caricaceae*. It is a soft-woody perennial plant that lives for about 5-10 years (Chay-prove *et. al*., 2000). Diseases that affect it include *Phytophthora* root and fruit rot caused by *Phytophtora palmivora*, black spot (*Asperisporium carica*), brown spot (*Corynespora cassicola*), anthracnose (*Colletotricum* spp) and powdery mildew (*Sphaeortheca* spp). Also crinker and dieback are both diseases of papaya caused by *Phytoplasma spp* (OECD, 2003).

Pineapple on the other hand, belongs to the order *Bromeliales*, family *Bromeliaceae* and sub family *Bromeioideae*. They are monocotyledons which are set apart by several unique characters, mostly epiphytic and many strikingly ornamental (Rohrbach and Leal, 2003). They are attacked by diseases such as root rots caused by soil fungi *Phytophtora cinnamoni* and *P. nicotianaeae, var. parasitica*, base rot caused by fungus *Ceratocystis paradoxa* (Dolunin, 2006). While tomato *Lycopersicum lycopersicum* show a great diversity in size and shape and include all colour types such as pink, red, and yellow (Roy, 2002) and are affected by the following pathogens bacteria, fungi and many viruses. Bacteria wilt (*Pseudomonas solanacerum*) is caused by a soil borne bacterium which infect the roots and stems of the plant causing a sudden wilt disease. Crop rotation and sanitation are controls of this (Conway, *et.al*., 1999). Other diseases include bacteria cankers (*Corynebacterum michiganense*), Speck (*Pseudomons syringae*) (Carattini, 2002). Fungal pathogens like *Fusaurium (Fusarium oxysporium* F.), and *Verticillum dalileae*, cause vascular diseases. Resistant cultivars are the most effective controls of these diseases (Wilson, *et. al*., 1995). Others include Anthracnose (*Colletrichum phomoides*) characterized by sunken spots on the fruits. Early and late blights (*Alternaria solani* and *Phythophtoran infestans*) respectively.

Mendazo (1990) reported that there was a loss of 9.4% when tomatoes were transported in wooden crates against 12.2% when bamboo baskets were used. The result is crushing, cuts and bruises or loss due to poor ventilation.

The effects of mechanical damage, during the harvesting operation manifests during storage and marketing. The wounds created during the operation are readily portals for entry of rot causing micro-organisms. Moulds and bacteria readily devastate the tissue causing soft rots (Nwufo, *et. al*., 1992).

One of the important ways of increasing the production of fruits is by improving the marketing system, since they are related. However, the absence of adequate and up to date marketing data creates the problem of information needed for the designing of enhanced production systems, including storage and processing facilities (David, 1996). There is need to improve the shelf life of fruits (Wilson, *et. al*., 1995).

Within the category of perishables, post-harvest characteristics vary greatly from leafy greens to soft flesh fruits. Like grains, perishable losses occur at all levels of the post-harvest system, during pre-processing, transportation, storage, processing and packaging and marketing. (Wos, 2003). Breaking the skin or bruising of the flesh releasing certain enzymes that cause browning of the fruits or vegetables hastens decomposition and makes way for fungi and bacteria, causing the rotting in over-ripe or old fruit (Coursey, 2000).

Hence the objectives of the study were to assess the losses of pawpaw, pineapple and tomatoes in Owerri Imo State, Nigeria, to identify the factors that predisposes these fruits to losses, to isolate and identify the micro-organisms responsible for these losses as well as to determine the nutritional losses of these fruits and suggest ways of reducing market losses of the fruits.

2.0 Materials and Methods

The main market in Owerri area of Imo State being old market was selected for this study. Owerri lies at latitude $5^{o}29'5"$ ($5^{o}28'99$) N and longitude $7^{o}1'49"$ ($7^{o}1'$ 82) E. Several portions of the market were randomly selected. Twenty traders or respondents were involved to ensure intensive study of the market system. Questionnaires were randomly distributed to the respondents. The primary data was collected personally by the aid of a well-structured questionnaire forms, oral interview and personal observations by the researcher. However before actual data collection started, visits were made to study the market to identify the target traders and the primary questions with guided questionnaires. Socioeconomic data of the respondents were collected such as gender, age of respondents and marital status using structural questionnaire forms.

Percentage occurrences of various physiological disorders at different stands of the fruits in the market were taken by physical count according to Williams, (1992). Also, proximate analysis to determine the moisture content, protein (nitrogen) and ascorbic

acid (Vitamin C) was carried out in line with AOAC, (1990). In addition, culture isolation and identification of micro-organisms were conducted according to Barnett & Hunter, (1998) using Potato Dextrose Agar medium and a sample microscope with an objective lens of magnification x40.The fruit samples investigated were pawpaw, pineapple tomatoes respectively. The experimental design was a completely randomized design in three replications.

Determination of Moisture Content

Two grams of the sample were weighed into pre-heated cooled and weighed Silica 80^{o}C to a constant weight. Then the percentage moisture content was obtained by

$$\% \text{ Moisture} = \frac{\text{Weight of sample before drying-Weight of sample after drying}}{\text{Weight of sample}} \times \frac{100}{1}$$

Determination of Crude Protein

The total protein content in the sample was quantified from its nitrogen content. Firstly, the samples were digested in boiling H_2SO_4 containing a copper catalyst. In the process, the protein was oxidized and the ammonia forms residue in solution as Ammonium sulphate. The concentration of ammonia liberated by alkaline distillation with NaOH was determined by distilling into Boric acid solution. Back titration was done on the solution using a standard acid (0.1N HCl).Then the crude protein was

$$\%\text{Nitrogen} = \frac{\text{Titre - Blank x Nitrogen x 0.0014 x 100 x 100}}{\text{Sample weight x Aliquot}}$$

$$\% \text{ Protein} = \% \text{ Nitrogen} \times 6.25$$

Determination of Ascorbic Acid Content

This was done using the Visual titration method as is generally applied to foodstuffs that give colourless or faint coloured extracts. 2g of the samples were weighed and 20ml of 1% Oxalic acid were diluted from 20% stock and titrated with the dye solution to get a faint pink colour that persisted for 15 seconds. The dye was standardized with a standard ascorbic acid.

$$\text{Mg Ascorbic acid} = \frac{2}{T_1} \times \frac{T}{1} \times \frac{100}{10}$$

Where T = Titre value for the sample

T1 = Titre value for standard Ascorbic acid.

Percentage Occurrence of Diseases

Twenty fruit stands of pineapple, pawpaw and tomatoes respectively were examined critically, for different diseases and physiological damage and percentage occurrence of the diseases calculated according to Williams, (1992) as follows:

$$\% \text{ occurrence} = \frac{\text{No. of fruits affected by each disease}}{\text{Total number of fruits sampled}} \times \frac{100}{1}$$

Preparation of the Medium used

The medium used for this experiment was the potato Dextrose Agar (PDA) medium. The potato was weighed 250 g against 100ml of Potato Dextrose Agar powder. The potato was washed with clean water, peeled and chopped into bits and was then placed on a magnetic stirrer (Voss of Malden) and allowed to boil for 30 minutes. The potato filtrate was extracted by filtering with a clean muslin cloth into a conical flask. Twenty grams of glucose and 20g of agar powder were added respectively. It was stirred a bit for a homogenous mixture and then corked with cotton wool with the mouth wrapped with aluminium foil. It was then put into the autoclave (portable Autoclave) to sterilize for 15 minutes, operating at 121b/sq in (120 ^{0}C) pressure for sterilization. The medium was then allowed to cool and then poured in sterilized Petri dishes, and allowed to solidify for 30 minutes.

Isolation and Inoculation

An advancing portion of each of the samples was plated on Potato Dextrose Agar (PDA) in Petri dishes by the use of the sterilized inoculating needle. The Petri dishes were carefully put into transparent polyethylene bags labelled and put in an incubator (Gallenkamp). The culture medium put into the incubator was carefully observed for 2 days. After 2 days, adequate growth was found on them. The culture was then sub-cultured to obtain pure culture of the different organs.

Examination of Culture medium

A drop of *lactophenol* (indicator) was placed at the center of a microscope slide. A bit of the fungal organism was obtained using a sterilized inoculating needle from the medium and placed on the slide and then covered with a clean cover slip. The slide was viewed under the microscope and the associated microorganisms observed, drawn and identified using laboratory manual according to Barnett and Hunter, (1998).

Data Analysis

The data collected were analysed quantitatively and qualitatively. Percentage was the statistical tool used as well as using Completely Randomized Design to collect data on disease occurrence and nutritional composition of the fruits and vegetables at 3 replications according to SAS, (1998) at 5% probability level.

3.0 Results

The results revealed that pawpaw recorded highest percentage occurrence of rot disease (42.86%), followed by tomato (31.75%) while pineapple was least(25.4%) . On the other hand, physiological damage was more sever in tomato (57.45%), followed by pawpaw (27.66%), while pineapple was least(14.90%) . (Table 5).Tomato recorded the highest percentage moisture content (64.95%) in comparison with pineapple (58.66%) when pawpaw had the lowest (51.88%). Also the healthy fruits recorded higher moisture content than the diseased irrespective of the fruit investigated. (Table 1)

Table 1: Percentage mean moisture content

S/N	Sample	Percent
1	Healthy Tomato	24.07
2	Diseased Tomato	29.07
3	Healthy Pineapple	89.96
4	Diseased Pineapple	31.30
5	Healthy Pawpaw	84.58
6	Diseased Pawpaw	32.70

Pawpaw recorded the highest ascorbic acid content (48.53%), in comparison with tomato (37.30%) then pineapple (14.2%), but on spoilage, pawpaw lost a higher percentage of ascorbic acid (40.60%), when tomato and pineapple gained by (31.04%) and (9.53%) respectively. (Table 2).

Table 2: Ascorbic acid content (mean values)

S/N	Sample	Percentage
1	Healthy Tomato	37.30
2	Diseased Tomato	68.34
3	Healthy Pineapple	14.21
4	Diseased Pineapple	23.74
5	Healthy Pawpaw	48.53
6	Diseased Pawpaw	7.93

Tomato recorded highest percentage nitrogen content (0.007), in comparison with pineapple (0.0036), while pawpaw was least (0.006) . On spoilage, tomato and pineapple recorded similar but lower nitrogen content, while pawpaw was higher. However, nitrogen content decreased as result of spoilage. (Table 3).

Table 3: Crude protein content

S/N	Sample	Percentage
1	Healthy Tomato	0.007
2	Diseased Tomato	0.010
3	Healthy Pineapple	0.056
4	Diseased Pineapple	0.010
5	Healthy Pawpaw	0.006
6	Diseased Pawpaw	0.013

The results revealed that tomato and pawpaw recorded similar but low scab 18.87% when pineapple was highest 62.26%. Also, pawpaw recorded high severity of mould 45.95%, when pineapple and tomato were similar but low 27.03% (Table 4).

Table 4: Mean percentage occurrence of scab, mould and rot

S/N	Sample	Physiological Damage		
		Scab	**Mould**	**Rot**
1	Tomato	18.87	27.03	31.75
2	Pineapple	62.26	27.03	25.40
3	Pawpaw	18.87	45.95	42.86
$LSD_{0.05}$		**5.265**	**8.450**	**7.250**

Result showed that 32% of the traders were males and 68% females. Also investigation revealed that 16% of responds were from the age of 10 to 19 years, 79% fall within the age limit of 20 to 39 years while only 5% were above 40 years. 58% were married while the rest were single (Table 5).

Table 5: Socioeconomic characteristics of respondents

Parameters	Frequency	Percentage
Gender		
Male	6	32
Female	13	68
Age/Yrs		
10 to 19	3	16
20 to 29	9	47
30 to 39	6	32
Above 40	1	5
Marital Status		
Single	8	42
Married	11	58

The most common means of transportation was public transport 42% followed by cycling 26%, while wheel barrowing 21%, when 11% trekked (Table 6). 26% store tomatoes with perforated cellophane bags some use baskets while 21% store in refrigerators and 10% expose the fruits on platforms to night dew falls and 11% on trays. 20% spread on the floor, 21%in well aerated stores and at least 16% used wooden boxes. 42% of the traders spread pawpaw on the floor, 32% in aerated

stores when 26% used refrigeration. 26% of the fruits were lost to spoilage or rottening, 21% to crushing, 16% to pest and disease attack, when 11% were by numerical loss (Table 6).

Table 6: Transportation, storage materials, methods and causes of loses (Mean values)

Parameters	Frequency	Percentage
Transportation means		
Trekking	2	11
Public Transportation	8	42
Cycling	5	26
Wheel barrow	4	21
Storage materials and methods		
Tomato in basket	5	26
Tomato in trays	2	11
Tomato in cellophane bags	5	26
Refrigeration	4	21
Exposed to night dew fall	3	16
Pineapple in wooden box	3	16
Pineapple on the floor	5	26
Pineapple in well aerated store	4	21
Refrigeration	7	37
Causes of losses		
Crushing	4	21
Spoilage/Rotting	5	26
Over ripening	5	26
Pests/ Disease attack	3	16
Numerical shortage	2	11

The micro-organisms identified were *Aspergillus niger*, mould, *Rhizopus stolonifer* and *Penicillum* spp, with *Aspergillus niger* occurring highest in all the fruits investigated.

4.0 Discussion

The high occurrence of scabs and mould in pawpaw, tomato and pineapple may be attributed to the adequacy of the environmental conditions for the growth, development and spread of the micro-organisms responsible for these diseases. These conditions were created by environmental factors and the fruits. Garrett, (1995); and Broadley, (2003) reported that scab and mould are major diseases of pineapple and pawpaw after harvest, as well as ring spots (Persley, 2005).

The high percentage of tomatoes affected by rot followed by pawpaw is in agreement with Markson, *et.al*., (2005). Who proposed that about 85% and 15% of the overall losses of tomatoes have been credited to soft and dry rots respectively. Physiological damage severe in tomato, followed by pawpaw, corresponds with FAO, (1989) report that post-harvest physiological damage is basically due to very high moisture content thin, weak, and soft per carp of fruits and vegetables.

The highest moisture content by tomato followed by pawpaw may be due to the action of micro-organism on the tissue of the fruits, softening and decay of the tissues which increased water accumulation. Differences were significant at 0.05 probability level. Markson, *et. al*., (2005) and Manshardt & Dew, (2003) attributed this to the different physiological and nutrient compositions possessed by respective fruits.

Highest ascorbic acid content by pawpaw followed by tomato may be due to the fact that pawpaw lost more nutrients to spoilage which increased the mean ascorbic acid content due to the action of pathogens on fruits which led to the reduction in the concentration of the acid in agreement with Markson *et. al*., (2005) who reported that the higher the nutrient composition physiologically, the higher the rate of disease incidence and loss.

The high crude protein (nitrogen) in the diseased than healthy fruits may be due to the presence of pathogens. They are proteins and so when they invade fruits, they increase the protein content of the fruits (Coursey, 2000).

Results showed that the farmers were mostly younger adults, strong enough to take up the stress and challenges involved in the business. Also, at least 58% were married, meaning that mostly mothers were in the business. According to the survey, it was gathered that greater percentage of the respondents use public transport mostly taxi or bus to convey their goods to the market. This implies that they cover quite a distance to get the goods and they are under small scale business and have no finance to obtain their own means of transportation. Therefore, in the bid to minimize cost and maximum profit, they tend to overstock the vehicles, thereby causing compression and over ripening due to pressure and heat which brings about post-harvest losses. Most of the tomatoes traders store them in baskets or well perforated cellophane bags, though they said that the use of baskets is better for proper aeration.

Most of the pineapple traders use refrigeration because it reduces the rate of ripening, softening and preserves the flavour while a bulk of the pawpaw traders prefer the bare floor. The micro-organisms identified for different types of disorder in the fruits agree with Lan & John, (1984) and Persley, (2005), who reported that *Aspergillus niger*, Mould, *Rhizopus stolonifer* and *Penicillum* spp are the major micro-organisms involved in the diseases and disorder of fruits and vegetables in the tropics.

In conclusion, post-harvest losses of pawpaw, tomato and pineapple are caused by so many factors, such as *Aspergillus niger, Rhizopus stolonifer*, Mould and *Penicillum* spp that reduce the nutritional values, physiological disorder, mechanical damage, as well as poor harvesting and storage materials and methods. Good sanitation and adequate management practices should be carried out in the field before and during harvest so as to minimize the effect of these factors that predispose the fruits to losses. Over or under packing and use of inadequate packaging materials help to reduce physiological disorders, infection and mechanical damages.

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