SECURING THE HARVEST TO ENSURE FOOD FOR ALL: A PLANT PATHOLOGIST'S PERSPECTIVE

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Mr. Vice- Chancellor,
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Fellow Staff and Students, Distinguished Ladies and Gentlemen

PREAMBLE

It is with gratitude to Almighty God that I am standing here before you today to deliver the inaugural lecture of this great citadel of learning, the only Federal University of Technology, east of the Niger. The lecture is the first from the Department of Crop Science and Technology. This lecture will portray what I have been doing for the past twenty years since I defended my PhD. Thesis at the University of Ibadan, Ibadan, Nigeria. I worked as a Research officer at the National Root Crop Research Institute, Umudike for six years before I joined the Federal University Of Technology, Owerri as Lecturer II in 1984. When I started my M.Sc research project which was on the Storage Diseases of Cocoyam (*Colocasia esculenta*), I came to my home town, Amawbia in Awka South Local Government Area of Anambra State to conduct the survey. My grandmother's barn was used as one of the experimental sites. When she saw me in her barn assessing the incidence and severity of the storage rots of cocoyam, she asked me what the drama was for. I answered that I was conducting an investigation for my M.Sc project. My grand mother Mgbeke nta exclaimed, "you mean Ekwunife that you have gone to the University to study about cocoyam which I have been growing and storing for over eighty years. My grand mother of blessed memory died at the age of 96 years?" Glory be to God for a life well lived. I am happy today that I am giving a lecture on the history of my research spanning twenty-four years. I consider it a singular privilege indeed to share my thoughts with you. Mr. Vice Chancellor, Staff, invited guests, fellow scientists, budding scientists, and friends of the University on a vital and topical issue "securing the harvest to ensure food for all; a plant pathologist's perspective". I have chosen this topic not only because of its relevance to our survival and requirement for food but because it is tangential to our economic development as a nation.

WHAT IS PLANT PATHOLOGY?

Mr. Vice-chancellor sir, at lectures of this kind, it is not right to think that one is talking to a group of professional colleagues and not remember that there are some highly educated persons who do not know what plant pathology means. Plant pathology or phytopathology is the study of the diseases of plants. Phyto-pathology is coined from three Greek words, pathos, phytos and logos; pathos means suffering, phyto means plant and logos mean study. So, plant pathology is the study of the suffering of plant. Plant pathology is also known as plant medicine. The only difference between human medicine and plant medicine is that in the case of plant medicine the patients do not talk while in human medicine the patient can give the clues that may guide the Doctor in his treatment of the ailment. Plant pathology is a broad discipline, which is a synthesis of both biological and scientific activities concerned with the understanding of the disease syndrome. Plant pathology is therefore the study of nature, development and control of plant diseases. A disease is a difficult phenomenon to define but a modern conception is that disease is an interaction among the host-pathogen and environment. The dictionary meaning of disease is any departure from health, presenting marked symptoms, malady, illness and disorder. Plants that are diseased are distinguished by changes in their morphological structures or physiological processes, which are brought about by unfavourable environment or by parasitic agents. Some workers have also defined disease as " a series of harmful physiological process caused by continuous irritation of the plant by a primary agent". Stakman and Harrer (1957) defined plant disease as a physiological disorder or structural abnormality that is harmful to the plant or any of its part or products that reduces the economic value"

THE NEED FOR FOOD STORAGE

Food shortages in Nigeria in the last few years have necessitated the need to reduce post harvest losses and to develop improved system for transportation and distribution of fruits, vegetables, tuber and root crops to and from rural areas. There seems to be higher losses of highly perishable fruits and vegetable than cereal and other field crops. In the United States, at a national conference on food losses held in 1976, a scientist defined post harvest loss as " that weight of wholesome edible product that is normally consumed by humans and that has been separated from the medium and site of its immediate growth or production by deliberate human action with the intention of using it for human feeding but which for any reason fails to be consumed by humans". Fruits, vegetables, roots and tuber crops are highly perishable crops. This endowment is derived from the fact that they are harvested at stages when they contain high water content and are still physiologically very active and therefore vigorously perform functions such as respiration, transpiration etc. Fruits, vegetable, root and tuber crops are very important in the diet of man in that they provide some vitamins, amino acids, minerals salt, fiber and carbohydrates. There may be changes in the nutritive value during the marketing of fruits, vegetable, root and tuber crops and this may contribute to quality loss. The overall losses in fresh fruits, vegetables, tuber and root crops between the farmer and consumer are about12% of the total production. According to a survey conducted in 1965 in USA, losses in fruits, nuts and vegetables were recorded to be about 23 % of the total loss that occurred during the post-harvest period. In Nigeria, some comprehensive studies have been carried out to determine the level of post-harvest losses of fruits, tuber and root crops during storage, transportation or at wholesale, retail or consumer levels.

Table 1: Causes of Post-harvest Losses of Fruits, Vegetables, and Root & Tuber Crops in Nigeria.

Commodity	Type of diseases	Percentage loss	Causal agent	Reference
Cocoyam (Colocasia esculenta)	Corm rot	22.5 - 76.2%	*Aspergillus niger; Botrydiplodia theobromae; Fusarium solani; Rhizopus stolonifer; Sclerotium_rolfsii;*	Nwufo & Fajola (1981)
African pear *(Dacryodes) edulis*	Soft rot	35.6 - 64.2%	*Botryodiplodia theobromae; Rhizopus stolonifer; Aspergillus niger; Erwinia spp;*	Nwufo et al (1989)
Cassava *(Manihot esculenta crantz)*	Tuber rot		*Botryodiplodia theobromae; Rhizopus stolonifer; Aspergillus niger; Yeast; Xanthomonas spp;*	Nwufo et al (1987)
African Breadfruit (*Treculia africana)*	Seed rot	15.2%	*Botryodiblodia theobromance; Rhizopus stolonifer; Botryodiplodia theobromae;*	Nwufo & Mba (1988)
Fluted Pumpkin (Telferia occidentalis)	Pod rot	42.2 - 72.5%	*Erwinia spp; Aspergillus niger Rhizopus stolonifer; Botrydodiplodia theobromae;*	Nwufo & Emebiri (1990)
Tomatoes (*Lycopersicon esculenta)*	Soft rot		*Nematospora coryii; Rhizopus stolonifer;*	Ofor & Nwufo (2002)
	Soft rot	5 - 12%	Rhizoctonia solani; Botryodiplodia Theobromae; Fusarium equiseti; Fusarium xylaroids;	Onesirosan & Fafunla (1976)

	Soft rot	7.6 - 21.2%	Geotrichum candidum: Sclerotium rolfsii: Pythium spp.	Akande (1975)
	Soft rot		Aspergillus niger; Aspergillus flavus; Peniciltuim spp. Rhizopus stolonifer:	Madunagu & Ebana (1994)
Cassava (*Manihot esculenta crantz)*	Soft rots		*Lasidiplodia theobromae; Trichoderma harztanum; Cylindroccarpon candidum; Aspergillus niger; Aspergillus flavus;*	Ekundayo & Daniel (1973)
Sweet Potato *Ipomala Batatas*	Soft rots		*Botryodiplodia theobromae;*	Arinze et al (1975)

Nwufo et al (1989) reported that the incidence of post harvest rots of *Dacryodes edulis* were high in all the locations surveyed in Southeastern Nigeria (35.6-64.2%). Nwufo and Mba (1987) also conducted a survey of storage rot disease of *Treculia africana* in Imo State and reported that the storage loss was about 15.2% during severe infections.

Table 2: The Incidence of Fruit Rots Caused By Pathogens in *Dacryodis edulis* Fruits Collected from Different Locations in South Eastern Nigeria (LSD At 0.05% = 6.645)

Locations in South Eastern Nigeria	Pathogens*				
	Botryodiplodia theobromae	Rhizopus stolonifer	Aspergillus niger	Erwinia spp.	% Incidence of Total Rots
Owerri	32.6 ± 2.4	48.2 ± 2.7	15.6 ± 1.2	5.8 ± 1.1	60.5 ± 2.1
Umuahia	32.4 ± 2.4	56.2 ± 3.2	17.8 ± 1.1	8.5 ± 2.3	40.4 ± 1.8
Nsukka	42.8 ± 4.2	12.4 ± 1.4	12.4	none	35.6 ± 1.6
Port Harcourt.	24.6 ± 1.2	58.6 + 3.1	20.4 + 2.1	8.4 + 1.4	64.2 ± 2.4
Arochukwu	36.4 ± 1.6	42.0 ± 2.4	15.6 ± 1.3	10.2 ± 1.2	45.6 ± 1.7
Amawbia	35.6 ± 2.4	52.4 ± 1.4	12.6 ± 2.2	10.2 ± 1.8	52.5 ± 3.2

SOURCE: Nwufo et al (1989)

*Amount of rot found, expressed as a percentage of total rots

+Significantly different at the 5% level

Parpia (1976) estimated the losses during the storage and handling of all crops in Tropical Africa at about 30%. In Nigeria, however, Onesiroson and Fatunla (1976) showed that up to 21% of the potential harvest of tomato fruits were lost to rot in the field while an additional 5-20% rotted during marketing. Also 7.6-21.2% losses of tomato fruits due to rots were recorded at Ife between 1974 and 1975 (Akande 1975). Fajola (1979) gave a comprehensive survey of the post harvest losses in tomato fruits in South-western Nigeria as 24.6% at harvest and 43.4% at different stages of handling. Olorunda and Aworh (1983) in quantitative assessment of post harvest losses recorded as high as 20% losses in fresh tomatoes, pepper and onions involved in North-south marketing chain. Adisa (1980) recorded 4.16-8.45% tomato fruit rots in the field, 10.66-39.28% rot at harvest and 31% and 40% respectively for the dry and wet seasons during marketing.

If post harvest losses can be serious in USA with the sophisticated technology, it is very likely that such losses will be higher in developing countries like Nigeria. Losses during storage and handling for all crops in tropical Africa were estimated at about 30%. In Nigeria, Nwufo (1980) and Nwufo and Fajola (1981) reported that storage loss of *Colocasia esculenta* was about 22% at low incidence while it may be up to 76.5% during severe infections in South Eastern Nigeria.

Table3: The Percentage Incidence and Severity of Corm Rots of *Colocasia esculenta* Determined at Different Locations.

Location	%Incidence	% Severity
Imo State		
Umudike	76.2 ± 2.9*	53.6 ± 1.2
Mbano	51.9 ± 2.1	37.5 ± 2.4
Anambra State		
Orji River	51.2 ± 1.9	38.8 ± 1.6
Amawbia	50.0 ± 2.1	28.1. ± 1.9
Ogidi	39.3 ± 1.1	28.4 ± 2.3
Nsukka	22.5 ± 1.2	12.3 ± 1.7
Cross River State		
Nwaniba	40.6 ± 2.3	23.4 ± 1.1

Source Nwufo and Fajola (1981)

* Standard error

Data are means of determinations from field and barns in each location.

A reduction in the losses will definitely contribute to improving world food supplies. The need to store cocoyam arises from two main reasons viz utilization for food and propagating materials during cultivation. Fruits, vegetables, root and tuber crops deteriorate under tropical conditions of high relative humidity and high temperature. It is not uncommon to have losses in Nigeria ranging from 30-50% or even more in respect of many fruits, vegetables, root and tuber crops between harvesting on the farms and consumption in our villages, towns and cities. There are no reliable data on production figures of fruits, vegetables, roots and tuber crops in Nigeria. However, Oyeniran (1985) suggested figures like 3.8m tonnes of onions, 6m tonnes of tomatoes, 15 million tonnes of plantains and 35 m tonnes of citrus as annual production figures in Nigeria. Ezedinma (1987) emphasized that the figures available on production and productivity in Nigeria do not inspire confidence and that there is need for reliable statistics to guide planning of production and utilization of crops in Nigeria particularly the food crops. Onwueme (1987) provided information on some production data of cocoyam, yam and cassava in Nigeria. He reported that 137 millions tonnes of yam, 80 million tonnes of cassava and 16.2 million tonnes were produced in Nigeria.

The quantity of fruits, vegetables, roots and tuber crops for the Nigerian food basket can of course be increased by decreasing the field and post-harvest losses now incurred in the crops. Of particular importance are the various storage losses, which not only decrease the quality of fruits, vegetables, tuber and root crops available but also effectively limit their availability to a few months of the year. The solution to the problem lies in the development of effective storage methods or use of pesticides that can adequately protect the produce during storage.

Fruits and vegetables are largely grown in Nigeria for consumption by the farmers' family or for sale at small village markets. According to the best production figures available, Africa accounted for 43 million tonnes of fruits and about 31 million tonnes of vegetables in 1989 respectively, 12.7% and 7.1% of world total (FAO. 1989). Africa produces 17.3% of the world roots and tubers but yields are very low, her average is only about 57.3% of the world average. Nigeria produced about 346 million metric tones of root and tuber crops in 1989 (FAO, 1989). The world population, which has doubled in the last four decades, is expected to double again in the 21st century (WMO, 1988). The high rates of population growth are generally to be found in the developing countries and are proving to be an increasing threat to world nutrition since it is in these countries that food supplies are already inadequate. According to the Food and Agriculture Organization of the United Nations (FAO, 1989) an estimated 50% of the world population are engaged in agriculture and over 50% of people in the developing countries are involved in agricultural activities while less than 10% of the people in the developed world are engaged in agriculture. In the third world where a large percentage of people is engaged in agriculture, people still grapple under the shackles of malnutrition which claims millions of lives, while many other people are faced with nutritional disorders symptoms varied by different shades of physical deformities, diseases, retarded vigor and growth, depression and inadequate potentials for hard work (Babalola, 2001). In September 1975, the United Nations General Assembly sitting in New York passed a resolution stating " the further reduction of post- harvest food losses in developing countries should be taken as a matter of priority with a view to reach at least a 50% reduction by 1985". That deadline expired 19 years ago and post harvest losses are still viewed as the most important factor responsible for food insecurity in Nigeria.

Post harvest losses of all perishable tropical produce have been reviewed and conservatively estimated at 25% of production (Coursey and Booth, 1972). Crops losses each year through pest and diseases are enormous. Field losses in excess of 25% occur regularly in many part of the world and storage losses are often at least as high (WMO, 1988). Post harvest losses have a double prolonged effect on the nation's development, the effect on the nutritional status of the population and ultimately they affect the country's economy.

CAUSES OF POST HARVEST LOSSES

Fresh fruits, vegetable, root and tubers have diverse morphological structures, composition and physiology. These crops are high in water content and thus are subject to desiccation and to mechanical injury. They are also susceptible to attack by bacteria and fungi resulting in pathological breakdown. Losses in quantity and quality occur in horticultural crops between harvest and consumption. Post - harvest losses of fruits, vegetables, root and tuber crops result from physical, physiological and pathological factors or a combination of these factors.

LOSSES DUE TO PHYSICAL FACTORS

Losses of fruits, vegetables, roots and tuber crops occur as a result of mechanical damage or injury which takes many forms and may occur at any stage from pre- harvest operation, harvesting, handling such as grading, packaging and transportation, storing to exposure in the market and finally at home. The market value of the produce will also reduce as a result of mechanical damage. The fruits, tubers and root crops that are damaged mechanically deteriorate quickly. They are also predisposed to attack by fungi and bacteria.

Losses due to mechanical damage are frequently overlooked because of the added complexity of secondary physiological and pathological losses, which are difficult to estimate. Nwufo (1984) reported that the mode of infection by the cocoyam rot pathogens is through wounds. The pathogens penetrated the parenchyma cells of the cortical region and established themselves both inter and intra cellularly. Various types of physical damage (surface injuries, impact bruising, vibration brushings etc) are major contributors to deterioration. Mechanical injuries are not only unsightly but also accelerate water loss, provide loci for fungal infection and stimulate Co_2 (Carbon dioxide) and C_2H_4 (ethylene) production by the commodity. Nwufo (1984) reported that *Botryodiplodia theobromae* and *Sclerotium rolfsaii*, which caused the corm rots of cocyam, are wound parasites for they did not cause any rot of the corms which were not wounded artificially. The pathogens penetrated the corms through the wounds. This suggests that to minimize rot, efforts should be made to avoid damage to corms during harvesting and transporting to storage barns.

LOSSES DUE TO PHYSIOLOGICAL FACTORS

The physiological condition of fruits, vegetables, root and tubers is very important and physiological losses are variable in nature. The commodities are living structures, so, natural endogenous respiratory losses of dry matter and transpiratory losses of water do occur. The respiratory and transpirational losses directly influence the quality of the produce and its susceptibility to microbial attack. Water loss can be one of the main causes of deterioration since it results not only from direct quantitative losses (loss in net weight) but also causes losses in appearance due to wilting and shriveling, textural quality and nutritional quality. The dermal system (outer protective coverage) plays an important role in the regulation of water loss by the commodity. Transpiration (evaporation of water from the plant tissues) which is a physical process can be controlled by various treatments applied to the commodity (surface coatings and wrapping with plastic films) or (by manipulation of the environment e.g maintenance of high relative humidity). Exposure of the fruits, vegetables roots and tubers to undesirable temperatures can result in physiological disorders like freezing injury and heat injury. Certain types of physiological disorders originate from pre-harvest nutritional imbalance e.g blossom end rot of tomatoes result from calcium deficiency, very low oxygen (< 1%) and / or high carbon dioxide (>20%) atmospheres can result in physiological breakdown of most fresh fruits and vegetables. The interactions among O_2, CO_2 and C_2H_4 concentrations, temperature and duration of storage influence the incidence and severity of physiological disorders related to atmospheric composition. Nwufo (1994) also reported that cocoyam corms are subject to chilling injury when exposed to very low temperature for a long time. The magnitude depends on the relationship between time and temperature interactions. The damage caused by low temperature manifest on internal tissue breakdown, increased water loss and susceptibility to decay. It is also known that if cocoyam is exposed to excessively high temperature storage, losses do occur. In some parts of Nigeria, the internal temperature of corms exposed to sun may reach 45°C - 50°C. Desiccation brought about by evaporation also causes loss of the cocoyam corms during storage. Sprouting which is a physiological process is known to cause the storage loss of root and tuber crops. Coursey (1961) showed that while sprouting of yams stored in different regions of Nigeria was very variable, it could reach 100% after 6 months in storage.

LOSSES DUE TO PATHOLOGICAL FACTORS

The most serious causal factor of post harvest losses of fruits, vegetables, roots and tubers in Nigeria is the attack by micro-organisms. These losses result from the rapid and extensive breakdown of hosts tissues by microorganisms. Most of the pathogens are traumatic or wound parasites. Initial attack is by one of the few specific pathogens followed by a massive infection by other weak pathogens and saprophytes, which grow on the dead tissues remaining from the primary infection. The pathogens reduce the quality of the produce when little destruction of tissue has occurred. Fungi and bacteria are frequently involved in the case of cocoyam storage deterioration. A variety of microorganisms have been recorded as responsible for the storage rots of fruits, vegetables, roots and tubers. Pathological breakdown is one of the common or apparent causes of deterioration. However, attack by many organisms usually follows mechanical injury or physiological breakdown of the commodity. In a few cases, pathogens can infect healthy tissues and become the primary cause of deterioration.

Table 4: Post Harvest Diseases of Tropical Fruits of Commerce

Disease	Condial state	Sexual state	Estimates minimum for Disease
Banana and plantain,			
Musa spp Anthracnose	Colectrochum musae (Berk. And Curt.) Arx = Gloesporium musarum cke. and Mass.	Glomerella cingulata (Stonem. Spauld and Schr.	+ 7° to 9°C
Thielviopsis Finger-stem rot	Theielaviopsis paradoxa (de Seynes) Hohnel = Ceratosmella paradoxa (de Seynes) Dade	Ceratocystis paradoxa Dade	+ 5°C

Botrydiplodia Finger-stem rot	Botrydiplodia theobromae Pat =? Diplodia natalensis?		+ 8°C
Fusarium Finger-stem and spot rot	Fusarium roseum Lk amend. Snyd and Hans.		+3°C
Cigar-end rot	Verticillium theobromae (Turc.) Hughes –Stachylidium theobromae Turc. = Verticillium staphylidium Holmes trachysphaera fructigena Tabor & Bunt.		+7°C +5°C
Squirter rot Crown rot	Nigrospora sphaerica (Sacc.) Mason Fusarium roseum often with T. Paradoxa B. theobromae. C. Musae N. Sphaerica, and V. Theobroame		
Guava, Psidium guajava L. Anthracnose	Colletortrichum Gloeosporidoides (Penz) Arx = Gloeosporium psidii Delacr.	Glomerella cingulata (Stomen) Spauld. And Schr	+ 3° to 9°C
Phoma rot Pestalotia rot Phytophthora rot	Phoma psidii P. Hen Pestalotia psidii Pat.	Phytophthora nicotiana var. Parasitica (Dast.) Waterh.	3°C– 10°C
Botryodiplodia stem-end rot	Botryodiplodia theobromae Pat.	+ 3°C+ 10°C	+ 8°C

Pineapple, Ananas comosus L.	Thielaviopsis paradoxa (de Synes) Hohnel	Ceratocystis paradoxa Dade	+ 5°C
Thielavopsis soft rot = water blister = black rot			
Bacterial brown rot	Erwinia ananas (E.F.Sm) Serr		
Pink disease	Unidentified bacteria		
Fruitlet core rot	Penicillium funiculosum Thom Fusarium moniliforme Shel		+ 6°c
Fruit rot Fruitlet core rot	Fusarium moniliforme var. Subglutinans Wr. and Reink		
Papaya, Carcica papaya L.			
Anthracnose	Colletotrichum gloeosporiodes (Pex) Ar	Glomerella cingulata (Stomen.) Spauld & Schr	+3 to 9°C
Stem-end rots			
Ascochyta	Ascochyta carciae-papaya Pat.	Mysocsphaerella sp.	+ 2°C
Phomopsis	Phomopsis caricae-papaya Petri & Cif.		
Phytophthora	Phytophthora nicotiana var. parasitica (Dast) Waterh		+10°C +8°C
		Rhiopus spp.	0° to 4°C
Botrodiplodia	Botryyodiplodia theobromae Pat.		
Rhizopus rot			
Alternaria rot	Alternaria alternata (Fr.) Keissler =A tenius auct.		-3°C

Tomatoes (Lycopersicon esculenum Mill			
Alternaria rot	Altrenaria alternata (Fr.) Keissher = A. tenius auct		-3°C
Pleospora rot	Stemphylium botryosum Wallr.	Pleospora lycoperisci El. & Em.Marchall	-3°C
Buckeye rot		Phytophthroa parasitica Dast P. capsici Leonin, P. Drechsleri Tucker	+ 10°C
Botrytis rot	Botrytis cinerea Pers. ex. Fr.	Botryotinia fuckeliana (d. By) Whetzl .	-2°C
Rhizopus rot		Rhizopus spp.	+ 2°C
Sour rot	Geotrichum candidum Lk. ex Pers.		+ 2°C

Source: Sommer N.F (1982)

Micro- organisms associated with the storage rot of fruits, tuber and roots crops are known to produce extracellar enzymes, which degrade the components of cell wall of the host tissues. The enzymes involved in the decomposition of the cell wall include pectinases and cellulases. The pectinases; pectinmythylesterase(PME) and polygalacturonase (PG) are known to degrade the pectic components of the cell wall. PME hydrolyses the methyl esters of the uronic acid residues while polygalacturonase cleaves the - 1, 4bonds between the uronide residues in pectin and pectic acid. It releases galacturonic acid. The celluloses are known to decompose cellulose in both its native state and crystalline forms. A complex of cellulose originally designated C_1,C_x and cellobiase are involved in the conversion of cellulose to glucose (Reese,1956). The C_x or endo-B-1, 4 gluconase splits soluble chains and cellobiase converts native cellulose susceptible to enzymes of the C_x type. A number of organisms have been reported to produce both cellulolytic and pectolytic enzymes in culture and in infected tissue. Nwufo (1984) reported that the two organisms (*Botryodiplodia theobromae*& *Sclerotum. rolfsii*) that caused the storage rots of cocoyam produced cellulolytic and pectolytic enzymes in culture and infected tissue. The culture filtrates of *B. theobromae* and *S. rolfsii* macerated the host tissue of cocoyam corm. The pectolytic enzymes (PG and PME) in the culture filtrates and the rot extract of *B. theobromae* showed maceration index of 4 and 5 respectively after 5 hours of incubation. The result revealed that there was a synergistic action between the pectolytic and cellulolytic enzymes in the merceration and cell death of host tissue of cocoyam corm..

Apart from the maceration of the host tissue, pathogens, are also known to destroy the structural integrity of the host tissue. Nwufo and Fajola (1985) reported that the two organisms, *B. theobromae* and *S. rolfsii* which caused the corm rot of cocoyam also destroyed the histological structures of the tissue of cocoyam corm . The two organisms penetrated and colonized the corm tissue intercellularly and intracellularly. The infected tissues were cleared of most of their starch grains and the cells disintegrated within 10 days on inoculation.

It has also been reported that during pathogenesis the food contents of the host tissue are greatly reduced. Apart from destroying the histological structure of the corm, the carbohydrate, protein and lipid contents were reduced on infection by both *B. theobromae* and *S. rolfsii* (Nwufo and Fajola, 1985). Nwufo et al (1987) reported that cassava root infection by *B. theobromae* caused a loss of 88.9% starch and 28.75% of the total nitrogen. The contents of reducing sugars increased by 11.7%. Infection by *Rhizopus stolonifer* caused a starch loss of 84% and a loss of total nitrogen of 23.8% whereas the increase in the content of reducing sugars was 40.60% and that of total lipid was 52.4% (Table5).

Table 5: Changes in Levels of Nutrients and Dry Matter During Incubation of Uninoculated and Inoculated Cassava Roots

Results are means of six determinations in two separate experiments

Period of Starch on Incubation	(g/100g)			total reducing sugar (g/100g)			total nitrogen (mg/100g)			total lipids (g/100g)		
	uninoculated	BT	RS	uninoculated	BT	RS	uninoculated	BT	RS	uninoculated	BT	RS
1.	24.35 ±2.1	-	-	0.5[illegible] ±0.0[illegible]		-	459.0 ±6.8	-	-	1.03 ±0.2	-	
2.	23.17 ±2.0	12.6 ±1.6	11.8 ±1.2	0.62 ±0.02	2.56 ±0.02	2.10 ±0.4	448.6 ±6.2	390.6 ±2.4	370.2 ±3.4	1.05 ±0.3	1.96 ±0.5	1.42 ±0.5
3	22.17 ±1.9	10.6 ±1.2	10.4 ±0.8	0.65 ±0.04	2.52 ±0.6	2.04 ±0.7	392.4 ±5.8	370.4 ±6.2	365.2 ±7.2	0.85 ±0.2	1.83 ±0.3	1.24 ±0.3
4	20.62 ±1.8	8.4 ±1.1	9.3 ±1.2	1.03 ±0.2	1.90 ±0.4	1.94 ±0.6	386.4 ±5.4	343.2 ±8.0	352.2 ±6.2	0.70 ±0.3	1.64 ±0.4	1.10 ±0.2
5.	19.03 ±1.8	5.1 ±0.9	6.6 ±1.1	1.78 ±0.3	1.33 ±0.2	1.98 ±0.3	388.6 ±4.9	329.8 ±4.6	340.6 ±5.8	0.58 ±0.4	1.13 ±0.2	1.30 ±0.2
6.	18.21 ±1.9	2.7 ±0.4	3.9 ±0.9	1.90 ±0.4	0.86 ±0.3	2.73 ±0.8	380.5 ±5.2	321.6 ±6.2	331.4 ±6.1	0.31 ±0.02	1.57 ±0.3	1.57 ±0.3

Source: Nwufo et al (1987)

BT= *Botrypdiplodia theobromae*

RS = *Rhizopus stolonifer*

Nwufo et al (1989) reported that African pear fruits infection by *B. theobromae* caused a loss of 61% starch and 2% of total nitrogen. The content of lipid increased by 19.6%. Infection of African pear by *Aspergillus niger* caused a starch loss of 71% and a loss of [illegible]% of the total lipid whereas the increase in the content of total nitrogen was 89.6%. Infection by *Rhizopus stolonifer* caused a starch loss of 81% and a loss of total nitrogen of 7.3%. The content of total lipids increased by 0.9% (Table6) Nwufo and Emehuri (19[illegible]) reported that the three fungi that cause the fruit rot diseases of fluted pumpkin (*Telfairia occidentalis*) reduced the starch, total nitrogen and lipid contents of the seeds after infection.

Table 6. Percentage Content of Starch, Protein and Lipid in Healthy and Infected Fruits of *Dacryodis edulis* after 4 Days Incubation at 2[illegible]°C

Period of Incubation (days)	Treatment	Starch		Total nitrogen		Lipid	
		% present	% change	[illegible]	[illegible]	[illegible]	[illegible]
0	Control	4.20	[illegible]	[illegible]	[illegible]	[illegible]	
	BT	-		-			
	AN	-	-	-	-	-	
	RS	-	-	-	-	-	
1..	Control		0	12.7	32.3	46.5	28.9
	BT	3.40	19.5	[illegible]	[illegible]	63.6	2.8
	AN	3.9	[illegible]	10.6	[illegible]	63.1	[illegible]
	RS	3.3	21.4	12.6	31.3	69.3	5.0
2.	Control	4.20	0	13.1	36.5	62.7	4.1
	BT	2.2	47.6	11.3	17.7	69.4	6.1
	AN	1.8	57.4	12.9	34.4	68.4	4.5
	RS	1.6	61.9	14.8	54.2	65.0	0.6
3.	Control	4.10	2.48	9.9	3.1	63.6	
	BT	1.8	57.4	9.7	1.0	76.7	17.3
	AN	1.4	65.9	17.9	86.5	64.8	0.9
	RS	1.2	69.1	10.9	13.5	65.3	0.2
4.	Control	4.10	2.4	9.8	2.1	62.9	3.8
	BT	1.6	61.0	9.0	2.0	78.2	19.6
	AN	1.2	70.7	18.2	89.6	62.4	4.6
	RS	0.8	80.5	8.9	7.3	65.8	0.9

Key: BT-*Botryodiplodia theobromea*; AN- *Aspergillus niger*; RS*Rhizopus stolonifer* Source: Nwufo et al (1987)
(Data are derived from six determinations in two separate experiments)

CONTROL OF POST-HARVEST DISEASES

Post-harvest losses of fruits, vegetables, roots and tubers can be controlled in Nigeria by employing four main methods; chemical; cultural practices, environmental manipulation and curing. It is very important that a thorough knowledge of the causes and occurrence of post-harvest losses of fruits, vegetables, root and tubers is known before any control measures can be recommended. It is also necessary to have knowledge of the storage and handling methods in order to minimize wastage. In Nigeria, social factors also contribute to post-harvest losses apart from the physiological, physical and pathological factors. These social factors include limited financial resources and non- availability of sophisticated facilities for storage of the produce. Post-harvest diseases must be considered in the selection of handling practices or methods. Therefore, an understanding of disease organisms, the host commodity and the relation of handling methods to both is of critical importance. Interrelated with the pathogen and the host commodities are the varied environments and handling stresses to which fruits are subjected. Handling practices may affect the commodities' disease susceptibility as a consequence of stage of maturity, ripeness or senescence cuts. Bruises and punctures may facilitate the entrance of the pathogen into the commodity. Environmental factors of primary concern in post-harvest diseases of fruits, vegetable, roots and tubers are temperature, relative humidity and atmospheric composition. The presence of pathogens completes the disease triangle (organism-host-environment). The appropriate control measures may vary from one growing region to another depending upon the nature and seriousness of the threatening diseases. Distances and time of transportation to market affect disease pressures. Finally the capital investment required for handling facilities influences greatly the choice of control strategy.

CHEMICAL CONTROL OF POST HARVEST DISEASES

Post harvest diseases of fruits, vegetable, roots and tubers can be reduced by application of fungicides. They are applied as dips, sprays and dust on the produce. Not much work has been done on the use of chemicals for the control of post-harvest diseases in Nigeria. However, Fajola and Nwufo (1985) reported that captan and benlate (at 100-500 ppm) completely inhibited the spore germination of *B. theobromae* and *Sclerotiuim rolfsii*. The fungicides were effective against the artificial infection of the corms of *Colocosia esculenta*. Benlate and Dithane M-45 inhibited the growth of *Botryodiplodia theobromae*, *Fusarium solani*, *Sclerotuim rolfsii* and *Rhizopus stolonifer* to varying degrees. Nwufo (1988) also reported that dipping of the corms in 500ppm captan or benlate before storing in soil pots was effective in reducing storage rots of cocoyam. The storage potentials of the African pear (*Dacryodes edulis* (G.Don.) were also investigated by Emebiri and Nwufo (1990). At 15°C fruits dipped in palm oil before being packaged were of better quality and retained firmness longer than fruits dipped in a 500 ppm benlate solution. Avocado fruits treated with benlate, captan and $KMnO_4$ and stored at 10% remained fresh after 21 days storage (Nwufo et al 1994).

I want to stress that chemicals are the foundation of the most manageable of the diseases control tactics at our disposal. However, the present range of fungicides available have a number of limitations. Most of the fungicides available are protectants. This means that the farmer has to apply them following a prophylactic schedule i.e whenever the probabilities of infection have reached a certain threshold value. Other issues aside, the increasing energy costs of this method are causing a major problem. All plant protection chemicals are applied wastefully. Another serious limitation is their toxicity to certain crops. Human and environmental hazard limit the present use of fungicides although one must admit that no major problem have so far arisen when the instructions for use have been followed. There have been severe cases of acute poisoning e.g in Iraq in the 1970s following the consumption of mercury treated seeds. There is little documented evidence of adverse environmental effect due to the use of fungicides in Nigeria.

These factors should be borne in mind when chemicals are to be used for the control of post-harvest diseases of fruits, vegetables, roots and tubers in Nigeria. Firstly the chemical must be efficient in controlling the diseases at low concentration, the cost of formulation and application should be put into consideration and most importantly chemical residues must not constitute a health hazard to the applier or the consumer. The chemicals that will be added to the commodities should be screened and only used in accordance with food additive regulations of Nigeria. It is unfortunate that in Nigeria, there are no legislations in respect of the amount of residues to be tolerated on our produce like yam, cocoyam, fruits and vegetables.

It is against this background, that in the use of synthetic chemicals in disease control while eliciting much concern owing to the undesirable side effects emanating from their use that I got interested in the use of natural products as fungitoxicants for the control of post harvest rots of fruits and tubers in Nigeria. Synthetic fungicides however, possess undesirable side effect which have necessitated the search for other viable alternatives. Compounds in higher plants have come under focus as successful natural fungitoxicants because of their phototoxic systemic and biodegradable nature (Fawcett and Spencer, 1970; Baye 1978). This emerging discipline of utilizing the essential oils from higher plants as potential plants disease eradicants has been enunciated by various workers (Chaurasia and Kher, 1978; Dubey and Kishore, 1987; Nwufo and Emebiri 1988; 1989; Nwufo, 1993). Nwufo and Emebiri (1988) reported that the essential oils extracted from Nchanwu (*Ocimum viridis*) and nche (*Saccogloltis gabonensis*) had fungitoxic effects on the five rot pathogens of cocoyam. Ofor and Nwufo (2002) also investigated the use of five spices: *Ocimum conum*, *Ocimum viride*, *Xylopia aethiopica*, *Piper guineense* and *Monodora myristica* in controlling tomato rot caused by Nematospora coryii and *Rhizopus stolonifer*. *Ocimum comum* oil reduced the rot caused by N. corryii and R. stolonifer by 89.39% and 87.63% respectively. Oils from *Xylopia aethiopica*, *P.guineeinse and M. myristica* were also found to be effective in reducing the fruit rots of tomato.

(ii) CULTURAL PRACTICES

The method of harvesting and handling of fruits, vegetable, tubers and roots after harvest is important because many of the pathogens involved in storage diseases enter through wounds. Such wounded fruits, tubers and roots if they are unnoticed during sorting provide avenues for fungal and bacterial pathogens. Improved methods of harvesting and handling during transportation can reduce mechanical damage. In Nigeria, the techniques of handling fruits, vegetables, tubers and roots are poorly developed. Fajola and Nwufo (1985) reported that storage trials under some environmental conditions showed that storage of cocoyam corms in soil pits particularly under shade was very successful during a 12-week storage period. Storage in well-drained pit significantly reduced natural infections of cocoyam corms without impairment to texture and taste.

(iii) ENVIRONMENTAL MANIPULATIONS

Post-harvest losses of fruits, vegetables, roots and tubers can be controlled by manipulating the environmental conditions in which they are stored. Refrigeration is recommended for the reduction of water and respiratory losses during storage. The rate of metabolism is generally slowed down with a decrease in temperature. Fajola and Nwufo (1985) reported that low temperature (5-10°C) was effective against artificial infection of the cocoyam corms. Storage studies of cocoyam corms were carried out under different environmental conditions (open laboratory, dry saw dust, moist saw dust, soil pit and polythene bags) and there were reduction in storage losses. (Nwufo, 1988)).

Table 7: Percentage Weight Loss, Length of Sprout (mm) and rot Of Corms of *C. esculenta* During a 12 Week Storage Period Under Different Environmental Conditions

	% weight loss, length of sprouts (mm) and % rot of corms under different conditions				
	Period of storage (Week)	Control (open lab)	Saw dust (dry)	Saw dust (moist)	Polythene bag
	0	0	0	0	0
	2	19.0	6.5	0	2.0
Percentage weight loss	4	17.3	21.4	7.5	4.5
	8	32.4	23.5	24.6	7.6
	12	39.2	39.6	32.7	9.2
	0	0	0	0	0
	2	10.0	11.4	12.1	12.2
Mean length of sprous (mm)	4	11.4	12.3	13.2	15.3
	6	12.1	14.6	13.2	15.3
	6	12.1	14.6	26.6	22.4
	12	11.2	19.4	32.6	27.5
	0	0	0	0	0
	2	0	0	0	0
Percentage comes sowing decay	4	23.5	42.6	35.4	19.5
	6	64.7	60.7	60.3	59.6
	12	75.5	72.5	71.4	70.4

Source: Nwufo (1988)

Data are means of 3 determinations, with 10 corms per treatment.

Improvement in packaging have contributed greatly to more efficient marketing of fresh fruits and vegetables in developed countries (Hardenburg, 1975). Consumers now recieve produce in fresher conditions with less damage, more potential shelf life and greater appeal and convenience than ever before because of packaging advances. Modern packaging has contributed to improved handling of food between farmers and consumers. Packaging in the form of using various containers and wrapping materials for fruits and vegetables have been embarked upon by me and other Scientists in the School of Agricultural and Agricultural Technology (FUTO) since 1985. Emebiri and Nwufo (1990) investigated the storage potentials of African pear (*Darcyodes edulis*) using four fruits types At ambient temperature (28.5-35°C) those fruits enclosed in either paper bag or polythene bags could be stored satisfactorily for 3-8 days after which they deteriorated rapidly. Storage life was increased at low temperature but injury due to chilling was observed at 5°C. At 15°C fruits dipped in palm oil before being packaged were of better quality and retained their firmness (Table8). Storage in moist sawdust, wood shavings or water were the least effective in extending shelf life. Post-harvest treatment of avocado pear with wax, fungicides and KMno4 and polyethylene and paper bag packaging were studied to extend the shelf-life of avocado (*Persea americana* Mill) under refrigeration and at ambient temperature (Nwufo et al, 1994). At ambient temperature fruits ripened within 6 days while those in polyethylene bags at 10°C remained healthy for 21 days. Fruits at ambient temperature (28-30°C) and at 10°C did not store well in paper bags. The different conditions and packaging materials affected the germination, percentage, growth and seedlings vigor.

Storage of cocoyam corms at low humidity may form an important aspect of disease control of storage rots but there may be rapid loss of water. Nwufo and Fajola (1981) reported that no rot developed when inoculated corms were kept under levels of relative humidity lower than 50%. Relative humidity not only affects the activity of decay causing organisms but also affect moisture loss from fruits and vegetables. Leafy vegetables should not be stored for a long period because they lose moisture readily. Good refrigeration practices are essential to reduce post harvest losses. They can be supplemented with controlled or modified atmospheres. Nwufo (1994) observed that unsealed leaves of *Telfaria occidentalis* and *Pterocarpus soyauxii* rapidly lost water during storage at either ambient or low temperature. Packaging of the leaves in polyethylene bags alleviated these losses and water stress.

(iv) CURING

Curing is one of the simplest and effective methods of reducing post-harvest physiological and pathological losses of root and tuber crops. Curing is a healing process, which involves suberization and development of a periderm, which is effective in reducing water loss, and acts as a mechanical barrier against pathogen attack. High temperature and relative humidity influence the process of curing. Cocoyam corm can be successfully cured by smoking. Proper handling of the root tubers after curing is important to avoid further mechanical damage, which may predispose them to fungal and bacterial attack.

POST-HARVSET LOSSES AND PRESERVATION OF INDIGENOUS FRUITS AND VEGETABLES IN IGBO LAND

Mr. Vice-chancellor sir, distinguished ladies and gentle men, people say that charity begins at home. I am happy to report that I have been involved in the post harvest losses of indigenous fruits and vegetable in Igbo land.

A large number of crops commonly classified as fruits and vegetables are grown in Igboland .

Table 8: Indigenous Fruits And Vegetables Utilized In Igbo Areas Of The South-Eastern Nigeria

Scientific name	Igbo name	Part used
Amaranthus hybridus	inene	leaves
Abelmoschus esculentus	Okwuru	fruit/leaves
Chrysophyllum abidium	Udara	fruit
Chrysopyllum delevoyi	Udara enwe	fruit
Dacroydes edulis	Ube	fruit
Dennetia tripetala	nmimi	fruit
Gongronema latifolium	utazi	leaves
Irvingea gabonensis	Ugiri/agbolo	fruit/seeds
Ocimim viridis	Nchanwu	leaves
Pterocaprus soysuxii	Oha	leaves
Pentaclethra macrophylla	Ukpaka,Ugba	seed
Piper guineense	Uziza	leaves/seeds
Solanum macrocarpon	Ayara	leaves/fruit
Telfairia occidentalis	Ugu	leaves /seeds
Vernonia amygdalina	Onugbu	leaves

Fruits and vegetables supply a lot of minerals and vitamins. According to FAO recommendation, not less than 5%of the total calories in-take should come from non-starchy vegetables. Vegetables are also valued for their high contents of unavoidable carbo-hydrate or fibre, which may be up to 16% by fresh weight. Vegetables are generally regarded as crops of minor or secondary importance. Many of our vegetables such as *Telfairia, Vernonia,* Pterocarpus etc, have suffered neglect (Okigbo, 1975). Sai (1965) concluded that fruits and vegetables are not accorded the importance they deserve in the diet of West African people and are hardly considered food. At best they are prepared and accepted as a relish or a flavoring agent. It is the basic carbohydrates staple, which is considered food. There are many important indigenous vegetables.

however, their ethno- botanical importance is buried in the sands of time.

By the year 2000, it was suggested that Igbo population will increase to about 20 million. Estimate indicate that between 3 to 5 million people in Igbo land do not have enough food to eat and this is likely to increase with increased population. Past governments in Nigeria have emphasized two lines of action to cope with this current and future food demand. These are reducing food demand by slowing population growth and augmenting food supplies by expanding production. A third vital measure is to reduce the loss of food after harvest and prior to consumption

In Igbo land enormous post-harvest losses of fruits and vegetables result from attack by micro-organisms, insects, birds, rodents and deterioration in storage. Physical and mechanical damage may arise at any stage in the handling chain pre-harvest operations, harvesting, packaging, transportation and storage. To quantify these loses in Igboland is scarcely possible. However, Nwufo and Mba (1988) and Nwufo and Emebiri (1990), Nwufo et.al. (1989) have estimated the losses of some fruits like Ube, *Dacryodis edulis*, Ukwa, *Treculia africana* and Ugu pods,*Telfairia occidentals* in south eastern Nigeria. Deterioration of the fruits during storage was associated primarily with the actions of pathogens or by physiological reactions.

Most vegetables and fruits are utilized at immature stage of development. At this stage they have a characteristically high metabolic rate and lack many of the protective structures such as wax and thickened cuticle or periderm, which protect them against physical injury, moisture loss and invasion by pests and diseases. Most of the post-harvest loses which occur are the result of the accumulative effects of careless harvesting, exposure to unfavorable environmental conditions, ineffective agents and poor packaging.

Table 9: Mean Score (Standard Error) for Fruit Type, Packaging and Treatment on the Storability of the African Pear

	Storage at Ambient temperature (7 days)	Storage at 15°C (15 days)	Storage at 15°C(15 days)	Storage at 15°C(15 days)
Means score of fruit types:				
Fruit type I	2.8 ± 0.02	1.0 ± 0.02	2.0 ± 0.11	1.0 ± 0.02
Fruit type II	2.5 ± 0.01	2.5 ± 0.10	4.0 ± 0.10	1.0 ± 0.01
Fruit type III	2.3 ± 0.04	4.0 ± 0.10	4.0 ± 0.13	2.3 ± 0.07
Fruit type IV	3.0 ± 0.06	4.0 ± 0.13	3.8 ± 0.17	3.8 ± 0.08
Partially matured	2.5 ± 0.10	3.5 ± 0.07	4.0 ± 0.07	3.8 ± 0.12
Coefficient of variation (c.v. %)	10.59	42.49	24.62	58.85
Packaging (mean score of all fruit types)				
Package with polythene bags	2.3 ± 0.02	3.3 ± 0.12	3.5 ± 0.08	2.3 ± 0.01
Package with paper bags	2.9 ± 0.11	2.7 ± 0.11	3.6 ± 0.12	2.4 ± 0.12
Post harvest treatment (mean score of all fruit types):				
Dipped in benlate solution	3.0 ± 0.02	2.8 ± 0.03	3.5 ± 0.07	2.2 ± 0.01
Dipped in palm oil	2.2 ± 0.01	3.2 ± 0.07	3.6 ± 0.13	2.5 ± 0.05

SOURCE: Emebiri and Nwufo (1990)

Nature of post-harvest losses

Fruits and vegetables form important sources of supplementing the predominantly carbohydrate diets of people in Igbo areas of southeastern Nigeria. In Igboland, consumption of fruits and vegetables is inadequate and can be improved through a scheme of efficient storage and distribution. This situation may be as a result of colossal wastage resulting from rapid deterioration of the crops. The traditional method of carrying fruits and vegetables to local market in baskets lead to much wastage of unsold produce. Fruits and vegetables also get wasted on the farms and never reach the markets. Successful storage of fruits and vegetables therefore involves the maintenance of their quality in terms of flavour, texture, and moisture content and other factors associated with edibility. Treatment to which traders in Igboland subject fruits facilitate their deterioration, hence the high percentage losses obtained.

A. Fruits

The most important causes of spoilage of fruits in Igbo areas of southeastern Nigeria is microbial attack usually resulting from infection through wounds or bruises. Most fruits are normally harvested during the rainy season, June-October and packaged into baskets, transported home and later taken to the market. During harvesting and post-harvesting handling, some fruits are bruised thereby facilitating development and spread of rot diseases. Bulking of fruits inside baskets also aggravate biodeterioration.

(i) Ube (African Pear) *Dacryodes edulis* member of the family Buserceae is an evergreen; the fruits are blue-purplish when ripe and shaped like sausage. The fruits are dipped in hot water to soften them and are served with either roasted or boiled maize.

Fruits of *D.edulis* are normally harvested during the rainy season June-September. A lot of wastage is however incurred resulting from some handling methods. During harvesting and post-harvest handling some fruits are bruised thereby facilitating the development and spread of rot diseases. Nwufo et.al. (1989) reported that the incidence of post harvest rot of *D.edulis* was high in all the towns visited in south-eastern Nigeria (35%-64.2%). The capacity of the African pear to produce fruits is considerable. The number gathered from a single tree during the major fruiting season varies from 7,000 to 10,500 with an average yield of 223-335kg/tree (Omoli and Okiyi 1987)

(ii) African bread fruit (Ukwa, Treculia africana) a member of Moraceae is a fruit tree which grows uncultivated and semi-wild .It produces mature fruits during the "hungry season" in Abia, Imo, Enugu and Anambra states of Nigeria following the planting of major staples such as yam ,maize and cocoyam. The seeds contain about 17-23% crude protein and are cooked and eaten as a main dish. The seeds can be processed into breadfruit flour from which several food products such as bread, cookies and biscuits can be prepared. The seeds are not stored for long period because they are highly perishable. In a survey conducted in Imo state in 1985-86(Nwufo and Mba, 1988) the storage loss reported was about 15.2% during severe infection. There is need to conduct investigation on the best and cheap method of storing the seeds for consumption and germplasm establishment.

(iii) Fluted pumpkin (Ugu, *Telfairia occidentalis*), a member of the family Cucurbitaceae is widely grown in south-eastern Nigeria for its edible leaves and seed. Longe et. al.(1983)reported that the seeds contain about 53% fat and 27% crude protein. Seeds are scarce during the growing period (April/May) because the fruits are normally harvested between October and December and cannot be stored for a long period. Nwufo and Emebiri (1990) reported losses of about 72.5% in some locations in southeastern Nigeria. Little attention has been given to the storage of the seeds of this nutritious leafy vegetables usually propagated by seeds. The net effect has therefore resulted in seasonal production and consumption. Nwufo et.-al. (1990) reported that partial drying after soaking in Benlate at 1000ppm further prolonged the storage life of Telfairia seeds. Storage of Telfairia seeds in polyethylene bags at 10°C was better than storage in paper bags. Storage of Telfairia seeds at ambient temperature (28-30°C) was unsuccessful. The traditional method of storing Telfairia pods is by keeping them in yam barns until they are needed for planting.

Leafy vegetables.

Leafy vegetables form an integral part of the diet of people in Igbo land areas of Southeastern Nigeria. Several varieties are available. Poor handling during marketing, however leads to wastage. The market women just pile the vegetables in baskets exposed to sunshine and rain. The vegetables lose colour easily turning brown and eventually black within a few days. In some places Telfairia and Vernonia leaves are harvested in cool weather, the vegetables are bunched together and tied. The bunched stems are dipped into water and stored in polyethylene bags. Telfairia and Pterocarpus leaves were kept fresh for 6-7 days.Many pre and post-harvest practices can be adopted to reduce the level of post-harvest losses of fruits and vegetables in Igboland. These include:

Pre-harvest factors

Environmental conditions during production can affect the shelf life of fruits and vegetables. Crops free from pests and diseases should be stored. Factors connected with cultural practices including time of irrigation, fertilizer level and plant spacing may also influence the physiological condition of a crop at the time of harvesting.

Harvesting and handling.

Post-harvest losses can be reduced by improving both harvest practices and subsequent handling methods adopted at all stages until consumption. In Igboland food handling techniques are poorly developed and fresh produce is frequently handled in the same way as durable crops, which results in excessive mechanical damage. Harvesting during or immediately after heavy rains should be avoided and it should be carried out during the cooler part of the day usually early morning. Vegetable crop harvesting is always carried out manually with the aid of a harvesting tool. For fruits and vegetables a knife is frequently used. Care should be taken to avoid mixing diseased produce with sound produce.

Packaging and transportation

The use of correctly designed containers for marketing the perishable products can considerably improve produce quality and reduce the level of loss. Farmers select the cheapest and most readily available container, which is ill designed for transportation of produce. In Igboland most fruits and vegetables are transported in bulk handling conditions. Under these conditions the lorries should be lined with leaves and the produce should be carefully stacked and adequately covered on top to protect it from adverse environmental conditions.

Refrigeration

The holding of produce at reduced temperature through the use of refrigeration is one of the important methods of extending produce life and reducing the level of post harvest loss. There are however a number of limitations to the use of cold storage for reducing losses of vegetable food in developing countries. Many of the vegetable commodities are too low a unit value to bear the cost of operation of mechanical and commercial refrigerated storage. Individuals or communities lack the capital needed for erection of cold stores or the expertise to run them. Many tropical fruits and vegetables are liable to low temperature injury. In Igboland areas of south-eastern Nigeria, commercial cold storage of fruits and vegetables is not feasible.

Phytosanitary control

Good phytosanitary practices can have considerable impact on product quality. Field hygiene through the removal of plant debris reduces the infection load in the field. The elimination of diseased material at harvest reduces the contamination of sound produce as does the washing and cleansing of harvesting implements, containers, lorries and store houses. Pesticide can be applied after harvest as fumigants, wraps, dips, dusts and sprays. Among the wide range of chemicals, which have been used to reduce post-harvest loss, are captain, dichloran, borax, sodium orthohenylphenate, thiabendazole and benomyl (Eckert and Sommer, 1967). Use of pesticides is not highly recommended for the farmers in the rural areas of Igboland. The farmers are not literate enough to know how to apply pesticide to fresh produce. There is then need on the part of the extension Agents to educate farmers in rural areas on the hazards of using pesticides.

Post harvest technology for reducing loss can generally be considered under three headings: handling, processing and storage. In attempting to develop or apply post-harvest technologies to reduce food loss in Igoland, it must be remembered that cultural, economic, social and political factors affect the nature and magnitude of food loss; and the attitudes of farm families and government to food conservation. Many kinds of costs can be associated with post-harvest losses and it is important to assess these costs as thoroughly as possible for an accurate picture of possible economic and social consequences.

Post-harvest losses in Igboland are as a result of unavailable and inadequate technologies. If the application of known post-harvest technologies is an appropriate means of conserving fruits and vegetables, why does a gap exist between the establishment and use of technologies in Igbo areas of south-eastern Nigeria? The major reasons for this are as follows: Firstly, proposed technical solutions are frequently copied or borrowed from developed countries rather than creatively appropriate technologies being adapted to the realities and needs of our people. Secondly, there are frequently no adequate incentives for individuals to invest in post-harvest technologies. This lack of incentives is frequently linked with aspects of government policies. Thirdly the decision to store fruits and vegetables to minimize losses and stabilize prices are made by administrators who do not have the expertise or fail to refer to adequate technical knowledge. Post-harvest losses can be substantially reduced by using methods adopted in developed countries like improved packaging and refrigeration. An awareness of the role of refrigeration in quality maintenance have made it possible to move perishable fruits and vegetable to distant cities in fresh condition and provide consumers with a relatively constant year-round supply.

In Igbo areas of Southern Nigeria, low cost storage of fruits and vegetables is not readily available. Increased research is required to develop low-cost alternatives. Dehydration or sun- drying is the simplest and lowest cost method of processing and preservation. Whenever dried or simply cooked and dried products are acceptable either for food or for secondary processing into needed products, this simple type of processing should be encouraged. A cheap and simple method of preserving fruits is known as osmotic dehydration. The principle involved is osmosis. Plant and animal tissue can be dehydrated by immersion in a strong solution of sugar or salt in water. Research should be conducted into the use of sophisticated techniques employed in developed countries for storage of fruits and vegetables. Future studies on post-harvest losses of fruits and vegetables should include varietal resistance and modern methods of handling fresh produce. There are multifarious problems associated with post-harvest losses of fruits and vegetables in Igbo areas of South-eastern Nigeria, so there is urgent need for post-harvest technologists and for scientists to focus their attention on the storage of indigenous fruits and vegetables which serve as food supplements for many million Igbos.

MODERN AND FUTURE DIRECTIONS FOR POSTHARVEST TECHNOLOGY OF FRUITS, VEGETABLES, ROOTS AND TUBER CROPS

Both quantitative and qualitative losses take place in fruits, vegetables, roots and tuber crops between harvest and consumption. In order to minimize losses, one must understand the biological and environmental factors involved in deterioration and use those good harvest technology procedures. which will slow down senescence and maintain the best possible quality. Fresh fruits, vegetables, roots and tuber crops are living tissues which are subject to continual change after harvest while some of these changes are desirable, most are not desirable from the consumers stand point. Post harvest changes in fresh produce cannot be stopped but can be slowed down within certain limits. Some of the biological factors involved in deterioration include respiration which is the over all catabolic process by which stored organic materials (carbohydrates, protein, fats) are broken into simple end products with a release of energy. Another biological factor involved in deterioration is ethylene production, which is one of the simplest organic compounds, which has an effect on physiological processes of plants. It is a natural product of plant metabolism and is produced by all tissues of higher plants and by microorganisms. Ethylene is considered the natural aging and ripening hormone and is physiologically active in trace amount (0.1ppm). Many compositional changes take place during development and maturation of the commodity on the plant. Compositional changes continue after harvest and this can be undesirable. Some of the changes include loss of chlorophyll, development of carotenoids, development of anthrocyanins, changes in anthrocyanins and other phenolic compounds. Changes in carbohydrates may also occur like the conversion of starch to sugar, which is undesirable in potatoes but desirable in fruits. Environmental factors, which influence deterioration, include temperature, relative humidity, atmospheric composition, ethylene, light and other factors like usage of chemicals (fungicides and growth regulators).

TEMPERATURE MANAGEMENT PROCEDURES

Temperature management is the most important tool that can be used to extend the shelf life of fresh fruits, vegetables, roots and tuber crops. Proper temperature management begins with the rapid removal of field heat by using one of the following evolving methods like hydro cooling in-package, icing, room cooling, vacuum cooling and hydro-vacuum cooling. Cold storage facilities should be well engineered and adequately equipped. These include (a) good construction and insulation including a complete vapour barrier on the warm side of the insulation (b) strong floors, adequate and well positioned doors for loading and unloading (c) effective distribution of refrigerated air (d) sensitive and properly located controls (f) enough refrigerated coil surface to minimize the differences between the coil and air temperature and adequate capacity for expected needs. Commodities should be stacked in the cold room leaving air spaces between pallet and room walls as well as among pallets to ensure good air circulation. Storage rooms should not be overloaded beyond limit for proper cooling. Commodity temperature should be monitored and not air temperatures. Transit vehicles must be cooled before loading the commodity. Delays between cooling after harvest and loading into transit vehicles should be avoided and proper temperature maintenance should be ensured throughout the handling system.

CONTROL OF RELATIVE HUMIDITY

Relative humidity influences water loss, decay development, incidence of some physiological disorders and uniformity of fruits ripening. Proper relative humidity is 85-90% for fruits and 90-98% for vegetables. Relative humidity can be achieved by one or more of the following procedures (i) Addition of moisture (water mist or spray, steam) to the air by use of humidifiers, regulation of air movement and ventilation in relation to produce load in the cold storage room; (2) halting the floor in storage rooms and sprinkling with water during retail marketing. Many biological procedures are used commercially as supplements to temperature management. None of these procedures, alone or in various combinations can substitute for maintenance of optimum temperature and relative humidity in extending shelf life of harvested fruits and vegetables. Supplemental post harvest technology procedures include washing, heat treatment, use of sprout inhibitors and post harvest fungicides.

Current technology based mainly on the use of refrigeration, controlled and modified atmospheres supplemented by various chemical treatments, has revolutionized the storage and transport of fruits, vegetables, root and tubers during the course of the past fifty years and it is now possible for wealthier nations to enjoy most of the commoner types of fruits and vegetables in a year round basis (Table 10). However, some of the methods on which this successful technology are based, are now being questioned and consumer pressure is demonstrating supplies of produce of the same range and quality without dependence on chemicals. The development of alternative storage and marketing strategies based on minimal use of pesticides and the adoption of environmentally safe methods will be central to the endeavors of post harvest technologies in the immediate future (Sharples, 1990).

Table10: Summary of Recommended Controlled Atmosphere or Modified Conditions During Transport and/or Storage of Selected Fruits.

Commodity	Temp. range (°C)*	CA		Potential for benefits	Remarks
		$\%O_2$	$\%CO_2$		
Deciduous Tree fruit					
Apple	0-5	2-3	1-2	A	About 40% of production is stored under CA
Apricot	0-5	2-3	2-3	C	No commercial use
Cherry (sweet)	0-5	3-10	10-12	B	Some commercial use
Fig	0-5	5	15	B	Limited commercial use
Grape	0-5	None	None	D	Incompatible with SO_2 fumigation
Kiwifruit	0-5	2	5	A	Some commercial use
Nectarine	0-5	1-2	5	B	Limited commercial use
Peach	0-5	1-2	5	B	Limited commercial use
Pear	0-5	2-3	0-1	A	Some commercial use
Persimmon	0-5	3-5	5-8	C	No commercial use
Plum and prune	0-5	1-2	0-5	B	No commercial use
Strawberry	0-5	10	15-20	A	Increasing use during transit
Nuts and dried fruits	0-25	0-1	0-100	A	Effective insect control method
Subtropical and tropical fruits					
Avocado	2-13	2-5	3-10	B	Limited commercial use

Banana	12-15	2-5	2-5	A	Some commercial use
Grapefruit	10-15	3-10	5-10	C	No commercial use
Lemon	10-15	5	0-5	B	No commercial use
Lime	10-15	5	0-10	B	No commercial use
Olive	8-12	2-5	5-10	C	No commercial use
Orange	5-10	10	5	C	No commercial use
Mango	10-15	5	5	C	No commercial use
Papaya	10-15	5	10	C	No commercial use
Pineapple	10-15	5	10	C	No commercial use
Artichokes	0-5	2-3	3-5	B	No commercial use
Asparagus	0-5	air	5-10	C	Potential for use by processors
Beets	0-5	None	None	D	98-1--% rh is best
Broccoli	0-5	1-2	5-10	B	Limited commercial use
Brussels sprouts	0-5	1-2	5-7	B	No commercial use
Cabbage	0-5	3-5	5-7	B	Some commercial use for long- term storage of certain cultivars
Cantaloupes	3-7	3-5	10-15	B	Limited commercial use
Carrots	0-5	None	None	D	98-100% rh is best
Cauliflower	0-5	2-5	2-5	C	No commercial use
Celery	0-5	2-4	0	C	Limited commercial use in mixed loads with lettuce
Corn, sweet	0-5	2-4	10-20	B	Limited commercial use
Cucumbers	8-12	3-5	0	C	No commercial use
Honeydews	10-12	3-5	0	C	No commercial use
Leeks	0-5	1-2	3-5	B	No commercial use
Lettuce	0-5	2-5	0	B	Some commercial use with 2-3% CO added

Mushrooms	0-5	air	10-15	C	Limited commercial use
Okra	8-12	3-5	0	C	No commercial use; 5-10% CO_2 is beneficial at 5-8°C
Onions, dry	0-5	1-2	0	B	No commercial use; 75% rh
Onions, green	0-5	1-2	10-20	C	Limited commercial use
Peppers, bell	8-12	3-5	0	C	Limited use
Peppers, chili	8-12	3-5	0	C	No commercial use; 10-15% CO_2 is beneficial at 5-8°C
Potatoes	4-12	None	None	D	No commercial use
Radish	0-5	None	None	D	98-100% rh is best
Spinach	0-5	air	10-20	C	No commercial use
Tomatoes					
Mature-green	12-20	3-5	0	B	Limited commercial use
Partially-ripe	8-12	3-5	0	B	Limited commercial use

Source A.A Kader and L.C.Morris (1977)
A = Excellent, B = Good, C – Fair. D = Slight or non

PACKAGING OF FRUITS AND VEGETABLES IN NIGERIA

Modern packaging methods have contributed immensely to more efficient marketing of fresh fruits and vegetable (Hardennburg, 1975). Consumers now get fresh fruits and vegetables because of the level of packaging advances. Good packaging serves as an efficient handling method and also serves as a convenience of some storage unit. This quality of produce is also protected and it reduces waste by protecting the produce from mechanical damage, moisture loss, provides clean or sanitary products and pilferage. Good Packaging now provides services and sales motivation, reduces cost of transportation and marketing. Wills et al (1977) listed many major requirements for a good packaging material and these include non-toxicity and compatible with the food, provision of sanitary protection for the food and sufficient mechanical strength to protect the contents. The packaging material must also protect moisture loss and be permeable to gases. The ease of opening and resealing is of principal importance to the consumer and disposal should be easy especially for retail traders and if possible it should be biodegradable. A few institutions have carried out studies on the packaging of fruits and vegetables in Nigeria. These include the Nigerian Stored Products Research Institute, Department of Food Technology, University of Ibadan and the Nationally Coordinated Project on Fruit and Vegetable storage. Packaging in the form of using various containers and wrapping materials for fruits have been embarked upon by Scientists in the Department of Crop Science and Technology, Federal University of Technology since 1984. In several studies (Nwufo (1984) and Nwufo (1988)), reported that packaging of fruits and vegetables serves a very beneficial purpose in reducing the rate of deterioration even under the ambient tropical conditions Sowunni et al 1980; Opadokun and Ubani, 1984, Opadokun et al, 1984 and Onuruzuh at the Nigerian stored Products Research Institute have also carried out some studies on the use of packaging materials in increasing the shelf life of fruits and vegetables in Nigeria. Nwufo et al (2002) reported that star apples (*Chrysophyllum albidium*) packaged in low-density polythene bags and stored at 10°C were of better quality than fruits packaged in either polythene or paper bags and stored at 28°C. Fruits treated with captaf or benlate retained freshness after 14 days storage in either polyethylene or paper bags at 10°C.The decay free percentage and percentage marketable fruits were significantly higher at 10°C than at 28°C. There were no significant differences in the protein, fiber and ash contents of stored fruits but the total sugar contents were higher in fruits stored at 28°C than that at 10°C. Fruits stored at 10°C in both packaging materials contain more ascorbic acid and lipid content than those stored at 28°C.

Table 11: Recommended Cold Storage Conditions and Loss in Weight of Vegetables Grown in the Tropics

Vegetables	Temp. °C	R.H%	Storage Life (Week)	Wt. Loss %
Asparagus	5.6.-7.2	85-90	3	12
Cabbage	0-1.7	92-95	4-6	-
Cauliflower	0-1.7	85-95	7	30.4
Colocasia	11.1-12.8	85-90	21	-
Cucumber	10-11.7	92	2	7.2
Egg plant	10-11.7	92	2-3	9.5
Lettuce	0	95	1	-
Muskmelon	1.7-3.3	85.90	1.5	7.2
Okra	8.9	90	2	6.8
Onion, white	1.1	70-75	16-20	14.2
Onion, red	0	70-75	20-24	16.3
Onion green (Immature)	0	90-95	2	-
Pepper (green)	7.2	85-90	3-5	-
Pepper (ripe)	5.6-7.2	90-95	2	-
Pumpkin	1.7-15.6	70-75	24-36	3.7
Tomatoes- VC Lines mature green	8.9-10	85-90	4-5	5.2
- VC Lines ripe	7.2	90	1	-
Turncip	0	90-95	8-16	-
Water melon	7.2-15.6	80-90	2	-

Fruits	Temp. °C	R.H %	Storage Life (Week)	Wt. Loss %
Avocado- West Indian	12.8°	85-90	2	6.3
Banana-Cavendish Green	12.8-14.4°	85-90	3-4	5.2
Banana Cavendish Ripe	12.8	85-90	1.5	-
Plantain-green	10	85-90	5	6.0
Plantain ripe	7.2-10	85-90	1.5	-
[illegible]	[illegible]	85-90	5	22.0
[illegible]	[illegible]	88-92	5-6	12.0
Lime- Yellow	[illegible]	85-90	8	15.0
Lime Green	[illegible]-12.8	85-90	7	18.0
Lemon	[illegible]	85-90	6	-
Grape fruit	[illegible]	85-90	8-12	-
Guava	[illegible]	85-90	2-5	14
Mango-Carabao	7.2-10	85-90	3-4	5.1
Papaya- Green	10	85-90	3-4	5.8
Pineapple all green	10	85-90	4-6	4.0
Pineapple 25% green	8.3 10	85-90	1-2	-

Source: Pantastico et al (1975)

CONSERVATION, DOMESTICATION AND UTILIZATION OF WILD FRUIT PLANTS IN SOUTHEASTERN NIGERIA

I am happy to report that many wild fruit varieties do occur in great diversity in southeastern Nigeria. The relevance and contribution of these plants to human nutrition have been grossly undervalued and their potentials as cheap sources of food and industrial raw materials have not been fully exploited. Most of these wild plants were found to be woody perennial and shrubs whose fruits are eaten raw. These plants fruit at various period of the year occurring between January and May. The wild fruit plants provide cheap sources of mineral, vitamins, protein and carbohydrate for the Ibo people of southeastern Nigeria (Okafor, 1992). The fruits are usually consumed raw and the nutrients supplied in fresh form. The fruits are also used as sweeteners and condiments while the leaves of some are used locally in the preparation of soup and stew (Emebiri et al 1992, Emebiri and Nwufo, 1990).

The abundance of these wild fruits to southeastern Nigeria is presently being forced into extinction because of neglect, abuse and other cultural and agricultural practices. The clearing of our forests yearly for agriculture, building and other commercial purposes have accelerated the depletion of these species from their natural habitat thereby denying the inhabitants the utilities of these plants. There is therefore need for their conservation either in-situ or ex-situ by domestication. The conservation in-situ may be achieved by protecting the wild trees in their habitat through cultivation. The ex-situ conservation (domestication) maybe accomplished by bringing the wild fruit under the management of man (Allord, 1960). Except for few of these wild fruit plants whose domestication have been very limited, there has been no conscious effort to domesticate them. Nothing is known about their conservation status or potential for genetic improvement. Little attention has been given to the storage of the seeds of tropical fruit species while there are many storage problems yet to be solved and no storage trials have been reported on the seeds of these neglected fruit tree crops. The maintenance of stored seeds of these fruit crops is of great importance. Nwufo et al (1997) carried out a survey of wild fruit plants in southeastern Nigeria. A great diversity was observed in the wild trees and twenty (20) species mostly woody perennials were collected and identified (Table12)

Table 12: The Wild Fruit Plants, Their Local and Botanical Name and Locations in Southeastern Nigeria

Common name	Botanical name	L.G.A/Village	State
Unighim	-	Ihitte-Uboma Obioma Ngwa	Imo, Abia
Mmimi	*Den[illegible] [illegible]petala*	Ngor Okpala Obioma Ngwa	Imo, Abia
Okpuocha	*G[illegible] ferruginea*	Ihiagwa-Owerri	Imo
Oba-nia	-	Etiti Orji River	Imo Enugu
Ubacheru	*[illegible]*	Ihiagwa Owerri	Imo
Uvune	*Macaranga [illegible]dii*	Ngwa Owerri	Abia Imo
[illegible]	*[illegible]*	Most villages	Abia, Anambra, Enugu, Imo
Udara	*Chrysophilum albidum*	Most villages	Abia, Anambra
Aki-Akwari	*Landolphia dulois*	" "	Abia, Anambra
Ose-Oji	*Afromomum melegueta*	" "	Abia, Anambra
Oji Ohia	-	Bende & Umuahia Idemili & Aguata Udi & Eziagu Owerri, Mbaitoli/Orlu Isi-Ikuato	Abia Anambra Enugu Imo Abia
Mmimi Ohia	*Uvaria chamae*	Owerri	Imo
Utuaka-nma	*Saba florida*	Ihiagwa & Obinze	Imo

Eqwe-Eqwe		Ngwa land	Abia
Ochicha	*Saba florida*	Most villages	Abia, Anambra, Enugu, Imo
Mgbamgba	--	Ozuitem & Ozuakoli	Abia
Ukpa	--	Most villages	Abia, Anambra, Enugu, Imo
Tomato Agwo	*Trichosanthes Cucumerina*	Ihiagwa-Owerri	Imo
Udara Nwaenwe	*Pachystela b[illegible]*	[illegible]	Abia State
Enyim-Ocha	--	[illegible]	Abia

Source: Nwufo et al (1997)

The successful domestication of these wild fruit tree and integrating them into the cropping systems of the various localities where they are found could enhance the prospect of agro-forestry as sustainable crop production systems in these areas. It may never be possible to stimulate the same level of concern for endangered forest trees as currently expressed for endangered animals. This is probably because it takes decades and centuries before forest trees species eventually disappear. Governments of Africans countries should show more concern about the conservation status of these indigenous tree crops, not just from a biological view point but from a wide array of economic, social, pharmaceutical, aesthetic and environmental values that these species provide for humanity and from ethical considerations and a responsibility to future generations.

Table 13: The Characteristics, Uses and Fruiting Periods of the Wild Plants in Southeastern Nigeria

Wild plants	Characteristics	Uses	Fruiting period
Unighini	Woody perennial tree	Sweetner	March - April
Mmimi (*Denettia tripetala*)	"	Fruit/peppery seed eaten	Feb.- April
Ukpuocha (*Cnestis ferriginea*)	Shrub	Mesocarp eaten	Feb - May
Oba-nta	Shrub	Mesocarp eaten	Feb - May
[illegible] (*Dialium guineense*)	Woody perennial tree	Tasty mesocarp eaten	Dec -May
Uvune (*Macranga studtii*)	Shrub	Fruit (Berry) eaten	Feb.-May
Ujuju (*Veronica conferta*)	Woody perennial tree	Fruit eaten leaves Used for soup	Dec.-March
Udara (*Chrysophyllum albidum*)	"	Mesocarp eaten	Dec - March
[illegible]-Akwari (*Landolphia dulcis*)	Herbaceous climber	Seeds ground for milk stems for rope Leaves medicinal	Jan-March
Ose Oji (*Aframomum melegueta*)	Herbaceous	Seed eaten with Kola nuts	All year round
Oji-Ohia	Woody perennial tree	Fruits eaten	Feb-April
Mmimi-Ohia (*Uvaria chamae*)	Woody perennial tree	Fruits eaten	April-May
Enyim-ocha	Liana	Mesocarp eaten	March-May
Utuaka-nma (*Saba florida*)	Herbaceous liana	Fruit eaten	March-May
Egwe-Egwe	Liana	Mesocarp eaten	April-June
Ochicha	Woody perennial tree	Mesocarp eaten	July-Sept.
Mgbamgba	Woody perennial tree	Fruit eaten	May-August
Ukpa	Liana	Seed eaten after boiling	April-June
Tomato Agwo (*Trichosanthes cucumerina*)			
Udara Nwaenwe (*Pachystela bericeps*)	Woody perennial tree	Mesocarp	July-Sept.

Source: Nwufo et al (1997)

CONCLUSIONS AND RECOMMENDATIONS

Fruits, vegetables, roots and tubers are highly perishable crops and are susceptible to post-harvest deterioration and heavy losses under conditions of high temperature and high relative humidity have been reported. The most common causes however of post-harvest losses in developing countries include rough-handling and inadequate cooling and temperature maintenance (Kitinoja and Kader, 1995). The fortune of the Nigeria farmer according to Salako (2002) is intricately linked up with the menace of crops pests. These include insects, mites, nematodes, plant pathogens, vertebrates pest and weeds. These pests are known to cause considerable damage to both field and stored plant produce. Crop protection is essentially the ultimate goal of a plant pathologist. The pathologist employs various avenues to achieve food for all. The strategies include use of resistant varieties, biological control, plant quarantine, cultural control, chemical and integrated pest management (IPM). Generally, each of these methods has its high practical points although there are also limitations bearing in mind the level of the farmers in the developing countries. In many developing countries where the resource-poor farmers have to produce and sustain the economy (Sengooba, 1991), these calibre of farmers require crop protection measures that are cheap so that the farmers can afford them, simple, so that they can be applied under traditional circumstances, cost effective, so that they can enable farmers to make profit and prosper. "Mother nature" seems to have catered for all of the above measures of plant protection by providing a wide range of natural plant protectants (Salako, 2002). Plant pathologists can ultimately achieve the goal of securing the harvest and thereby achieving food-for all by exploring the various natural plant protectants.

Success in post-harvest research and development depends on close collaboration between plant pathologists, physiologists, biochemists, physicists, engineers and food scientists. It is only by bringing together these disciplines to work on common projects that practical solutions can be developed which are robust enough to meet the needs of commercial storage and marketing. In Nigeria, the lack of refrigeration and packaging house facilities results in severe losses. Seal packaging of fruits and vegetables may gradually come into common use in the post harvest handling of fresh fruits and vegetables. If Nigeria wants to secure her harvest to ensure food for all, I wish to make some recommendations as follows:

1. Government policy on infrastructure and institutional development should be intensified. This will not only encourage private inventors in the country to invest in Agro processing, packaging and refrigeration but will also attract their foreign counterparts in the same direction. Their participation should be in the following areas
   (a) Mechanized handling from field of harvest to packaging house and destination markets
   (b) Expansion and enhancement in consumer packages, transits vehicles and cold storage under modified atmospheres to achieve product longer shelf life. This policy will make fruits and vegetables available throughout the year.
   (c) Production of returnable and disposable containers to enhance efficient packaging, distribution and storage of these products. These containers should be such that could maintain the quality of the products for longer periods.

2. Government organs on enlightenment and public awareness should publicize the need for and profitability in Agro-products packaging, refrigeration, processing and the large market opened to the prospective investors in the West African sub- region.
3. There should be modification in handling procedures to economize in labour, materials and energy use and to also protect the environment.
4. Other treatments like waxing, delayed ripening, use of chemicals like fungicides in conjunction with cold temperature storage will help to prolong the shelf-life of fruits and vegetables.
5. Government should establish laboratories in research institutes and tertiary institutions to assess the level of

residues on fruits and vegetables. The resource-poor farmers should be educated on the use of pesticides and stress on the environmental hazards.

6. Most research and development efforts on tropical fruits, vegetables, root and tuber crops should focus on further improving pre-harvest production aspects with a view to increasing the role of these crops in meeting the food requirement of expanding population. However, improvement in the production potentials will only be acted on by the farmers if they are financially rewarded. Improved storage techniques can reduce losses and increase the market demand for fruits, vegetables, roots and tubers by ensuring more constant quality and better storage life. The inherent storability of these crops should be considered in breeding and crop improvement programmes.

The problem associated with the post-harvest losses of fruits, vegetables, tuber and roots is complicated. The losses are also enormous but can be reduced if a comprehensive, rational and scientific approach is employed.

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