EVALUATION OF TUBER STORAGE AND PROCESSING IN FEDERAL CAPITAL TERRITORY AND NASSARAWA STATE

BY

ABIADE OLANREWAJU ADEKUNLE

97/5888EA

BEING A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE NIGERIA, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE IN AGRICULTURAL ENGINEERING

NOVEMBER, 2004

ABSTRACT

The middle belt of Nigeria constitutes one of the areas in which tuber crops are predominantly grown .The study of tubers storage and processing in Federal Capital Territory and Nassarawa State was conducted through extensive review of literature on the subject followed by a limited survey which was carried out in twelve randomly selected local government areas which cover towns and villages within each of those local government areas.

The major tuber storage problems of losses were found to be insects , moulding and rotting ,mechanical damage ,rodents and thieves .This study shows that the highest loss from moulding and rotting with Bwari and Awe LGA having the highest mould and rotting infestation recordings about 32.69% and 35.29% annually.

In most areas visited sacks, pots and drums were widely used for the storage of processed produce .Akwanga LGA lead the chart of sack storage with 57.89% while Bwari LGA lead the chart of pot storage with 28.13% while Agidi LGA lead the chart of drum storage of processed produce. Averagely, sacks, pots and drums having 44.31%, 19.93% and 16.15% respectively in their use in Nassarawa state. The leading may be attributed to the fact that more farmers in the Federal Capital Territory cultivate majorly for sale while majority of farmers in Nassarawa state store and process more produce

It is almost impossible to recommend a particular type of storage method of structure in all the LGAs covered but based on the findings of the research work improved mud hut and improved Barn are recommended for tuber storage in most areas.

DEDICATION

This work is dedicated to God Almighty who gives wisdom to everyone who asks for it.

DECLARATION

I hereby declare that this thesis is an original work of mine and has never been presented elsewhere for the award of any degree. Information derived from published work of others has been acknowledged in the text.

25/11/2004

SIGNATURE OF STUDENT DATE

The above declaration is confirmed

……………………………… ………………………………

ENGR. (DR.) MRS Z.D. OSUNDE DATE

CERTIFICATION

The undersigned certify that they have read and recommended to the school of Engineering and Engineering Technology for acceptance, a thesis titled " EVALUATION OF TUBER STORAGE AND PROCESSING IN FEDERAL CAPITAL TERRITORY AND NASSARAWA STATE"in partial fulfillment of the requirements for the award of the Bachelor Engineering Degree.

…………………………………… 25/11/04 ……………………

ENGR. (DR.) MRS Z.D OSUNDE DATE

(SUPERVISOR)

…………………………………… 25.11.04 ……………………

ENGR. DR. ADGIDZI DATE

HEAD OF DEPARTMENT

AGRICULTURAL ENGINEERING

…………………………………… 25/11/2004 ……………………

EXTERNAL EXAMINER DATE

ACKNOWLEDGEMENT

Foremost I want to acknowledge the love and grace supplied by Almighty God throughout my study period .In wring this project I owe many thanks to my Supervisor ENGR. (DR.) MRS Z.D.Osunde for her care and my Head of Department Engr Dr Adgidzi for your concern about me most especially untiring guidance may God bless you and your wonderful families .My profound gratitude also goes to all members of staff of the department.

I also wish to extend my thanks to the zonal extension officer Nassarawa Agricultural Development Project -- Akwanga, Mr yohanna Mashaki and Mr. Obamiro of Abuja Agricultural Development project Gwagwalada for their support during the course of this project .

Special mention must be made of my beloved late Uncle Chief K.Abiade who left behind a legacy that no one never take away from me .I rememeber you today because you have furnished me with dreams of success right from my tender age.

My special thanks also go to Mrs Moyeni Fayemisin of Nigerian Stored Product Reaserch Institute Onike Yaba Lagos and Engr S.Owolabi of federal Capital Development authority Abuja for their support and guidance during the course of the research work My sisters and brothers thank you all for being there and believing in my struggles may Almighty God be with everyone of us .I am grateful to all my course mates for their contributions

Finally, I give God the glory for giving me the grace and wisdom to partake in this course of study.

TABLE OF CONTENTS

CHAPTER FIVE

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

1.0 INTRODUCTION

GENERAL CONSIDERATION

Storage of farm produce is of great importance in agricultural production and consumption. Efficient storage ensures market profitability of a farming enterprise. If the produce deteriorates in storage its economic and nutritive value may decrease,. Factors which brings about deterioration may be physical (mechanical injury, temperature, dryness); physiological (respiration); pathogenic (qualitative and quantitative microbiological deterioration) or pests (rodents, birds, insects). The effects of these factors are usually expressed in terms of storage losses which may be as high as 40 percent in the tropics.

The world population will double over the next 40 years, mainly in the developing countries of tropical Africa. To meet demand, food production must increase by 3-4 percent per year but at present there is only marginal increase of 1-2% in developing countries. Roots and tubers contain over 65% moisture when harvested but lose up to 40% after 2-3 months in storage. In cassava, the key to efficient storage and utilization is processing which reduces poisonous alkaloids, lessens cyanide toxicity in cassava and irritants in tubers such as coco-yams (colocacia spp. and xanthosoma spp.) and improves the palatability and food value of the resultant foods and industrial products.

The introduction and application of science and technology has greatly helped to increase food production but the problem of food shortage is worsened as a result of excessive post-harvest food losses. Minimizing physical damage of tubers during post-harvest operation has been recommended and is being practiced. For instance, treatment of yam tubers with fungicides such as Benlate and catan has been found to be effective in reducing fungal yam rot (Ogundana 1971, 1981).

Adequate processing facilities are essential to increase agricultural development and industrial growth. Root and tubers are highly perishable since they are succulent living plants with over 70 percent water content. There is need for prompt processing of roots and tubers crops to render them into forms with a longer shelf life and able to meet the demand for convenience foods in urban areas. Processing of roots and tubers becomes imperative when there are anti-nutritional factors or toxic substances involved, such as the presence of cyanide in cassava.

It is a known fact that all food crops suffer deterioration almost as soon as they are harvested. The extent of storage varies from crop to crop, from season to season and from one locality to another. This deterioration leads to losses which is being experienced by the farmer. However, the factors involved are not fully understood and storage is not always successful.

The consequence of these losses includes less supply of farm produce to the country's agro-allied industries, reduced economic return for farmers, traders and the state. It is highly desirable that such large amount of losses be minimized if they cannot be completely eliminated.

1.0 IMPORTANCE OF ROOTS AND TUBER CROPS

Yam, cassava, sweet potatoes and cocoyam can be consumed after being boiled, pounded, mashed, fried, roasted or baked. The fresh tubers can also be fed to livestock. Also leaves and peelings may also be fed to livestock either fresh or in the form of silage.

Root and tuber crops can be processed into various food form such as flour, chips and flakes. They are used in industry for the manufacture of starch glue, alcohol, syrup, mucilage for paper and pharmaceuticals.

1.1 STORAGE LOSSES

Farm storage deterioration increase with storage period, the following factors are responsible for losses in Agricultural crops production:

a) Physical factors which result from harvesting, transportation and storing operations.

b) Physiological factors which include respiration, transpiration and germination which leads to loss in weight, quality and viability for seed.

c) Biological factors consist of the attack of micro- organisms, insects, rodents and mammals.

d) Poor storage techniques which make the produce to be susceptible to adverse effects.

e) Infestation of the crops by insects on the field, this will result in poor quality tubers with short shelf life.

f) The initial quality of the crop to be stored.

g) The duration of storage. The longer the storage time the more the deterioration.

The major aim of storage in crop production is to preserve the crop in acceptable condition until it is needed for use.

Storage of tuber crops is carried out to accomplish one or more of the following objectives.

- Food security.
- Alleviation of poverty and actualization of better lives for rural dwellers.
- Strengthening the role of rural families.
- To supply raw materials to agro-based industries.
- To preserve seeds or stems from one season to another in order to get enough plant stands.
- Promotion of sustainable agriculture.

1.2 OBJECTIVE OF THE STUDY

This research work was carried out to achieve the following objectives;

i) Collection of storage and processing data in the areas which cover Bwari, Kwali, Gwagwalada and Abaji Council Areas in the Federal Capital Territory and Akwanga, Kokona, Agidi, Wamba, Keffi Doma, Awe and Lafia in Nassarawa State.

ii) Evaluation of storage methods and losses: giving suggestions as to how best to minimize the storage losses.

1.3 JUSTIFICATION

Increase in food production has not been able to solve the problem of food scarcity and increase in the prices of crops. This is due to the high level of food losses which occur right from harvesting via storage to the marketing outlets.

Although some reduction in crop losses after harvest had been noted in the country, a major reason for the losses still suffered has been attributed to ignorance or inadequate knowledge of the suitable techniques available for storage and pest control methods.

Although some reduction in crop losses after harvest had been noted in the country, a major reason for the losses still suffered has been attributed to ignorance or inadequate knowledge of the suitable techniques available for storage and pest control methods.

Therefore, it is important to continue to examine present storage techniques and strategies with a view to identify storage problem areas and suggesting possible solution to this problem. In this lies the justification of this study.

1.4 LIMITATION

Various problems were encountered in carrying out the project due to financial requirement that the project entails and the low level of development of many areas visited. The following limitation during the course of the project.

i) Finance- The project is costly due to money spent on transportation, accommodation and feeding.

ii) Language barrier- In administering questionnaire, an interpreter was needed to carry out translation.

iii) Poor transportation system- Most of the areas visited had bad roads which made the distribution of the questionnaire to be slow. Often times, much time is wasted in getting vehicles from one village to the other.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 STORAGE METHODS OF FRESH ROOT AND TUBER CROPS

Ajisegiri (1987) defined storage as "the setting aside for future use of separable items". Storage of root and tuber crops in the form of tuber for consumption is fairly easily achieved only for a period of about six months. The natural changes in weight and quality of these crops cannot be entirely prevented. Past experience has shown that the first step is to analyze the local situation together with the farmers and design solutions for their problems with them.

The storage methods for the three root and tuber crops looked into(yam, cassava and sweet potatoes) are thus discussed.

2.1.1 Traditional storage system for fresh yams (a) leaving the yam tubers in the ridges after maturity. The tuber are ripe for harvesting when the foliage has died, without having to fear any great loss in yield, they harvest crop cum then takes place sometime afterwards and the tubers can simply be left in the ridges. The duration of this type of storage depends on the particular variety of yam and cum extend over 1 to 4 months (Coursey, 1983).

From an economic point of view, this method of storage is quite feasible since no costs are incurred in creating a store. However, this method provides no protection from pests (insects, nematodes and rodents) or rot (Coursey 1967). Neither does this method allow a periodic check of the condition of the stored produce. During the dry season when the ground dries out and becomes as hard as rock, harvesting without greater losses becomes almost impossible (Nwankiti and Makurdi, 1989)

b) Storing the yam tubers in trench silos (pit Storage) a typical storage facility made in the field is the trench silo. To make this a pit approximately corresponding to the expected volume of yams to be harvested is excavated. The pit is lined with straw or similar material (Nwakiti and Makurdi, 1989). The tuber are then stored on the layer of straw either horizontally beside each other so far it is not known whether the method of storing – horizontal or vertical – influences storage behaviours. The trench silo can be built underground or so that part of the store is above the ground. It is covered with straw or similar materials. In some cases a layer of earth is also added. This type of storage system can be found in regions with a pronounced dry season. The trench silo provides protection from respiration and transpiration weight losses of the tubers. A disadvantage is the lack of ventilation and the direct contact of the tubers. This causes the stored produce to become warm and thus promotes the formation of rot (Nwarkiti and Makurdi, 1989).

c) Storage of yam tubers in heaps on the ground according to this method of storage the yam tubers are piled on a carpet made of dead yam climbers into a heap. This normally happens under a tree providing shade and the heap is covered with maize or millet stalks or similar materials (F.A.O, 1990). This method of storage can be erected without any costs. The shady tree some what balances out the temperature occurring throughout the day and provides certain protection against overheating of the produces. This storage is badly ventilated. As it is closed, the produce cannot be checked regularly. This promotes rapid spreading of rot which men that storage duration is strictly limited. The stored produce is also damaged by insects and rodent which can hide themselves very well in the store (Nwarkiti and Makurdi, 1989).

d) Storage of yam tubers in champ silos

In Nigeria, attempts have been made to store yam tubers in clamps silos. The techniques of building the clamps silo was oriented to experience gained in northern Europe the results of storage in clamps silos in Nigeria were contradictory. They were better for some varieties of yam in comparison to the traditional yam barn but were worse for others. The clamp silos met with little acceptance for the storage of yams among the local population for socio-cultural reasons (Coursey, 1967.)

e) Storage of yam tubers under a conical protective roof made of maize or millet stalks.

This type of storage is often erected under a shady evergreen. It consist of a conical protective roof which can also be lengthened. The tubers lie on top of each other under this protection (Nkpenu and Tougnon, 1991). This methods requires no financial investment. The additional work input required is also limited. The shady tree makes temperature fluctuation throughout the day milder and the light protective roof allows sufficient ventilation. Problems arise with the possible entry of insect pests and rodents in addition, there is also the risk of wild and domestic animals damaging the roof construction in their search for food and causing damage by feeding on the tubers which can lead to rot. As the tubers are piled on to each other and the roof completely covers the tubers, it prevents regular visual checking of the produce stored.

f) Storage of yam tubers in mud huts.

This type of storage is often encountered in the savanna areas of the yam belt that is in regions with a pronounced dry season. They have firm walls erected in the traditional mud style. The roof consists of grass or other part materials, the construction is generally oriented to the particular regional architectural customs. The yam tubers are piled on top of each other in the hut. The mud hut provides very good protection from rain and direct sunlight. With the roof made out of plant materials, this method of mud construction evens out temperatures. The lack of ventilation and the piling of the yams are problems here. Both promote the formation of rot and stored yams can only be checked with difficulty. To build the mud hut requires a high input capital and labour. However, the hut acknowledges this by having a low degree of maintenance need and a service life of 20 – 30 years (Npenu and Tougnon, 1991).

g) The storage of yam tubers in the yam barn

This system of storage is the most widespread among traditional yam farmers in West Africa. A yam barn consists of vertically erected wooden posts of about 3 meters lenght and set a distance of 50cm to each other. The vertical posts are stabilised by attaching horizontal posts to them. Frequently, trees which are still growing are integrated into the storage system for static reasons and also to provide natural shade.

The yam barn is erected in the open air and it is importtant that there is sufficient shade available. To provide this, a roof is sometimes made of palm leaves, or evergreen are used as natural shade. The barn has to be constructedin an airy spot so that the surplus humidity in the air occuring from respiration and transpiration of the tubers can be emitted. Sufficient ventilated also reduced the risk of the tubers heating and thus limits weight loss due to respiraton and transpiration (Onwueme, 1987).

2.1.2 Improved method of Root and Tuber storage.

Farmers wishing to improve their income all year round must aware of costomer demands, especially those living in urban areas. Good quality and varieties of tubers preferred by consumers and possessing good storage qualities should be chosen and the advice of the local extention services should sought be on this topic. The following steps are recommanded.

2.1.2.1 Careful Harvesting, handling and transportation – care should be taken that tubers are harvested without squeezing or breaking them. Use appropriate tools for lifting the tubers.Avoid exposure of the yams to strong sunlight for longer period. Handle tubers gently never drop them. The best way to transport yamsis by placing them into baskets or other containers of approprite size.

2.1.2.2 Pre-harvest measure – Use only healthy planting material derived from tubers of medium size and regular shape. Grow tubers exclusively on fertile soil that is not contaminated by nematodes, termites or other infestations that may harm the crop.

2.1.2.3 Hygienic measures – choose only healthy and undamaged tubers for storage. They should be of medium size and regular shape. Grade tubers according to their size before storing them so that a uniform quality can be provided at any time. Tubers that are not suitable for storage or will not fetch a good price should be separated from the market tubers before storing. They may be used for home consumption. Clean the storage structure thoroughly before storing and keep it clean at all times. Keep the surrounding clean and clear to discourage rodents.

2.1.2.4 Construction of the raised hut: The raised hut is a storage structure made of locally available materials such as wood, bamboo, straw etc its dimensions may vary according to need. The hut should be at least one meter above the ground. Rat guards should be fixed o the legs to prevent access by rats and mice. The rodents guards consist of metal sheets that are wrapped around all legs and have a length of at least 30 cm. Fix the rodent guard with some nails. The store should be protected against theft with a strong padlock. In some areas, protective measures against termites have to be considered. A simple and cheap method for example is dipping the lower part of the legs that support the hut into wood preventives or neem oil. Inside the vaised hut, the yam tubers are best stored on shelved so that they can be inspected easily and rotten tubers should be removed.

Large tubers are placed in one, whereas small tubers in two to three layers. Different yam varieties should always be stored separately.

2.1.2.5 Regular surveillance – The tubers should be inspected at least every three weeks. Remove rotten tubers immediately to prevent further contamination. Partially damaged tubers may be chipped and dried or used immediately. Remove sprouts before, yam tubers loose moisture and shrivel. This minor quality change, however, is unavoidable on the marct. In dry climates the shriveling can be reduced by covering the tubers with yam vines, straw or similar materials of plant origin.

2.1.2.6 Modern technology for yam storage – Adesuyi, 1973, 1978. retained the methods of lowering tempering of the storage area to 15°c and the direct irradiation of the tuber by gamma irradiation (7.5 to 15 krad) in his effort to apply advanced technologies to the improvement of yam storage in Nigeria. He applied low temperature and different intensities of irradiation on the same cultivar, D. rotundata, this enabling the result of the 2 techniques to be compared. Irradiation blocks germination irreversibly at 10 krad (starting at 8 krad according to Demeaux, 1981) as with the potato, probably by the same processes of disorganizing the synthesis of nucleic acids and growth regulators. Although at his dose, the rate of loss at 6 months is identical to the rate obtained in storage at 15°c, the dose of 12.5 krad only reaches a similar rate of loss at 8 months. A comparative sampling (Adesuyi, 1973) had shown 95% in class A (the highest) for 12.5 krad, 75% for 15°c and only 20% for storage on shaded screens in corresponding samples. Another advantage of irradiation is that it does not require any particular storage structure, Demeaux (1981) was able to store several tones in the open air for six to eight months, with a loss of 15 to 20%, after an irradiation of 10 krad. The cost price would in principle be much lower than that of any other technique, as the radio – element installation could also be used for purposes.

2.1.2.7 Storage of other crops (cassava and sweet potato) three improved storage methods which have undergone sufficient testing, including field testing, involve;

i) Storing in moist saw dust

ii) Dipping fresh tubers in fungicide and packing them in polythene bags and

iii) Storing them in specially prepared trenches.

i) This involves placing freshly harvested tubers in moist sawdust (67%m.c) contained in boxes or baskets. The moist sawdust prevents desiccation of the produce as well as preventing bio deterioration. This methods has been successfully used to store cassava tubers for 4 month (Nnodu, 1983) and ginger for 6 months (Okwowulu and Nnodu, 1985. cassava tubers stored in sawdust must be freshly harvested with 15 to 20cm of the stem attached. The 3 types of container which can be used for this methods are woven baskets paper cartons and wooden boxes with covers. In this way with layers of saw dusts followed by layers of fresh cassava tubers, carefully arranged so that the tubers do not touch each other that is saw dust is packed between the tubers and also at the top of the container and is then moistened, the containers can be transported or stored in this way (IITA, 1990)

It is essential in this type of storage to inspect cartons every 3 days to ensure that the sawdust is moist. It is also important to ensure that the harvested tubers has no mechanical damage as this method is suitable only for storing undamaged tubers. Experimental results have shown that sweet potato tubers can be stored in sterilized moist saw-dust for a period of up to 4 months. The tubers were stored in baskets, 10% sodium hypochlorite (bleach) we used to disinfect the tubers before storage (Umeh, 1987). The moist sawdust was kept constantly moist by sprinkly 400ml of water over it every fortnight (Nnodu, 1983), Nnodu (1990) also showed that Benlate or Thiabendazole (TB2) could be used as disinfectant but they are very expensive.

ii) Storage in polythene bags: this method appears to be the simplest way of storing tubers. If properly conducted it ensures as a shelf of two weeks or more. The method is based on the principle of "curing" the capacity of the tuber to form a new layer of cells over damaged tissues. Freshly harvested roots are treated with 0.4% solution of mertecta thiabendazole base fungicide. They are then packed in polythene bags and sealed.

(iii) Storage in trenches. This low cost method developed by the Nigeria stored products research institutes keeps cassava fresh for at least 6 to 8 weeks and can be implemented easily by easily by farmers and processors. A trench is dug in the ground at a site which has low water table. The trench should be 12m long, 1.5m wide and 1m dep. Depending on the size of tubers, a shed made of wood and iron or bamboo with a thatched roof is constructed over the trench. It is economical to make several trenches under the same shade. This method is somewhat similar to the underground pit storage.

2.1.2.8 Quonset - Type storage: The Quonset storage building is constructed with galvanized metal sheets. The metal sheets are joined together using planks or woods nails in order to obtain a half circular structure with both ends of the construction touching the floor or ground (Wagner, Buns and Peterson, 1983). Before the storage of the sweet potato tubers, they are first of all cured for 7 days at 30^{o}c and 95% relative humidity. The tubers are then packed incrates which have black, double walled plastic covers installed inside it. The Quonset type structure is equipped with a fresh air exchange system. Under this storage condition the tubers could be preserved in good condition for 3 months without change in taste, colour, moisture content and others, sprouting within this period is insignificant (Umeh 1987). The advantages of the Quonset style storage are that the plastic covered structure can be located near points of production thereby minimizing hauling cost, its disadvantage is that the material required for construction of this storage method is relatively expensive.

2.1.2.9 Storage of processed root and tuber produce: The storability of a processed root and tuber crops depend on the dryness of the processed product, the environmental condition of the store and how often the product is being disposed by the marketers. About 20-25% of yam harvested in some states in Nigeria are processed into dried yam chips. This is done by peeling off the skin and cutting lengthwise or laterally into slices and soaking in water. The water is brought nearly to boiling point and the slices are finally sun-dried or air-dried to about 15% moisture content which is the highest suitable moisture content for storage.

Insect infestation usually occurs for the first time at the traders store in the urban areas due to cross-infestation from other stored products like maize, rice, beans etc. under this condition, the dried yams already stored and transported in jute bags should be fumigated by products research institute, the ministries of Agriculture, with phostoxin at 8 – 10 tablets per ton. The phonostin tablets may be put on the bags as against inside the bags and covered with gas proof sheet. All adjacent stores should be fumigated stores.

In the alternative all the products in an area can be fumigated in a control stores and later returned to traders stores. Polythene lined jute bags can also be used for storage and more effective individual bag fumigation, but this is a more expensive procedure than using just bags alone. Jute bags for storing, transporting and disinfecting yam chips should not be overfilled predisposes the dried yams to heavy insects infections. Dried yam should be protected from wetting by rain or water as this will raise its moisture content above safe level for storage and it will become mouldy. Dried yam chips are milled into flour when required for food. The flour is stirred vigorously in boiling water to give a mass of good consistency called "Amala".

The following methods are used to store processed root and tuber produce:

i) Pot storage – These are clay pots. They are usually used to store yam and cassava chips, they are either placed on top of ground in a shed (usually huts) or buried up to its neck in the hut.

It has higher storage capacity than the guards and are easily loaded and unloaded due to their wide mouth. However, the absorb moisture and damage such as molding could occur.

ii) Drum storage – the dried chips are stored in drums in homes and by some small-scale traders. They can be made relatively airtight by tightening a clamp to hold the lid to the drum, fumigants are usually required to reduce the incidence of insects infestation. To reduce the problem of rusts, the inner layer may be lined with polythene material. This is strictly for small scale and heating up is a major problem, particularly if the clips is not properly dried.

iii) Sacks: There are three well-known types; the sisal, the jute and the plastic bags. Chips or flour are stored in these bags which are sacked mostly on raised planks in stores, barns, houses or warehouses. The major disadvantage of this method is that it encourages insects infestation. Except the thick plastic bags, they also break easily when old and allow free passage of moisture. It is a very popular form of storage with marketers and retailers. It could be improved by the provision of plastic lining to the inner parts. This would increase its strength. Its water exchange capacity and the ease of infestation would also be reduced by this simple improvement. As at now, sacks are considered a transit storage container and so, although popular, attention is not focused on its improvement. If properly improved, it could serve as long-term storage device. However, the cost is another problem to c addressed by packing experts.

iv) Rhumbu: This is either roughly cylindrical in shape or flask shaped tempering at one end. There are other varieties of shapes in-between these two shapes. Rhumbu floor is usually raised slightly from the ground to avoid damages by rain torrents, to reduce rodent accessibility and to facilitate the process of unloading the structure which is normally done by gravity at the center underneath the structure.

It is very common in all the parts of the country. There are disadvantages in this type of storage. Its low capacity' and the incidence of heating up of the inside. In spite of these problems, rhombus still remains a promising method of processed root and tuber storage.

v) Warehouse storage- in cases of store and warehouses, produce are already bagged. The construction of such structure is a specialized function and qualified storage engineers must be involved if one intends to undertake such a project. For example, the building must be located in a flood-free area with smooth walls, leak proof and sealed eaved roos and moisture-proof floors. The doors and windows must be tight fitting to facilitate fumigation and to prevent rain and rodents from entering the store or warehouse. The bags must be sacked on wooden pallets away from the walls. This method, when all the rules are obeyed, has been proved to be highly successful in both developing and developed countries.

2.2 **STORAGE LOSSES**: As crops are grown annually, it is necessary to store for 6 months or longer. Substantial losses occur during storage under the existing methods already described.

2.2.1 Factors causing storage losses in roots and tuber crop storage: The factors are divided into two main groups;

(i) Primary causes (ii) Secondary causes. The primary causes are those that directly affect the stored tubers while secondary causes are those the lead to conditions that encourage a primary cause of loss.

2.2.1.0 PRIMARY CAUSES OF LOSS IN ROOT AND TUBER CROP STORAGE

2.2.1.1 PHYSICAL FACTORS

Tubers are often damaged during harvesting, handling and transportation especially varieties, that yield large tubers. Work in Puerto rico have indicated a strong correlation between tuber size and extent of damage during harvesting. It was found that less than five percent of the smallest tubers examined were damaged, whereas 50 percent of the largest tubers were damaged. The tubers may be further bruised or damaged during handling and transportation. Tubers also suffer mechanical damage as a result of pre-harvest infestation by pests like beetles and nematodes. The different types of mechanical damage create entry point for micro-organisms causing rot during storage.

Another physical change of importance in tuber storage is desiccation caused by evaporation, tubers are generally stored during the dry season, and large losses of water might be expected especially in material of such high moisture content. It was noted that different varieties of D. alata grown in the Philippines change in moisture content by amount varying from almost zero to 7 percent during storage for two months. With the same species in Venezuela reported a reduction in moisture content of 5 percent in months storage. However, as neither of these observations was related to the change in weight must have occurred, it is impossible to estimate the actual amount of water losses by the tubers.

2.2.1.2 PHYSIOLOGICAL FACTORS

Tubers especially yam are natural organs and are living although dormant systems. The basic metabolic process continues in the dormant tuber, although at a rate much lower than in the actively growing phase of the plant. The most important of those metabolic processes is respiration which results in the conversion of part of the carbohydrate of the tubers into carbon-dioxide and water which are lost to the air, west Africa stored product carried out primary respiratory studies. The usual technique of using slices were rejected in favour of a system utilizing whole tubers as the results obtained would have a closer relation to changes occurring under field storage conditions.

When first put in store after harvest yams are dormant system. Emilson (1949) regarded a dormant period as the time after harvest when the bid were not growing for whatever reason, differentiating it from "rest period" which he defined as the dormancy after harvest during which tubers would not sprout under favourable conditions. During storage at optimal sprouting condition the dormant period would coincide with the rest period. Dormancy is critical to yam storage for two seasons.

First, it determines the length of storage like of tuber, more sprouting marks the beginning of tuber disintegration. Secondly, the suppression of endogenous metabolism during dormancy reduces the rate of loss of storage carbohydrate. In the absence of dormancy, the respiratory rate of yam at tropical ambient temperature could be very high and the life of the tuber very short indeed. There is a strong belief in West Africa that yams stored under shade usually deteriorate fast resulting in greater loses in weight and quality.

The most important of yam metabolic activities is respiratory in which carbohydrates in the tubers are converted to carbon dioxide and water both of which are lost to the atmosphere. Like yams, potatoes and sweet potatoes respire during storage. They loose weight as a result of respiration that consumes some of the stored food primarily sugar and starch. During respiration carbon dioxide and water are given off. Sweet potatoes loose water and carbon-dioxide in such a manner that the ratio of water and carbon dioxide in such a manner that the ratio of water and carbon dioxide is such that the ratio of water and carbon dioxide in such a manner that the ratio of water to dry matter (starch and sugar) in the root changes very little even when the roots are held under widely different conditions temperature and relatively humidity (Wilcox and Demare, 1959) have found that the rate of respiration of potato tubers tended to decrease as the duration of storage was prolonged whether sugar contents of the tubers were increasing or decreasing. The downward trend was, however, interrupted whenever sprouts appeared and as sprout became abundant, respiratory rate was greatly increased.

2.2.1.2 ENTOMOLOGICAL FACTOR

Insects attack is generally of little importance in the storage of unprocessed tubers, although they may affect the viability of stored seed tubers. Yam tuber beetles (Heteroligus meles, H. appius, Prionoryctes rufopiceus, P. Cuniculus) are by far the most serious pests in West Africa but H. meles, the greater yam beetle, is the most common and widespread species and is found in the Savanna areas. These beetles do not breed in the yam field but in swampy areas. The eggs are deposited in moist soil during November and December. The three larval instars and the pupal stage are completed by March or April when the beetles emerge. Beetles fly to the yam field with the advent of rains and remain until the end of the rain. In part of Nigeria, considerable damage is occasionally caused by cricket (cymoryllus lucens) and in association with ants of the genus componotus, the citrus mealy bug (planococcus citri). Chemical control of these is effective. The variegated grasshopper (zonocerus Variegatus) has been reported to cause loss of stand or reduced yield. Nymphs and adults defoliate the plants and may kill young plants. Yam and cassava are subject to attack by several species of termites both when growing and during storage. Another insect that is important in root and tubers storage is the sweet potato weevil, cylas spp. They can destroy the whole lot of stored potatoes once they infest. Infestation starts from the field and the damage gets worse in storage. White flies and scale insects (Aonidonytibus) also cause considerable damage to tubers.

2.2.1.4 PATHOLOGICAL FACTOR

Storage rots are the main factors responsible for the deterioration of stored tubers. Several fungal tubers species have been identified as associated with tuber rots, including hard, brown, dry rots wet rot slimy rot (Ogundana et'al 1970, 1971; Ogundana, 1972). Nematode infections also increased susceptibility of tubers to storage rots; Ekundayo and Naqvi (1972) show their association with dry rot disease.

Various bacterial infections have also been observed in yams. Pathogenic invasion of the tubers is greatly facilitated by mechanical damage by accidental cutting or bruising or by pre-harvest nematode attack. In some producer countries it is a common practice to treat cut or bruised portions with an alkaline material such as line wash or wood ash, to reduce the probability of infection. Coursey (1961) has shown that lime-washing and other fungicidal treatments reduce weight loss during the first 2-3 months of storage, but may be in effective over longer periods. Losses due to causes such as wound pathogens, weight loss and respiratory loss, are reduced by "curing" or storage at low temperature (Gonzalez and Collazo de Rivera, 1972). Thompson et'al (1977) have summarized the use of fungicides in the storage of yams.

Table 1: Micro organisms found associated with the stored and marketed yam tubers obtained from tropical forest region of South Western Nigeria and their pathogenicity on yam.

Pathogens	**Symptoms of infection**	**Pathogenicity**
Botryodiplodia Theobromae	Dry rot	+++
Aspergillus. Tamari	"	++
Pencilillium oxalicum	"	+++
p. cyclopium	"	+++
P.italicum	"	+++
fusarium oxysporium	"	++
F. solani	"	++
Rhizopus nigricans	Soft rot	++
Scerotium rolfsii	"	+++
Mussor circinelloides	"	+++
Trichoderma. Viridae	"	++
Erwinia cartovora	Wet rot	+++

Source: *(Amusa and Baiyewu, 1999)*

++ Mildly pathogenic (◄ 10► 50mm in diameter. +++ highly pathogenic

(50mm in diameter).

Quite beyond the loss of acceptability that occurs when yams decay, infection leads to greatly enhanced weight loss. Sound tubers that later become rotten lose weight faster than those that remain sound, suggesting that pathogens actively contribute to weight loss even before symptoms of decay are visible. This agrees with the observation by Coursey et'al (1966) that the respiration rate of apparently sound yam tissues is reduced by antibiotics.

Table 2: major pathogens associated with post harvest deterioration of root and tuber crops in Nigeria

ORGANISM	ROOT AND TUBER CROPS				
	CASSAVA	YAM	COCOYAM	SWEET POTATO	IRISH POTATO
Fusarium Solani	-	+	+	+	-
Fusarium Moniliformae	+	-	-	-	
Botryodiplodia theobromae	+	+	+	+	-
Selotium rolfsii	+	+	+	+	-
Rhizopus stolonifer	-	+	+	+	-
Corticium rolfsii	-	-	+	-	-
Rosellinia bunoides	-	+	-	-	-
Lasiodiplodia theobromae	+	+	-	+	-
Penicillium spp.	-	+	-	+	-
Macrophomina phaseoli	-	+	-	-	-
Serratia- spp	-	+	-	-	-
Aspergillus niger	+	+	+	+	-
Forus- lignosus	+	-	-	-	-
Hendersonala terubidea	-	+	-	-	-
Erwinia- cartorora	-	+	+	-	-

Key + = present - = Absent

Source: Booth, 1978

2. 2. 1. 5. NEMATODE ATTACK:

Nematodes can cause post harvest loss of tubers.During the storage of yam the nematode population increased (Thompson etal. 1973). Fumigation was not successful, although hot water treatment reduced the numbers, damage still occurred to the tubers. Nematode infections also increased susceptibility of tubers to storage rots: Ekundayo and Nagvi (1972) show their association with dry rot disease

Nematodes occur on yams as roof and tuber parasites. The nematodes mostly infest the plant during the vegetation period and remain in the tubers after the harvest. They damage not only the tubers themselves but also create entries for other pests, in particular for mould fungi. For this reason infestation by nematodes is often accompanied by tuber rot which mostly causes greater economic damage than infestation only by nematodes.

The yam worm (scutellonema bradys) is one of the most important nematode parasites of the yam tuber. The yam worm particularly damages the periderm and superiderm, call layers which are directly under the cork shell. The beginning if infection can be detected by narrow, yellow wounds which are directly under the shell. In the course of time these wounds become brown. On the exterior, deep cracks indicate infection. The yam worm can cause symptoms of dry rot if other pathogens are missing.

As the yam worm destroys the meristem, the tuber often loses its germination capacity as a result of infection. The root-knot nematode (meloidogyne spp.) is a widespread pest in the tropics. Several varieties of this pest also infest the roots and tubers of yams. The root-knot nematode lives freely in the soil and can penetrate softer parts of the tuber. The larvae grow quickly in the adult phase only the females are parasites. These lay their eggs in the tuber as well as in the earth surrounding it. After harvesting, the larvae and eggs continue to live in the tuber. The roof knot nematode causes nodulation and often wrinkled and shrunk yam tubers.

The root-lesion warm (pratylenchus spp) infests the tubers as a larva or as an adult worm. It causes dark-brown dry rot which penetrates the tuber irregularly. In some cases, the shell of the tuber is open by the infection leaving the way free for secondary infections.

The major methods of control are to avoid nematode infested lands and to avoid planting nematode – infested setts, seeds or stem. crop rotation, to reduce the build up of nematodes, is also useful. in special cases, fumigation with nematicides may be used.

2.2.1.6 Rodents and mammals - They often attack cassava roots. Tubers crops are occasionally attacked in store by rodents. Although the quantities actually consumed are generally small, the damage done to the tubers predisposes them to decay. Most damage is probably done by the large can-rat or "cutting grass" (Thryonomys swinderainus) and the giant rat (Cricetomys ganibianus). Stored tubers are also popular with monkeys and warthogs as well as with domestic animals like goats and sheep. Problems arise with the possible entry of pests and rodents in addition, there is also risk of wild and domestic animals damaging the roof construction in their search for food and causing damage by feeding on the tubers which can lead to rot. As the tubers are piled on top of each other and the roof completely covers the tubers, it prevents regular visual checking of the produce stored. Conventional control measures can be applied with good effects.

2.2.2.0 **SECONDARY CAUSES OF LOSS IN ROOT AND TUBER CROP STORAGE:** These are causes that lead to conditions that encourage primary cause of loss. They are usually the result of adequate or non-existence capital expenditure, technology and quality control (F.A.O, 1980) Examples are:

i) Inadequate storage facilities.

ii) Bad roads which leads to injury of transported produce.

iii) Inadequate drying equipment or poor drying season

iv) Inadequate harvesting, packing and handling skills.

v) Illiteracy of the farmers which make it difficult for them to adopt better method of harvesting storage and processing.

vi) Lack of market outlet for easy sale of produce.

vii) Poor management for preservation and storage of produce.

In Nigeria, post-harvest food losses is centered around these causes and ameliorating these problems will reduce the deterioration of root and tuber crops caused by the primary factors which causes loss in the farm produce.

2.3 CONTROL OF POST-HARVEST CROP LOSSES

Any measures to improve existing storage structure have to be in harmony with the relevant reasons and purposes for these improvements must not have a negative effect on the socio-cultural symbolic character which many storage systems have in addition to their purpose of providing protection. Furthermore, measures towards improvement have to be economic from viewpoint of the farmers and must not place excessive demands on his resources. The suggestions made below primarily serve to improve the traditional storage structures and methods. The basis for the suggestions towards improvement derives mostly from the traditional storage structures and methods. The basis for the suggestions towards improvement derives mostly from experiences share by the yam farmers themselves or experiences share by these. The results of research are also taken into consideration as far as these appear suitable for use by smaller farmers. The following measures should be adopted for control of post-harvest losses.

2.3.1 PRE-HARVEST MEASURES

Good quality and varieties of tubers preferred by consumers and possessing good storage qualities should be chosen. The best varieties between regions should be chosen and the advice of the local extension services should be sought during planting.

2.3.2 THE CHOICE OF AN APPROPRIATE STORAGE SITES

This should be situated in the village or close to the road or market, this is a precondition for the improvement of the storage system.

2.3.3 CAREFUL HARVESTING, HANDLING AND TRANSPORTATION

Care should be taken that tubers are harvested without squeezing or breaking them. Use appropriate tools for lifting the tubers. Avoid exposure of the tuber to strong sunlight for longer period. Handle tubers gently and never drop them. The best way to transport tubers is by placing them into baskets or other containers of appropriate size. High pile on transport vehicle increase the risk of injury stemming from pressure and should consequently be avoided

2.3.4 USE OF CHEMICALS

Conventionally, insects are controlled by using a variety of chemical sprays and fumigants, combine with careful disinfestations of warehouses before storage is generally effective treatment of tubers with fungicides such as benlated and captan has been found to be effective in reducing fungal infections. Due to toxicity of many chemicals, the use of tecto (Thiabendazole), locally made dry gins or wood ash before storage which are known to have little or no mammal toxicity have also been recommended.

The boring beetle attack on shoot and tubers can be controlled by granular application of diazinon and carbofuron, while treatment of tubers with insecticides dust (Actellic 2% Dust; ai = primiphos – methyl) will reduce fungal infections and also ameliorate physical damages acquired during harvest resulting on significantly fewer fungal lesions (morse at'al, 2000).

2.3.5 CURING

To prevent rotting during storage wounding of the tubers during harvesting and handling is to be avoided. Curing of yam tubers at 25°c and low humidity (90 – 95 percent) for five days before storage, prevents, to a certain degree, storage rot. Tubers are humidifies to promote wound healing through suberization and periderm formation.

TABLE 3: Conditions required for curing root and tuber crops

CROP	TEMPERATURE (°C)	RELATIVE HUMIDITY (%)	TIME (DAYS)
Cassava	30-35	80-95	4-7
Sweet-potatoes	30-32	85-90	4-7
Yams	32-40	90-95	1-4
Coco-yams	32-35	95-100	3-5
Irish potatoes	15-20	85-90	5-10

Sources: Booth, 1974.

Curing has been used in Nigeria to reduce storage losses in yam (adesuyi, 1973) and sweet potatoes (NRCRI, 1981).

2.3.6 HYGENIC MEASURES

Storage structure should be clean thoroughly before storing the tubers while the walls and the floors should be regularly disinfected. Every debris around the strong structure should be properly disposed and all the handling equipments should be sterilized.

2.3.7 COLD STORAGE

The application of low temperature is limited due to the relatively high cost of the technology involved. Temperature of 16-17°c have been successfully employed to prolong the storage time of yams (Gonzalez and callazodc Rivera, 1972). The storage of tubers at lowered temperatures has the advantage of reducing the major sources of storage loss (respiration, sprouting and rotting).

2.3.8 IRRADIATION

Gamma radiation at dose between 7.5 and 12.5 krads prior to storage substantially improves the keeping properties of stored yam in barns. Sprouting is inhibited for up to eight months by this method with consequent maintenance of yam quality and palatability. The same process apply to sweet potato in which synthesis of nucleic acids and growth regulators are avoided.

2.3.8 THE USE OF IMPROVED YAM BARN

The improved yam barn is a shed but the sides are constructed with wire mesh or wooden slates for free flow of air (ventilation). To prevent entry of rodents, the sides of the barn should have a barrier of about 1 step high (1 meter) which rodent cannot climb or pass through. The roof is also constructed with thatch to make the barn cool and the floor is cemented for easy cleaning. Open sided shelves should be provided in the yam barn. This can be constructed with plants materials or sawn wood. The use of shelves allows the tubers to be easily handled without wounding them during storage. The shelves also allow for easy removal of sprouts and yam tubers that are bad. Door is provided for the barn to discourage thieves.

2.4 PROCESSING

Roof and tuber are highly perishable since they are succulent living plants parts with over 70% water content. They are therefore not easily stored for relatively long period of time, unlike cereals and legumes.

The demand for roots and tubers generally declines with rising income unless they are processed to render them into forms with a longer shelf life and able to meet the demand or convenience foods in urban areas. Processing of roots and tubers becomes imperative when there are anti-nutritional factors or toxic substances involved. such as the presence of cyanide in cassava. Prompt processing of harvested crops prevents the infestation of pests and microorganisms which causes losses in stored produce. For instance cassava can be processed into gari or flour which can be stored for up to a year whereas freshly harvested cassava could hardly be stored for three months. Also, the wastages and losses that is common to the harvested cassava could hardly be stored for three months. Also, the wastages and losses that is common to the harvest seasons are brought to the bearest minimum level.

Fresh cassava, like yams, potato and coco-yam is primarily a source of carbohydrates and contains very little protein or fat. Sweet cassava is characterized by low level of hydrocyanic acid while bitter varieties process high levels of the acids a major processed forms of the cassava tuber fall into four general categories; meal, flour, chips, and starch. Meal form includes gari and meal of retted cassava. The meal and flour forms account for bulk of cassava used for human food in the tropics. Cassava chips and cassava starch are mainly industrial products that are little used for direct human consumption, but they account for most of the cassava that enters international trade. The food industry takes advantage, in its uses of cassava starch, of the high paste clarity and resistance to retrogradation of the unmodified starch pastes and gels.

Gari - This is the product obtained when cassava is fermented and fried for its preparation, the cassava roots are peeled, washed and grated. The grated meal is then packed into cloth bags. Heavy stones and logs are piled on top of the bags to press out the moisture and then allowed to ferment for four days in the bags when the meal is sufficiently dried, it is removed from the sack for final drying. It is first forced through a sieve and is then put, in small amount at a time, into a wide shallow iron pan and constantly stirred over a low fire until thoroughly dried.

Meal of retted cassava - This is produced by steeping the fresh cassava in water for several days until it has soften by fermentation. The steeping may be done in house hold tubs or pots, or it may done at the edge of strings. It is important that all parts of the tuber be submerged in water. Exposed portion will fail to soften. Peeling may be done before or after the rating has occurred. The steeping of the tubers in water serves to reduce the hydrocianic acid content. After steeping the soften pulpy mass is then disintegrated in water and passed through coarse sieve. The meal is then allowed to sediment, packed in cloth bags and squeezed slightly to expel the excess water. The final meal that results is white and crumbly. It is usually cooked before being eaten. It is rolled into large balls steamed or boiled until well cooked, pounded and then eaten as fufu in the same manner. One major objectionable feature of the meal of retted cassava is that it tends to have an odour.

Cassava Chips And Pellets - They are produced for feeding livestock. The chips are produced from fresh tubers which are washed peeled and cut into slices of three to six centimeter length. The are then dried and bagged. Pellets are produced from chips. After the chips have been dried, they are ground and hardened into cylindrical pellets about two centimeter long and up to one centimeter in diameter. It is in the form of chips and pellets that most of the cassava used for live stock feeds is utilized. Is lightly different form of cassava chips is used for human consumption. The fresh tuber is peeled, boiled in water and sliced into thin longitudinal slices or chips. The chips are then steeped in water for 1 to 2 days during which the water is changed once or twice. The chips are finally washed and consumed at this stage but more commonly they are removed from water after washing and dried in the sun.

Cassava Flour - The preliminary stages in the making of cassava flour are similar to those for making cassava chips. The fresh roots are peeled, washed and cut into large longitudinal slaps. The slaps are allowed to dry thoroughly in the sun they can be stored. When the four is needed, the dry slaps are milled to produce a grayish white flour. The flour is prepared for consumption by pouring it slowly into a pot of boiling water over a fire and stirring it on the fire until it form a brownish, viscous paste. This paste is eaten with stew or soup.

Cassava Starch - The starch is isolated from tuberous roots of cassava plants where they occur as birefrindgent granules ranging in size from 5 to 35cm within the tuber cells. The method of commercial isolation is entirely a wet process. Tubers arriving at the production plant are peeled and washed. The tubers are then crushed to produce a pulp. The pulp is suspended in water and by use of a series of revolving screens the fibrous material is removed, leaving the starch milk. Water used for this extraction stage will contain about 0.05% sulphur dioxide to prevent microbial action or fermentation during the extraction. The starch milk is passed through a sand cyclone to remove sand and dirt particles, then the starch is allowed to settle in settling tanks. It is then dried to a moisture content of 10 to 14%; after which it is pulverized, dry screened, and bagged. Like other industrial starches, cassava starched finds use in factories producing glucose textiles and confessionary.

Grocery Tapioca - is essentially cassava starch produced by a special process. Before the starch is dried, it is put on a sheet of metal previously smeared with oil and placed over a fire. It is stirred to prevent burning. The starch grains expand, and there is partial dextrinisation causing the particles to adhere together the food product is more digestible than ordinary cassava starch. Tapioca flakes are prepared by spreading the starch in a thing layer on the pan cooking for about two minutes, and drying at 50^{o}c to a moisture content of 12%.

Tapioca pearls are made by first granulating well starch, then gelatinizing them roasting for 15 minutes on hot pans smeared with coconut oil. They are dried at 40° – 50° in a stream of hot air for about 2 hours.

Industrial yam processing; yam have not been utilized in food industry to any appreciable extent. Very limited quantities are used for starch production. However, yam floor production is being put on a technologically bounder basis than it has either to been put by different research efforts in Nigeria. The production on an industrial scale of instant yam known as yam fufu by the National root crops production company of Nigeria in cooperation with the Department of Food Science and Technology, University of Nigeria, is very illustrative. The product reconstitutes simply on addition of hot water follower by starry to yield yam fufu of a smooth consistency.

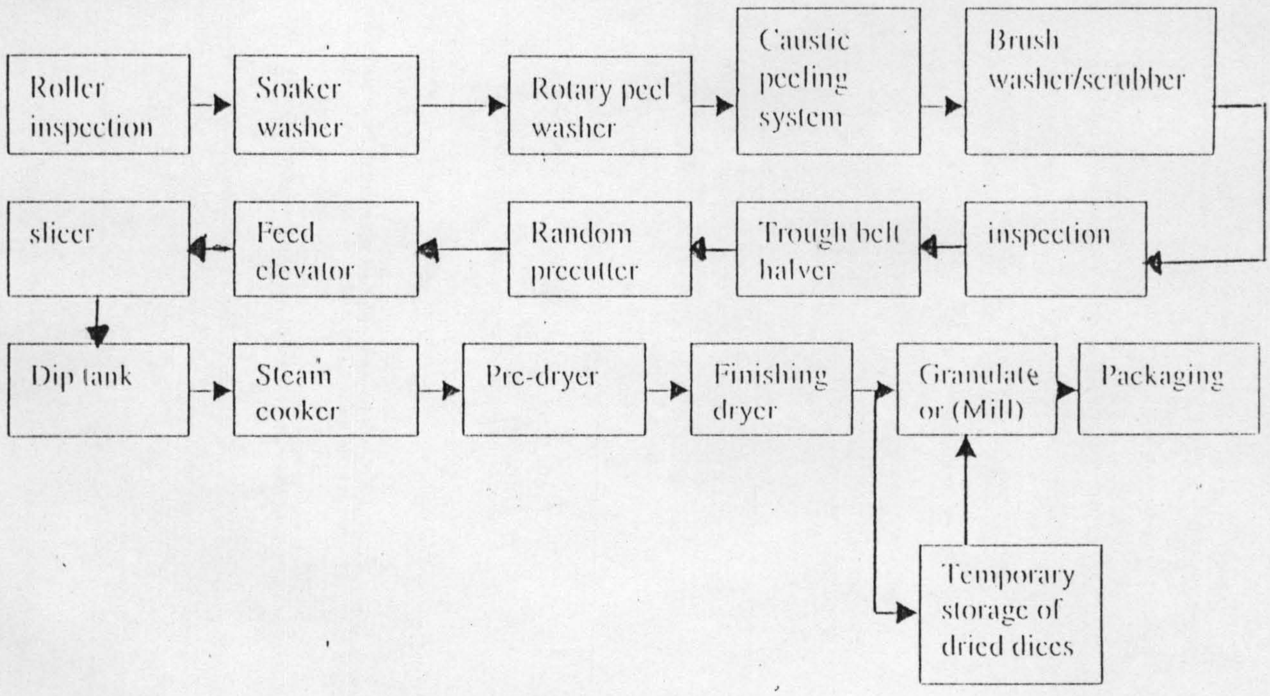

Figure 1: Flow diagram for production of instant yam flour.

The product is made by plechy, cubing and sulphiting yams; steaming for a few minutes, drying and mechanically grinding the dried cubes to form yam flour. The flour is packed in polythene bags. The economic success of this development will depend upon the availability of yam tubers and the adaptability of e ach processing stage to mechanization. The yams are manually peeled and the efficiency of the peeling process may affect both the quality of the finished product and the amount of waste. Mechanical peeling is likely to be applicable even though the tubers differ in shape and size. In particular iye peeling which utilizes chemical and thermal action on the tuber surfaces may be applicable.

2.5 LOSS ASSESSMENT

There are great variations of storage suitability between species and cultivars, or even within cultivars, influenced by such factors as conditions of growth, time of harvest, and fertilizer treatment. Gooding (1960) quotes loss after 4 months' storage as between 7 and 23 percent in different dioscorea alata cultivars. Farmers are usually well acquainted with variations in storage quality among forms grown in their area.

Sources of storage losses are rotting, pests, respiration and sprouting. It is observed that weight losses of 10-15 percent are normal during the first 2 months' storage, while after 6months the losses may be as much as 30-or even 50 percent. Allowing for the proportion of the crop that is it has been estimated that in west Africa alone about a million tones of edible yams are lost annually in storage (coursey, 1965). These weight loses of food material arising but are, at least in part, losses of food material arising from the metabolism of dry matter to carbon dioxide and water. Yet many varieties of tubers may be stored for long periods without significant reduction in quality.

Storage losses from various fungal rot diseases are generally severe, particularly when the tubers are damaged. The commonest and most important is botryodiplodia theobromae which also causes a rot in the field. It has been shown to be responsible for wet rot, soft rot and brown rot. Other fungal rot diseases in storage causing considerable damage arwe rosellinia bunodes, penicillium spp. And fusarium spp. Chemical control of these diseases is effective to some extent.

Various attempt have been made by different people to reduce the incidence of rotting. Such attempts include the isolation of rot associated fungi, (Adeniyi, 1970); using Bordeaux mixture (colloidal copper hydroxie,)

Coursey D.G; 1966 and use of RE 49 Halophen (Wilson, 1984) these attempts have reduced the effects of the micro-organisms that cause tuber rot by impairing their activities.

Table 4: *Summary of information on weight losses in stored yams.*

Country Of origin species	**Percentage weight loss during storage**						
	1 month	2 month	3 month	4 month	5 month	7 month	8 month
Nigeria D. orundata	5	7	12	20	29	(at bori)	
	4	6	10	14	21	(at Abakaliki)	
	3	6	14	23	30	(at Umuahia)	
Nigeria D. Cayenensis	6	17	29	39	48	-	
Nigeria D. rotundata	-	-	-	-	-	50 (at Abak)	
	-	-	-	-	-	67 (at Umuahia)	
	-	-	-	-	-	33 (at Abakaliki)	
Ghana D. rotundata	1	5-7	15-17	26-27	34-40	-	-

*Source(*coursey, 1968*).

Sprouting generally reduces the quality, weight and palatability of the tuber which becomes fibrous and bitter especially at the head region where sprouting occurs. Also, it causes the tuber to become soft to touch from bottom to head thereby heading to rotting. Therefore, buds should be removed as soon as they appear and barn should be regularly inspected for sprouting tubers.

The amount of loss depend on storage, tuber variety and length of storage. Farmers should practice a market oriented store management and raise their incomes by providing well preserved tubers as long as possible.

CHAPTER THREE

3.0 METHODOLOGY

This section presents the various methods employed to evaluate the losses in the structures available for root and tuber storage in Federal capital territory and Nassarawa state .It also explained into details the nature of the questionnaire and its administration .

The local government areas where the project was carried out are those where root and tuber crops are predominately cultivated.

The research study covers the following local government areas in the two states (i.e FCT and Nassarawa sate) Abaji,Bwari Gwagwalada Kwali Akwanga Wamba Agidi Keffi Kokona Awe, Doma and Lafia.

3.1 METHODS OF DATA COLLECTION

The data collection was done through questionnaire administration and oral interview .The simple random selection method was employed to cover the ten local government areas method was employed to cover the local government areas questionnaire was administered to people randomly selected in the LGA areas. These people comprises of farmers and traders, this eliminates discriminating and favoring some villages or set of people.

The questionnaire were interpreted when necessary and they were prepared to collect information such as type of tuber cultivated, storage methods causes of spoilage amount of tuber grown of tuber processed amount harvested amount stored and sources of loss.

The villages in each LGA were picked at random and there LGA headquarters inclusive during the survey; the state map was used as a guide to cover the various towns and villages of both FCT and Nassarawa state in other to ensure a good coverage of the total area .For example, On a market day in a village located in Bwari area council of FCT and Keffi LGA of Nassarawa State, with a row of yam traders, the pattern followed was the first trader was interviewed, then the fourth, the seventh, tenth and so on .

Farmers in other towns and village were also chosen for interview using this method. In the same pattern, three to five villages were selected from each LGA, which makes a total of fifty-one villages covered. Table 5 shows the distribution of the various LGA visited and the total number of villages and houses sampled in each of the village.

Table 5 Pattern of questionnaire administration in each lga of F.C.T and Nassarawa states.

S/NO	LGA	NO.OF VILLAGES	NO.OF HOUSES
1	ABAJI	5	12
2	BWARI	5	7
3	GWAGWALADA	5	15
4	KWALI	5	10
5	AGIDI	3	7
6	AKWANGA	5	11
7	AWE	4	7
8	KEFFI	4	8
9	KOKONA	3	7
10	DOMA	4	9
11	LAFIA	5	13
12	WAMBA	3	6

Oral interview was also conducted with the help of an interpreter. Respondents (farmer and trader) who were illiterates filled the questionnaire and the illiterate ones were helped to fill the questionnaire based on the responses from them.

Three to five farmers were chosen from each village. The pattern employed was that two adjacent houses were picked along a street, then another set of two were picked after a specific block of houses

Depending on the population of the village, other location where root and tuber crops storage structures were found were visited. Such places include the International Institute of Tropical Agriculture (IITA) at kubwa in the Bwari area council of FCT and Nassarawa Agricultural Development Project Keffi Nassarawa State. At the former location, hundreds of improved wooden yam barns were sighted while at the latter raised hut s made of locally available materials such as wood, bamboo, and straw were sighted.

3.2 IDENTIFICATION OF DAMAGED ROOT AND TUBER CROPS

Method chosen for identifying damaged root and tuber crops when in store includes visualization, touching, tasting and smelling: This activities were carried out in the following sequential manner during the course of the survey

a. Visualization – Spoilt tuber were observed by mere looking at them, this served as the first sign of damage of tuber crops. /some of the affected tubers were noticed to turn red brown, grey or black. Some of the tubers were noticed to be pulverulent, breaking into small dry particles
b. Touching – When touched the infected tubers were softly ramified and some of them were wet due to a rapid collapse of the cell walls. Some of the infected tuber was characterized by oozing of whitish fluid out of the tissue when pressed. The

various micro – organisms which causes infection on stored tubers were either contacted at the site where the tubers were cultivated or through bruises which the tuber sustained during harvesting, handling or transportation

c. Smelling – Some of the tuber checked had fermented grain smell while others had irritating odors

d. Tasting – Some tubers which were about to be spoilt were cooked and the fresh tuber cooked separately. The spoilt tubers tasted soured when both of them were cooled.

3.3 EVALUATION PARAMETERS

The questionnaires were carefully distributed to the farmers and traders for easy administration throughout the ten LGA. Quite a reasonable number of people were interviewed during the survey work in all the LGA covered. A total of 220 questionnaires were distributed to farmers while 112 houses were visited. The evaluation parameters include percentages, averages and ratios.

During the interview, the various storage methods and structures were carefully observed. Also, farmers were also advised on preventive measures, which will make their tuber crops to be well preserved.

CHAPTER FOUR

DATA ANALYSIS

4.0 DISTRIBUTION OF ROOTS AND TUBERS CULTIVATED IN EACH L.G.A.

During the course of this project work, it was generally observed that most farmers cultivate more root and tuber crops throughout all the local government areas visited except Gwagwalada where yam is predominantly cultivated with little cultivation of sweet potatoes. The commonly cultivated root and tuber crops are yam, cassava, and sweet potatoes.

Table 6: Percentage distribution of crops grown in each L.G.A. of F.C.T

L.G.A.	Cassava	Yam	Yam & cassava	Yam & Sweet Potato	Sweet Potato & cassava	Yam, Cassava & Sweet Potato
Gwagwalada	6.20	95.2	-	4.76	-	-
Bwari	-	19.0	28.57	38.10	-	14.29
Abaji	9.52	28.5	19.05	33.33	9.52	-
Kwali	5.00	45.0	30.00	15.00	-	5.00
Average	3.63	46.9	19.41	22.80	2.38	4.82

Table 6 shows that averagely, yam is predominantly grown in all the local government areas of Federal Capital Territory, Gwagwalada local government takes the lead while Bwari shows an interest on the planting of cassava despite the activities of the extension workers from Federal Capital Development Authority towards orientation and initialization of cassava planting for export.

The cultivation of sweet potato is carried out along with other tuber crops as could be seen from the table. Most farmers cultivate yam and cassava for sales because these crops have longer shelf lives than sweet potatoes.

Table 7: Percentage distribution of crops in each LG.A. of Nassarawa state

LG.A.	Cassava	Yam	Yam & cassava	Yam & Sweet Potato	Sweet Potato & cassava	Yam, Cassava & Sweet Potato
Agidi	23.53	29.43	17.65	-	23.53	5.76
Akwanga	22.22	44.44	11.11	-	13.01	9.22
Awe	19.04	28.57	14.29	23.81	14.29	-
Keffi	14.28	28.57	7.14	21.43	7.14	21.44
Kokona	21.05	5.26	10.53	15.78	21.05	26.33
Doma	23.25	18.75	30.00	10.50	-	17.50
Lafia	7.69	15.38	7.69	23.10	30.76	15.38
Wamba	25.00	-	18.75	12.55	31.20	12.50
Average	19.50	24.34	14.64	13.39	17.62	13.52

From table 7 above, cultivation of yam takes the lead while it is closely followed by the cultivation of cassava. In Nassarawa State, most farmers cultivate all these crops. Agricultural statistics shows that the production capacity of Nassarawa state is greater than that of Federal Capital Territory.

4.1 ROOT AND TUBER STORAGE STRUCTURES IN EACH L.G.A. OF F.C.T AND NASSARAWA STATES.

In most of the areas visited in Federal Capital Territory, pit storage is the leading storage structure with Bwari having the highest percentage in pit storage and Kwali having the least numbers of pit storage. The base and sides of these structures are lined with grass, straw and leaves before the tubers are put into them. Mudhut is the least adopted method in most of the areas visited in the Federal Capital Territory.

Table 8: Percentage distribution of storage structures in F.C.T.

L.G.A.	Pit Storage	Barn	Warehouse	Midhut
Gwagwalada	23.80	23.80	9.52	32.86
Bwari	40.00	20.00	20.00	30.00
Abaji	38.88	20.36	27.77	12.96
Kwali	12.50	27.50	47.50	12.50
Average	28.79	22.92	26.19	22.08

Warehouse is second largest predominant storage structure in use, Kwali local government having the highest percentage followed by Abaji L.G.A. then Bwari. Mudhut storage is another popular storage method in the areas visited with Gwagwalada LGA taking the lead and closely followed by Bwari LGA, while Kwali LGA had the least percentage of mudhut storage. Barn storage had the highest usage in Kwali LGA follows closely by Gwagwalada LGA while Bwari LGA have the least percentage of Barn users.

Contrary to the observation in Federal Capital Territory, mudhut is widely used among farmers in Nassarawa state. Most of the structures were constructed either in the farm or near homes Agidi LGA has the highest number and it is followed by Kokona and Keffi respectively. Following mudhut method of storage is the barn storage with Doma LGA leading the chart followed by Awe and Keffi LGA respectively. The barn is preferred by many farmers in these areas because of the tuber 's prevention from heat compared with other methods of storage even though the mudhut had larger capacity than the barn structure .The yam barns are mostly find in the farm or at times in farmers compound which is most cases are not too close to their farms, aside from using it to store harvest tubers, they are also used to store yamsett.To prevent entry of rodents, the sides of the barn are protected with a barrier of about one step high (one meter) which rodent can not climb. The floor is also cemented for easy cleaning

Table 9: Percentage distribution of storage structure in Nassarawa state

L.G.A.	Pit Storage	Warehouse	Midhut	Barn
Agidi	16.66	-	55.55	28.56
Akwanga	19.04	23.81	28.56	27.77
Awe	12.90	29.03	22'58	35.48
Keffi	8.77	22.28	37.69	31.21
Kokona	15.90	20.45	38.63	24.99
Doma	15.63	9.38	28.13	46.88
Lafia	23.52	15.62	23.95	28.12
Wamba	32.28	41.76	17.64	17.05
Average	18.09	20.29	31.59	30.00

Pit storage is a popular method of storage during the harvest period. It is used to store yam shortly, it is transported to market or to the industries where is used or various purposes. In Nassarawa state, Wamba, LGA lead the chart of those LGA where pit method of storage is widely used. It is followed by Lafia LGA area which Keffi LGA has the number of pit storage structures.

Wachouse storage is very popular in the market places due to its ability to store substantial amount of tubers though some farmers construct this structure near their farms. Wamba LGA leads the chart of warehouse storage, while Awe LGA and Akwanga LGA follow it respectively. Doma LGA has the least number of warehouses in all the local government areas visited.

4.2 PERCENTAGE DISTRIBUTION OF PROCESSED PRODUCT

Most tuber crops are either processed into chips or flour. In many areas visited, sun drying is used and it takes 3-10 days depending on the weather. When the moisture content is reduces to 12-13 percent, the chips have good storage qualities but if stored too long , they are subjected to insect attack, atmospheric moisture absorption leading to mold, and souring. Cassava or yam flour is produced by grinding the chips products.

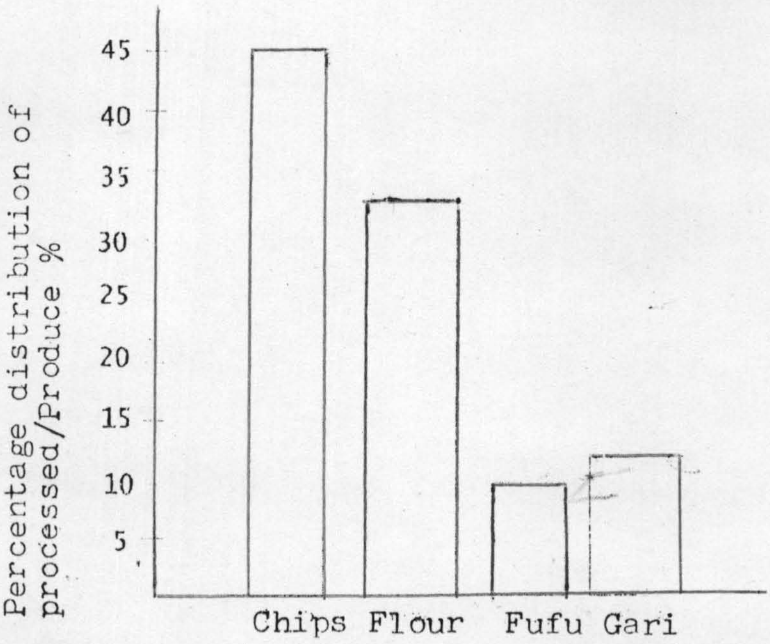

Fig. 2: Root and tubers processed products in F.C.T.

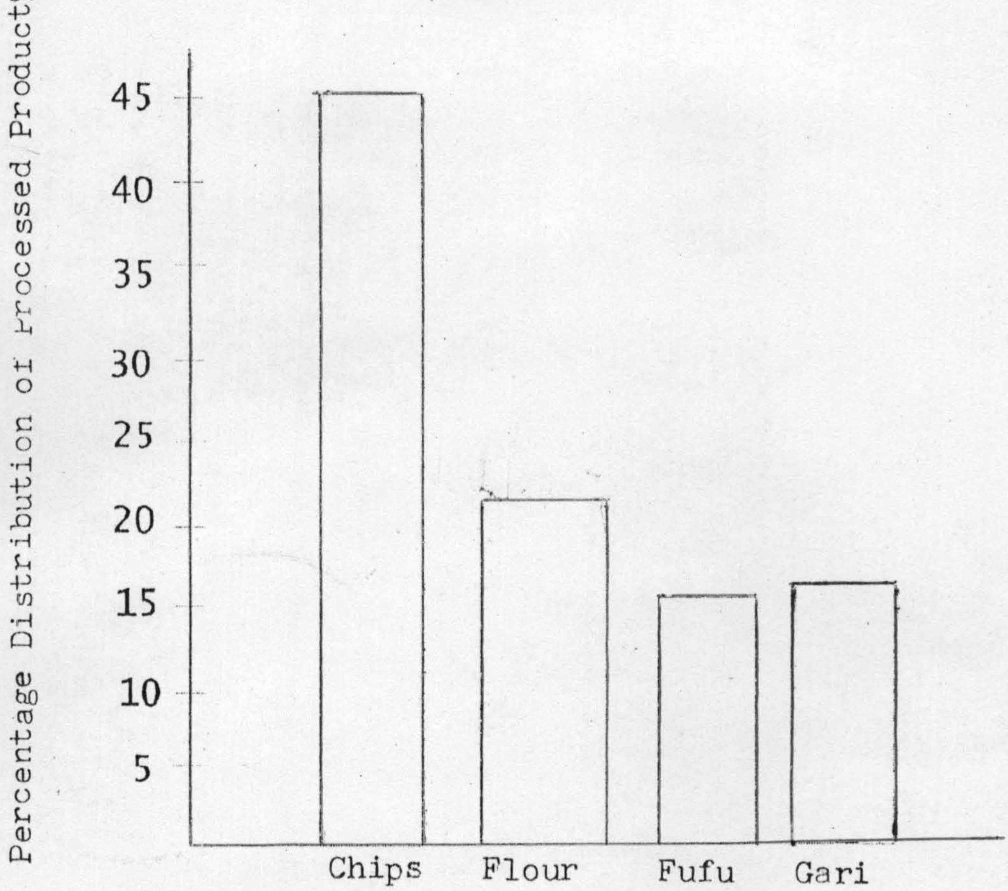

Fig. 3: Percentage distribution of processed product in Nassarawa State.

In figure 5 and figure 6, it could be seen clearly that the production of chips takes the lead in both F.C.T. and Nassarawa States. This might be attributed to the availability of cheap sun energy readily available for drying of the chips. When properly prepared chips are crisp and white and break easily without crumbling. They have a comparatively low density which means they required relatively large storage facilities. As could be seen from tables 5 and 6, flour product is th next method processing tuber produce after chips production in both F.C.T. and Nassarawa States. Further investigation in both States revealed that the production of Garri is slightly greater than fufu production in both States.

In most areas visited sacks ,pots and drums were widely used for the storage of processed produce .Akwanga LGA lead the chart of sack storage with 57.89% while Bwari LGA lead the chart of pot storage with 28.13% while Agidi LGA lead the chart of drum storage of processed produce. Averagely, sacks, pots and drums having 44.31%, 19.93% and 16.15% respectively in their use in Nassarawa state. The leading may be attributed to the fact that more farmer in the Federal Capital Territory cultivate majorly for sale while majority of farmers in Nassarawa state store and process more produce

4.3 Distribution of Storage facilities for storing processed produce in each State

In both F.C.T. and Nassarawa States, the storage of processed root and tuber product in sacks is well practiced. The types of sacks are popularly used and thee are the sisal, the jute and the plastic bags. The produce in these bags is stacked mostly on raised planks in stores, barns, houses or even warehouse. In Bwari LGA and Akwanga LGA central markets trucks loaded with hundreds of bag of Gari were seen been off loaded into stores. The uses of pot s closely follow the sack storage in both States with 20.34% and 20.70% in F.C.T. and Nassarawa States respectively. The main difference noticed in the storage of processed product was that Rhumbus were used to store processed produce in F.C.T while it is not used in Nassarawa state. Drums are make relatively airtight by tightening a clamp to hold the lit to the drum, fumigants are usually required to reduce the incidence of infestation. 15.19% of drum storage is being used in F.C.T. while 16.27% is being used in Nassarawa State. Pots and drums were mainly used among the small scale farmers in both States while the large scale farmers make use of sacks and polythene bags for the storage of their processed produce.

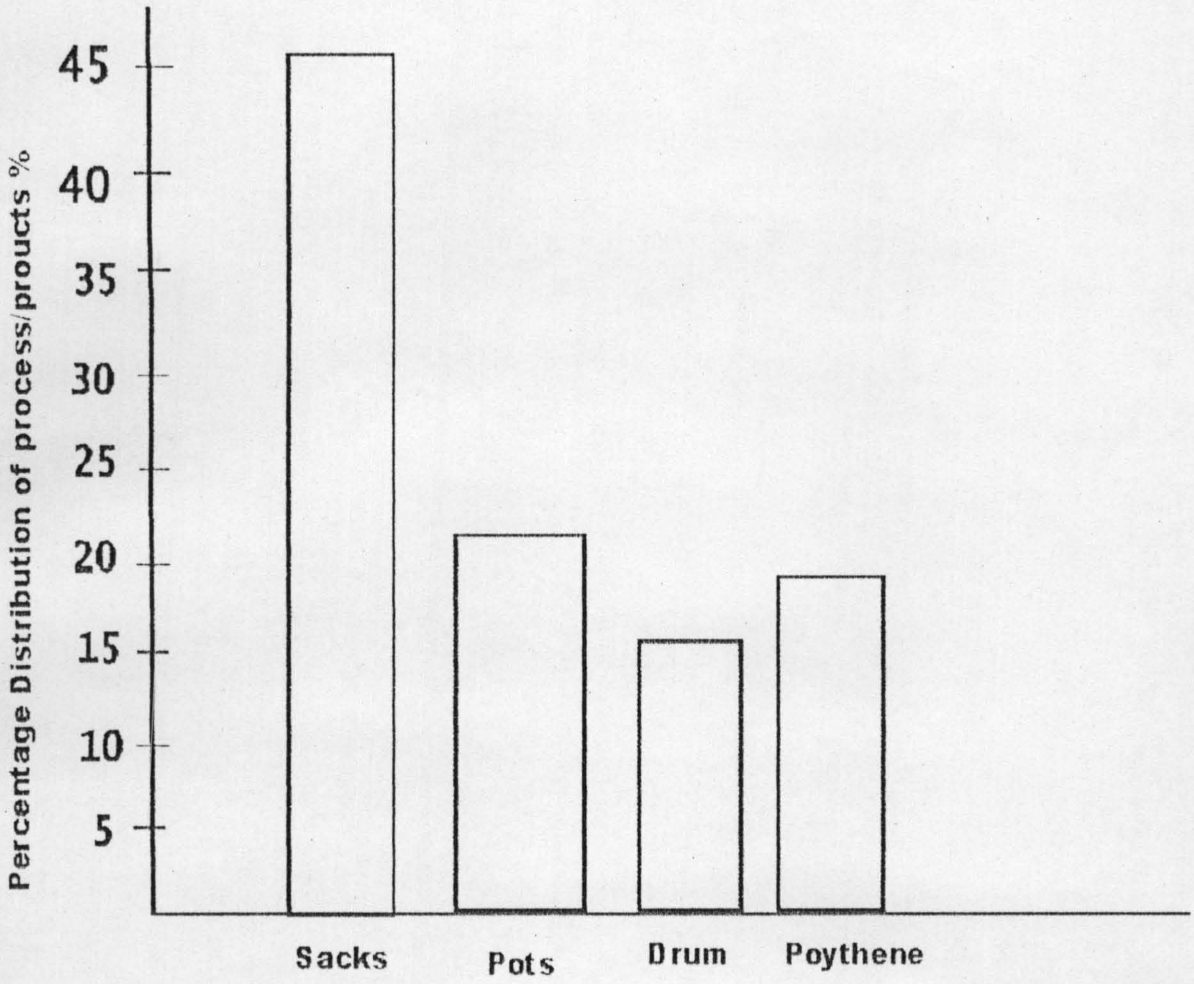

Fig. 4: Various types of Storage for processed root and tuber produce in Nassarawa State

Storage of processed tuber crops is more pronounced in Nassarawa State than F.C.T. In the use of sacks, Akwanga LGA leads with 57.89% and Kokona LGA and Lafia LGA closely follow it with 54.54% and 50% respectively. In the use of pots, Lafia LGA takes the lead with 27.77% while Wamba LGA and Keffi LGA follows with 22.72% and 21.43% respectively while the Agidi LGA have the least percentage of pot users. Agidi LGA had the highest number of drum users of 21.73% while Akwanga had the lowest of 10.52%. The use of polythene bags which is more popular among the large scale farmer is being lead by Wamba LGA and Lafia LGA had the lowest percentage of polythene users.

Table 10: Percentage Distribution of Storage facilities for Processed Produce in Nassarawa State.

L.G.A.	Sacks	Pots	Drum	Polythene
Akwanga	57.89	21.05	10.52	10.52
Awe	36.66	16.66	20.00	26.86
Wamba	27.27	22.72	13.63	36.36
Agidi	43.47	13.04	21.73	21.73
Keffi	42.85	21.43	21.43	14.28
Konona	54.54	18.18	13.64	13.64
Doma	41.86	18.61	11.62	27.90
Lafia	50.00	27.77	16.66	5.55
Average	44.31	19.93	16.15	19.60

Storage losses of stored processed produce present entirely different problems from storage of fresh tubers. Insects attack is a serious threat: several stored products insects infest yams flour of which Aracerus Fasciculatus and sitophilus Zeamays motsare by farthe most common. Pieces of dried yams arriving at mills are often riddle with holes caused by the first species and storeswhere yam flour is kept in normal sacks are usually heavily infested with oneor both types.

In F.C.T., most farmers in this LGA cultivate root and tuber crops mainly for sales so they don't process their produce, they only store raw produce up to the point they will be transported to the market. A group of farmers interviewed in Gbako village in Gwagwalada LGA pointed out that they have distributors who always patronage them every harvesting period.

Table 11: Percentage Distribution of storage facilities for processed produce in F.C.T.

L.G.A.	Sacks	Pots	Drums	Rhumbus	Polythene
Gwagwalada	-	-	-	-	-
Bwari	34.38	28.13	18.75	12.50	6.25
Abaji	36.36	18.18	12.12	18.18	15.15
Kwali	35.29	14.71	14.71	20.59	14.71
Average	35.34	20.34	15.19	17.09	12.04

From the look of table 11, Abaji LGA leads in the use of sacks with 36.36% while it is closely followed by Kwali LGA which had 35.29% while Bwari LGA had the least number of 34.38%.

In the use of pot, Bwari LGA leads with 28.13% while Abaji and Kwali LGA had 18.18% and 14.71% respectively. The number of drum users is reduced compared to the number of sacks, Rhumbus and pots users, with Bwari taking the lead with 18.75% followed by Kwali and Abaji with 14.71% and 12.12% respectively. Rhombus which is not commonly used for storing processed produce in Nassarawa State is used for storing processed produce in F.C.T. Kwali LGA had the highest percentage of Rhumbus users

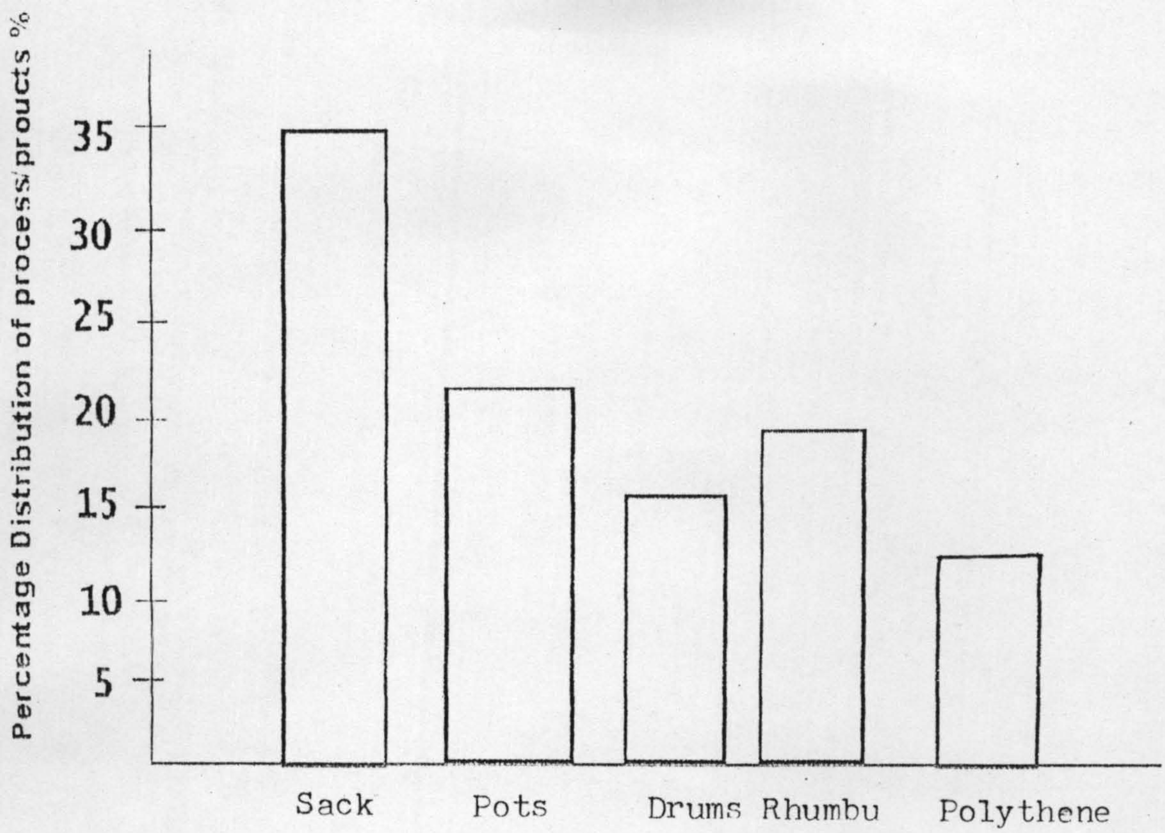

Fig. 5: Various methods of Storage for processed product Storage in F.C.T.

while it is followed by Abaji LGA and Bwari LGA with 18.18% and 12.50% respectively. Last but not the least, use of polythene bag which is common among the large scale farmers is being lead by Abaji LGA with 15.15% while it is closely followed by Kwali LGA with 14.71% while Bwari had the least users of 6.25%.

while it is followed by Abaji LGA and Bwari LGA with 18.18% and 12.50% respectively. Last but not the least, use of polythene bag which is common among the large scale farmers is being lead by Abaji LGA with 15.15% while it is closely followed by Kwali LGA with 14.71% while Bwari had the least users of 6.25%.

4.4 VARIOUS LOSSES IN ROOT AND TUBER CROPS IN EACH LOCAL GOVERNMENT AREA

Losses, which can occur during the storage of fresh tuber crops have varying causes these, include rodents, insects, mould/rotting, thieves and mechanical damage.

Table 12: Losses through various agents in F.C.T.

L.G.A.	Rodents	Insects	Mould/Rotting	Thieves	Mechanical Damage
Gwagwalada	26.92	21.15	26.92	20.46	4.54
Bwari	15.38	15.38	32.69	30.92	5.62
Abaji	26.86	25.37	15.09	29.41	3.41
Kwali	26.47	25.00	23.53	21.76	3.24
Average	23.90	21.73	24.55	27.13	2.70

From table 12, it can be seen that rodents, insects, thieves and mould / rotting are the major agents of losses destroying stored tuber crops in Gwagwalada LGA. In Bwari LGA, mould/rotting, thieves, insects and rodents were the major agent of losses affecting tuber crops with 32.69%, 30.92%, 15.38% and 15.38% respectively. In Abaji LGA, thieves, insects and rodents majorly affect the storage of roots and tuber crops with 29.41%, 25.37%, and 26.86%, while major losses in Kwali LGA were found to be27.13%, 24.55%, and 23.93% due to thieves, mould / rotting and rodents respectively.

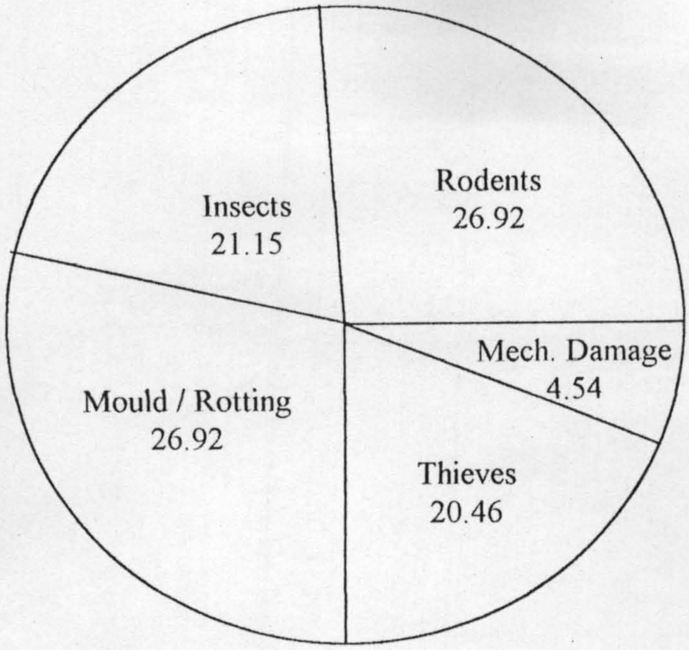

Fig. 6: Total percentage of root and tuber lost to each of the agent of losses in Gwagwalada Local Government Area.

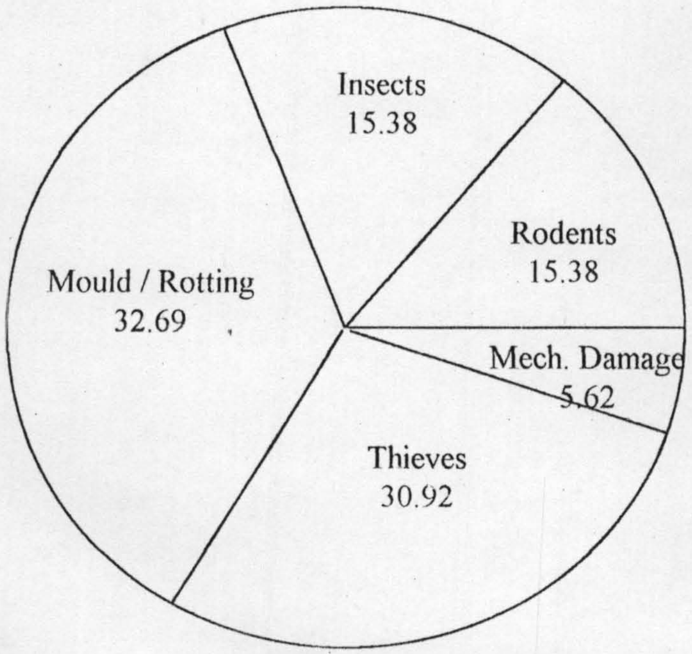

Fig. 7: Total percentage of root and tuber lost to each of the Agent of losses in Bwari Local Government Area.

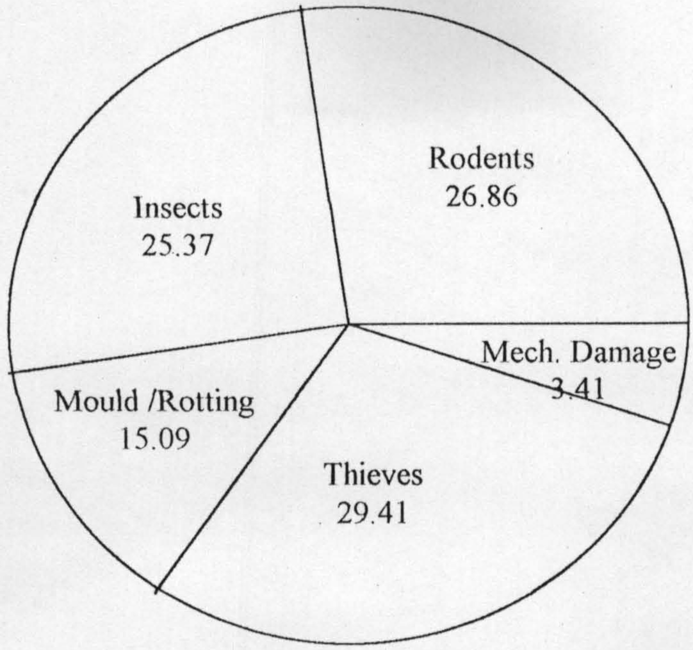

Fig. 8: Total percentage of Root and Tuber lost to each Agent of losses in Abaji Local Government Area.

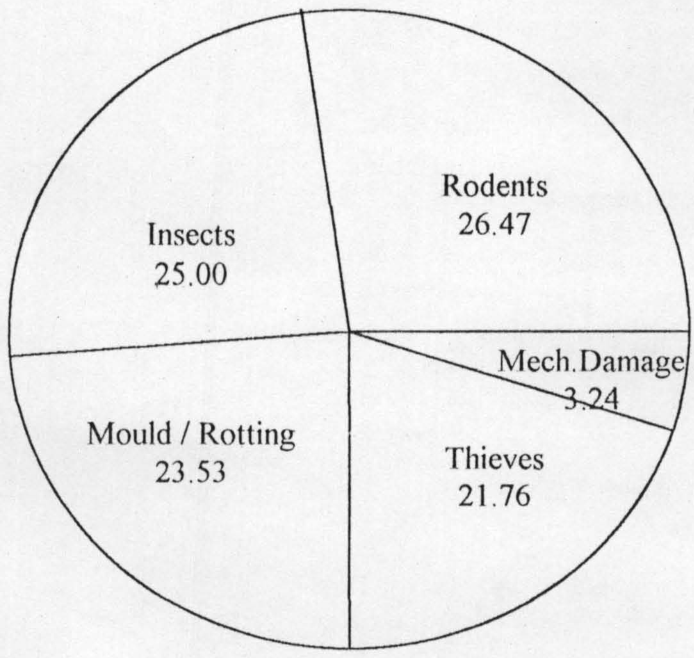

Fig.9: Total percentage of Root and Tuber lost to each Agent of losses in Kwali Local Government Area.

Table 13: Root and Tuber losses through various Agents in Nassarawa State.

L.G.A.	Rodents	Insects	Mould/Rotting	Thieves	Mechanical Damage
Akwanga	30.03	27.03	29.42	10.81	2.81
Awe	16.72	19.65	34.29	25.49	3.84
Wamba	30.00	25.75	30.14	17.86	2.07
Agidi	30.73	24.73	27.27	15.91	1.36
Keffi	26.66	25.00	29.00	15.00	2.33
Kokona	28.03	25.73	27.42	16.95	1.86
Doma	22.32	30.13	25..54	19.81	2.44
Lafia	25.08	23.08	28.08	18.85	1.92
Average	26.19	25.13	28.89	17.58	2.32

As could be seen in table 13, rodents, insects and mould/rotting constitute the major losses experienced by the farmers in each Local Government Area of Nassarawa State while thieves and mechanical damage had less effects than the former.

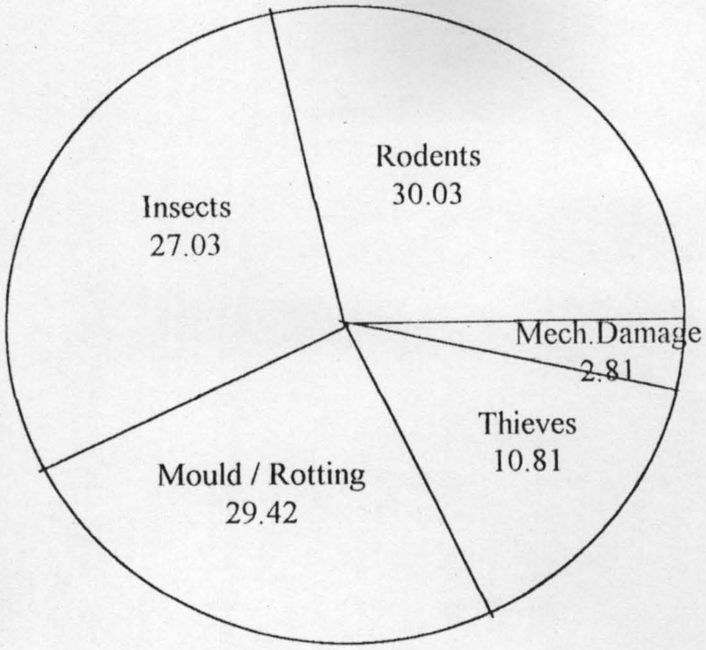

Fig. 10: Total percentage of Root and Tuber lost to each of the Agent of losses in Akwanga Local Government Area.

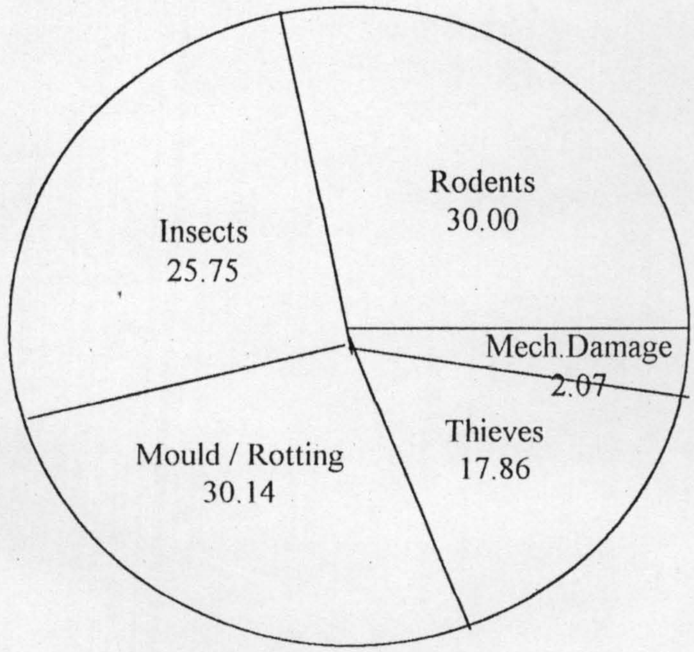

Fig. 11: Total percentage of Root and Tuber lost to each of the Agent of losses in Wamba Local Government Area.

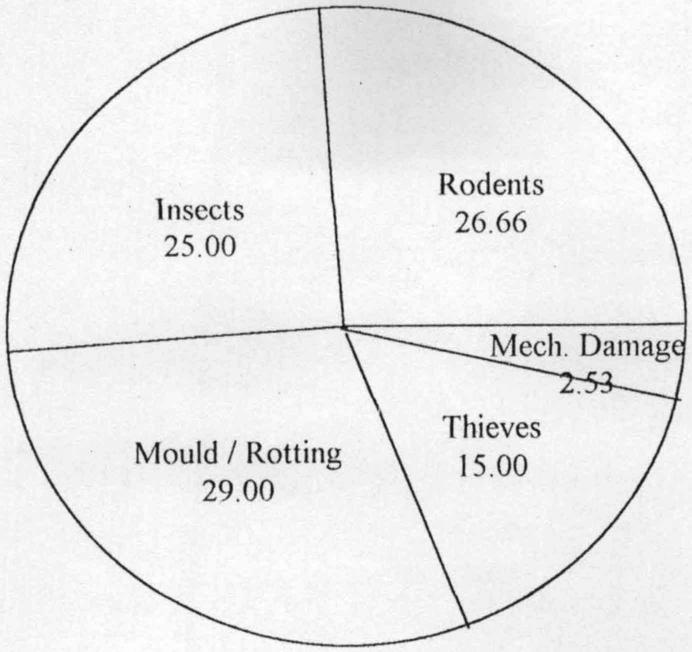

Fig. 12: Total percentage of Root and Tuber lost to each of the Agent of losses in Keffi Local Government Area.

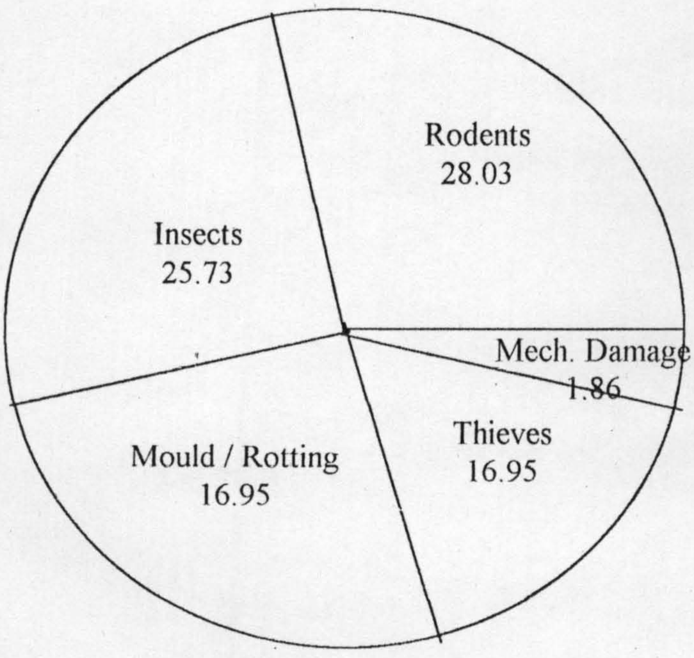

Fig. 13: Total percentage of Root and Tuber lost to each of the Agent of losses in Kokona Local Government Area.

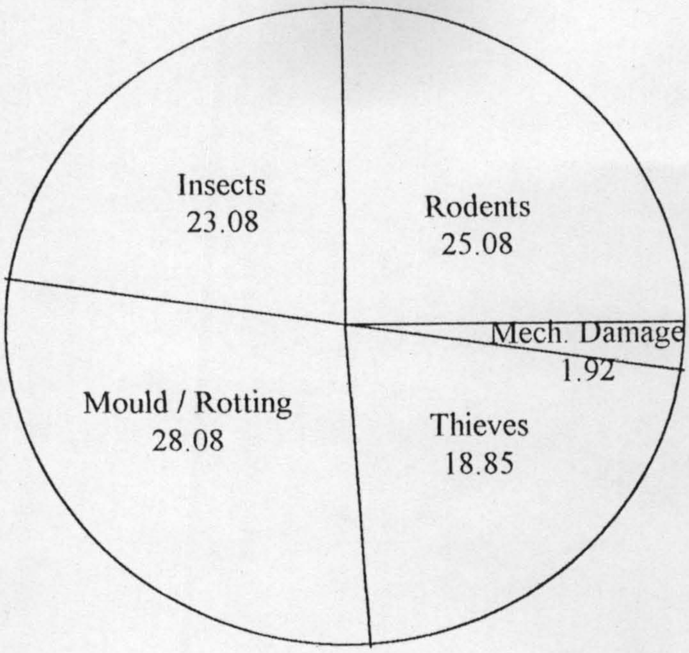

Fig. 14: Total percentage of Root and Tuber lost to each of the Agent of losses in Lafia Local Government Area.

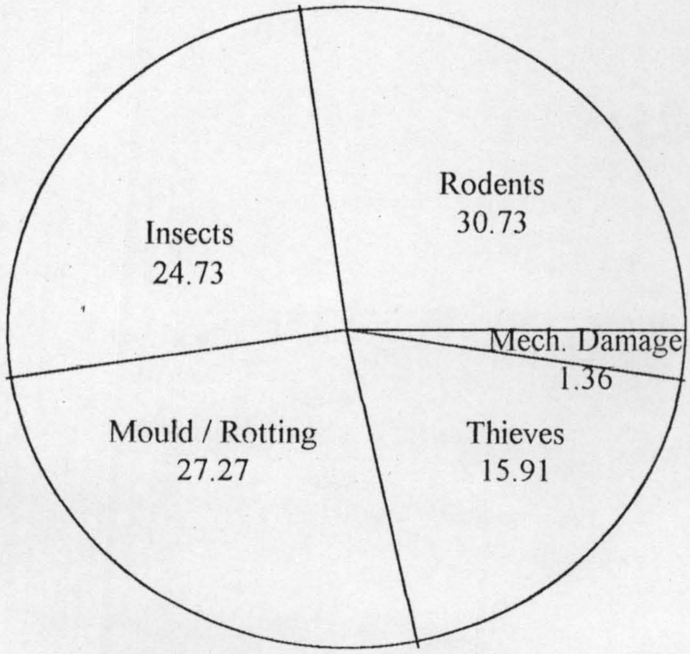

Fig. 15: Total percentage of Root and Tuber lost to each of the Agent of losses in Agidi Local Government Area.

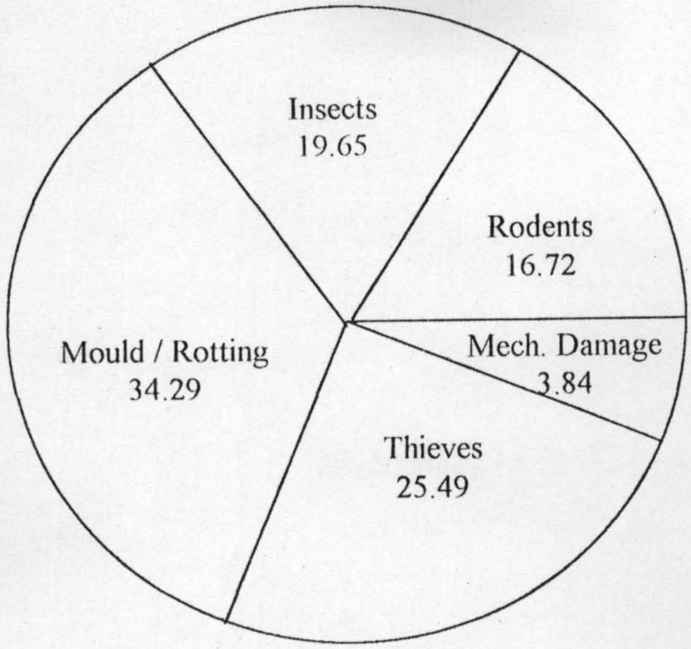

Fig 16 Total percentage of root and tuber loss to each agent of losses in Awe LGA

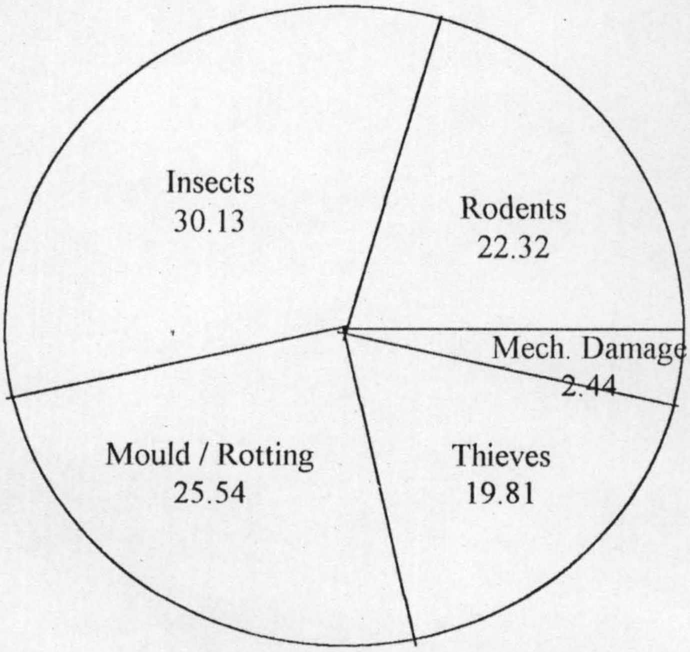

Fig 17 Total percentage of root and tuber loss to each agent of losses in Doma LGA

4.5 PRODUCTION CAPACITY

Based on the information from the questionnaire the following analysis were obtained from the respondents in those LGA visited.

Table 14 Production capacity of root and tuber crops in Nassarawa state

Crops	Average harvest per farmer in tonnes in all LGA'S							
	Akwanga	Awe	Wamba	Agidi	Keffi	KoKona	Doma	Lafia
Yams	10.92	23.31	13.2	12.63	4.64	9.826	16.35	6.01
Cassava	5.11	14.42	7.17	5.22	4.09	10.16	18.69	9.54
Sweet Potato	1.09	4.29	2.626	1.299	2.94	2.17	3.46	4.74

Table15 Production capacity of R & T . crops in F.C.T

Crops	Average harvest per farmer in tonnes in all LGA'S			
	Gwagwalada	Bwari	Abaji	Kwali
Yams	17.36	17.69	15.71	19.52
Cassava	7.095	4 170	7.626	9.071
Sweet Potato	1.071	2.27	1.50	1.11

Table 16 Production of tubercrops in F.C.T and Nassarawa State

	1996		1997		1998	
Yam	Area'000Hectares	Production Tonnes	Area '000 Hectares	Production '000 Tonnes	Area '000 Hectares	Production '000 Tonnes
Nassarawa	123.43	1505.87	73.95	1264.19	88.15	1330.55
F.C.T	31.39	323.65	36.25	33.52	38.06	350.20
Cassava						
Nassarawa	59.25	799.84	47.77	755.33	50.16	793.10
F.C.T	3.56	63.79	13.11	235.00	13.77	246.75
Cocoyam						
Nassarawa	NA	NA	4.72	25.00	4.96	26.25
F.C.T	0.06	0.78	3.64	20.00	3.82	21.00
S.potato						
Nassarawa	0.6	3.88	9.23	60.00	9.69	63.00
F.CT	NA	NA	7.74	35.00	8.13	36.75

Source: Annual Agric Statistics 1999 edition A publication of Agric Statistics and Information Management System.

Table 17 Estimated amount of tuber lost per farmer (Kg) in 2003 harvest Season.

LGA	Yam	Cassava	Sweet potato	Total
Agidi	1137.9	71.54	51.9	1261.34
Akwanga	269.79	78.8	35.7	384.29
Awe	935	261.08	165.65	1361.73
Keffi	388.91	130.54	49.9	569.35
Kokona	577.27	158.86	42.9	799.03
Doma	734.91	348.08	172	1254.99
Lafia	487.30	115.6	41.9	644.8
Wamba	361.31	116.82	31.05	509.18
Gwagwalada	387.53	87.92	96.8	572.25
Bwari	315.40	97.64	63.70	476.74
Abaji	351.63	57.50	37.4	446.53
Kwali	328.60	149.48	164.25	642.33

4.6 EFFECT OF STORAGE DURATION ON TUBER CROP PROCESSED PRODUCE

The local government areas visited gave information based on the questionnaire distributed on their effective storage duration. For instance in lafia LGA most people interviewed said they cassava processed produce for 6 – 12 months while they store cassava processed store yam processed produce for between 6 -9 months .Some in Akwanga LGA said they store gari for more than 12 months while they store sweet potato chips for less than 2 months .In wamba LGA a foodstuff trader said the length of storage of yam flour depends on the specie of yam used to prepare the flour .She added that some specie of yam had tenancy of absorbing moisture content from the surrounding than others .She also pointed out that regular disposal of stock and prevailing environmental condition also contribute to good quality storage of root and tuber processed produce .For the storage of cassava and sweet potato in kokona LGA people store for maximum of 9months both their processed produce of yam and cassva .

In all the LGA's the most effective storage duration for sweet potato as gathered from the answered questionnaire is a few weeks (about 6 weeks).In keffi LGA, 48.48% of the people store cassava product between 9 – 12 months..Abaji and Kwali LGAs has almost the same storage period of yam processed produce with the highest percentage of people storing for between 6 to 9 months followed by the percentage of people that store between 4 to 8 months

In both LGAs only very few people store for between 9 t0 12 months Both LGAs also follow the same pattern for storing effectively for between 6 to 12 months.A greater percentage of people in bwari LGA store yam processed produce between 6 to 9 months.

Summarily the storage duration depends on the conditions for preparing the processed produce the environmental condition of store where the processed produce were kept and the market forces.

4.7 GENERAL DISCUSSION

The simple random sampling technique was employed in the administration of the questionnaire .The method is used to collect information such as type of tuber cultivated, storage methods, cause of spoilage amount of tuber grown, amount processed and sources of loss .During the administration of the question,a wide sample space was adopted to ensure that the information received are without preference. Most of the farmers interviewed plant more than one tuber crops, type of crops cultivated depends on the interest of the farmers, some set of farmers in gbako village of Gwagwalada LGA do not show any interest in the cultivation of cassava that is they major in cultivating yam and some plant few sweet potato seedlings. Some of the farmers cultivate tuber crops for sales and to feed their family while few cultivate in order to process greater percentage of the harvest.

The harvested tubers are carefully selected and sorted out after harvesting for sales or storage .At times yield is quite small the farmer could sell off everything and leave just a handful for the next planting season or store them for his family consumption or process everything depending on the crop and what plans he/she had in mind as regards the crop.

In all the local government areas visited there are more cassava processed produce than yams probably because cassava could be processed into different forms more than any other tuber crops .Cassava processed produce such as flour chips starch

Tapioca and cassava processed paste were noticed in the market while few processed produce of yam were noticed .It was very difficult to identify sweet potato processed produce in the market often times one could only price the raw produce especially during the harvest season.

The harvest could be single or double .The double harvest is divided into a second harvest depending on the sort of tuber ,the first harvest takes place about 9 – 6 months after emergence of the plants .The tubers are carefully uncovered and separated from the plant without damaging it .After the harvest the bed which has been dug open is re – prepared .The plants react to this interference with increased production of tuber tissue so that a second harvest can take place after wilting point .The double harvest is a properly of the tuber .The tuber from the second harvest have pronounced planting features and are less suitable for eating .Thus the high work input in the process of double harvesting is mainly for the purpose of producing plants for vegetative propagation .The tubers from the first harvest are available early .they are highly estimated and attain corresponding high prices on the markets. The double harvest is a process with a very high input of labour .Mechanization is very difficult which means work relief through the use of technical progress is hardly possible. From my studies averagely in all the local government areas visited moulding and rotting .Rodents and insects are the major losses experienced by farm produce.

For instance in Federal Capital Territory 24.55% of the produce were loss to moulding and rotting, 23.90% were lost to rodents while 21.93% were lost to insects. In Nassarawa State 26.25% were lost to moulding and rotting 20.94% to rodents and 23.14% to insects.

Storage losses of stored of stored processed produce present entirely different problems from storage of fresh tubers .Insects attack is a serious threat :several stored products insects infest yams flour of which Aracerus Fasciculatus and sitophilus Zeamays mots are by far the most common. Pieces of dried yams arriving at mills are often riddled with holes caused by the first species and stores where yam flour is kept in normal sacks are usually heavily infested with one or both types

However insects attack can be fairly easily controlled first by milling the dried yam pieces shortly after preparation before any infestat3ion has a chance to build up and second by packing such as polythene bags or polyethylene – lined sacks .Infested materials can be fumigated by normal methods for example with methyl bromide .Rodent attack can be controlled by good storage hygiene and conventional control measures.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The species of tuber crop cultivated and storage methods varies from one local government area to the other .The type of structure to be found in a particular area or location depends on the urbanization and geographical location of the area.

Losses of roots and tuber crops start from the field because some organism such as termites and grass cutter attack tuber right from the field when they are yet to be harvested thereby causing destruction of some of the tubers while some tubers sustain injury from such attack exposing them to activates of micro – organism such as fungi which could cause rooting during storage .Therefore both technical and chemical means should be employed to fight these organisms right from the field.

The reports available during conduct of this study indicates that one can not recommend a particular type of storage method for all the local government areas covered but based on my observation modified mud hut and improved barn are recommended since they allow easy access to tubers stored in them so as to detect any spoilage .

The study is hoped at solving the problem of food shortage and bringing crop losses to the barest minimum level.

5.2 RECOMMENDATION

Problem of root and tuber losses during storage could be reduced by introduction of various scientific techniques .Farmers should ensure that they cultivate good quality and varieties of tubers processing good storage qualities. The tuber should be grown on fertile soil that is not contaminated by nematodes termites or other infestations that may harm the crop. Only healthy and undamaged tubers should be chosen for storage .Damaged tubers could be used for home consumption or processing.

Farmers should realize that good maintenance culture of various storage structure is important .This can be achieved by a thorough cleaning of store to remove all traces of previous crops stored. Pest control treatments such as fumigation must be carried out as instructed .There must be an adequate system of monitoring the condition of tubers during storage period .Every crack in the storage structure should be closed to prevent insects hiding in such places.

Intensification of efforts on engineering extension to disseminate research findings and related development on the use of various storage structures to the farmers and Agricultural establishments should be encouraged by various research institutes ,Ministries of Agriculture and Agricultural Development projects.

The pit storage method which is predominantly used is shown to have insects and rodents problem. There is need for improvement of the barn and mud hut type of storage structure since most farmers can not afford construction of a warehouse such as improvement must include using a tougher construction materials to reduce insects penetration .The sack storage condition or the use of non – poisonous insects repellant impregnated materials for the manufacture of bags.

Finally there should be establishment of processing plants in villages which would process farm produce promptly and eliminate traditional method of processing which is cumbersome .Improved techniques and quality control measures should be maintained in these industries in order for the products to be patronized,this will increase farmers income and reduce unemployment in the country.

REFERENCES

1 Ihekoronye A.I.And Ngoddy P. O (1985) Integrated Food Science And Technology For The Tropics Publishers Ltd Chapter 17.

2 Gonzales M.A And Coller De River (1972) Storage Of Fresh Yam (Dioscorea Alata) Under Controlled Conditions of Agric.

3 Olorunda And Adesuyi S.A (1973) A COMPARISON BETWEEN THE BARN AND CLAMP METHODS Of Storing Yams. Nigerian Stored Product Research Indtitute Of Technical Report No 757 – 59

4 Onwueme I c (1978). The tropical tuber crop yam cassava sweet potato and cocoyam John wesley and sons section A yams.

5 Post Harvest Food Losses In Developing Countries National Academy Of Sciences Washington DC, 1978

6 F.AO (1998) Production Year Book Vol 38 Rome

7 Passan H.C. (1997) Sprouting And Apical Dominance Of Yam Tubers Tropical Science (9) 29 – 39.

8 Coursey D.G. (1967) Yam Storage. A Review Of Storage Practices And Information On Storage Losses

9 Adesuyi S. O. Odihirin R.A. (1977) Plant Parasite Nematodes Associated With Yam Tuber In Mid – Western State Nigeria.

10 Akinnusi O.A, Oyeniran J.O.Sowumni O (1989) Effect Of Chemical Treatment Of Yam Stored In An Improved Yam Barn .Report Of The Nigerian Stored Products Research Institute ,Institute Technical Report 17:69 – 77

11 The Yam A Tropical Root And Tuber Crop .L DEGRAS

12. Ajisegiri E.S.A(1987) Soption Phenomena and storage stability of some tropical agricultural grains. P.hd thesis, Agricultural Engineering Department University of Ibadan, Ibadan, Oyo state.

13. Booth(1978), storage of tropical roots crops.

14. Adesuyi, S.A and Mackeuzie J.A (1973). The inhibition of sprouting in stored yam. Discorea rotundata, by gamma radiatin and chemicals. Radiation preservation of food.

APPENDIX

PATHOGENS

Penicillum Oxalicum

P.Cyclopiuum

F.Oxporium

F. Moniliforme

F.Solarii

S.Bradys

Botryyodilodia Theobromac

A Sergillas Nigricans

Selerotuim Rolfsii

Mouscor Cricinelloides

Armillricell Melleea

Trichoderma – Viridae

Erwinia Cattovora

WEEDS

Aclipha Ciliate

Chromolaeria Odoranta

Euphobia Heterophilla

Ipomea Triloba

Commelia Erecta

Glomera Cingulata

Lasodiplodis Sp

Rhizopus Nodosusnainslowwski

Spharerostilbe Repent It Br

Rosellina Bunosdes

Hendersonuka Toruloidea

Macrophomina Phaseoli

Colletotichium Gloesporioides

INSECTS

Yam Beetle (Heteroligus Spp)

Mealy Bugs(Aspidiella Hartic)

Yam Mealy Bug (Planococcas Doscorea)

Pyralid Moth (Euzopheras Vapidella)

Moth (Timedae Spp)

Termites

MAMMALS

Giant Rat (Cricatomys)

Common Rat (Rattus)

Monkeys

Warthog

Yonts

Sheep

PEST CONTROL CHEMICALS

Aldrin

Gammali N

Fernasan D

Benlate

Captan

Thiabendazole

Tecto

Diazinzinnon

Carbofuran

Actollic Dust

Anthracnose

QUESTIONNAIRE ON A SURVEY OF THE STORAGE AND PROCESSING OF ROOT AND TUBER CROPS

A. BACKGROUNG INFORMATION

1. NAME: --
2. L.G.A/VILLAGE: --
3. EDUCATIONAL QUALIFICATION:

PRIMARY ☐ SECONDARY ☐ ABOVE SECONDARY ☐ NONE ☐

4. MAJOR OCCUPATION

FARMING ☐ FISHING ☐ HUNTING ☐ HANDCRAFT ☐ TRADING ☐

B. PLANTING AND HARVESTING

5. TYPE OF TUBER CULTIVATED BY YOU

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

6. HOW MANY FARMERS IN YOUR VILLAGE GROWS ANY TUBER CROPS?
7. WHAT AMOUNT OF TUBER/TUBERS IS GROWN BY YOU

NUMBER OF HEAP ☐ NUMBER OF STEM ☐ NUMBER OF SEEDLING ☐

8. WHAT TIME DO YOU START PLANTING

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

9. WHAT TME DO YOU HARVEST

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

10. WHAT AMOUNT IS HARVESTED

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

11. DO YOU NORMALLY HARVEST ALL THE CROPS AT ONCE YES/NO

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

12. IF NO, HOW LONG DO YOU NORMALLY LEAVE THEM UNDER THE GROUND

YAM---------------- CASSAVA--------- COCOYAM---------- POTATO--------

C. STORAGE

13. AMOUNT OF TUBERS STORED

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

14. STORAGE DURATION

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

15. STORAGE METHODS

YAM------------ CASSAVA--------------- COCOYAM------------ SWEET POTATO -------------

WHAT AMOUNT OF YOUR PRODUCE IS CONSUMED IMMEDIATELY

YAM-------------- CASSAVA------------------ COCOYAM-----------------SWEET POTATO---------------

16. WHAT AMOUNT IS PROCESSED

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

17. WHAT ARE THE MAJOR CAUSES OF SPOILAGE ON STORED TUBERS

AMOUNT SPOILT DUE TO ROTTENING---------------------EATEN BY ANIMALS---------------------------

18. IN WHAT WAY DO YOU STORE YOUR TUBERS

PROCESSED ☐ UNPROCESSED ☐

19.DO YOU APPLY CHEMICAL TO YOUR STORED TUBERS YES NO

20. IF YES WHICH TYPE?---

21. WHAT METHOD OF PRESERAVTION IS EMPLOYED FOR YOUR STORED PRODUCE----
----

22. WHAT ARE THE NAMES OF MAJOR INSECTS/ANIMALS, WHICH INVADE YOUR TUBER CROPS DURING STORAGE?

WEEVILS ☐ TERMITES ☐ RODENTS ☐ BEETLES ☐

23. WHICH OF THE FOLLOWING MATERIALS DO YOU USE IN CONSTRUCTION OF YOUR STORAGE STRUCTURE

MUD ☐ WOOD STEEL ☐ SAND ☐ CONCRETE☐ OTHERS SPECIFY ☐

24. HOW OFTEN DO YOU CONSRUCT YOUR STORAGE STRUCTURE

DO YOU MAINTAIN THE EXISTING STORAGE STRUCTURE YES OR NO

D. PROCESSING

25. WHAT PERCENTAGE OF YOUR PRODUCE IS PROCESSED

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

26. INTO WHAT PRODUCT? CHIPS ☐ FLOUR ☐ OTHERS SPECIFY ☐

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

27. WHICH METHOD DOYOU USE FOR STORAGE OF YOUR PROCESSED PRODUCT. YAM ☐ CASSAVA ☐ COCOYAM ☐

SWEET POTATO ☐

28. HOW IS THE FINISHED PRODUCT STORED

YAM ☐ CASSAVA ☐ COCOYAM ☐ SWEET POTATO ☐

29. WHICH METHOD OF PROCESSING DO YOU NORMALLY ADOPT

	MACHINE	MANUAL
YAM	☐	☐
CASSAVA	☐	☐
COCOYAM	☐	☐
SWEET POTATO	☐	☐

30. HOW DO YOU STORE THE PRODUCE

	RAW	PROCESSED
YAM	☐	☐
SWEET POTATO	☐	☐
CASSAVA	☐	☐
COCOYAM	☐	☐

31. WHAT IS THE TUBER CROPS PROCESSED INTO

	FLOUR	CHIPS		FLOUR	CHIPS
YAM	☐	☐	COCOYAM	☐	☐
CASSAVA	☐	☐	SWEET POTATO	☐	☐

32. HOW DO YOU NORMALLY STORE THE PROCESSED PRODUCE

YAM	SACS	POTS	DRUMS	RHUMBUS
FLOUR				
CHIPS				

COCOYAM	SACS	POTS	DRUM	RHUMBUS
FLOUR				
CHIPS				

CASSAVA	SACS	POTS	DRUMS	RHUMBUS
GARRI				
FLOUR				
CHIPS				

SWEET POTATO	SACS	POTS	DRUM	RHUMBUS
CHIPS				
FLOUR				

33. HOW LONG DOES IT TAKE BEFORE NOTICE OF DAMAGE IN THE PROCESSED PRODUCE? DAYS, WEEKS, MONTHS, OTHER SPECIFY

YAM------- CASSAVA-------------COCOYAM-------------SWEET POTATO-------------

34.WHAT ARE THE MAJOR CAUSES OF SPOILAGE DURING STORAGE OF PROCESSED PRODUCT?

MOULDING☐ CHANGE IN COLOUR ☐CHANGE IN TASTE☐ ANY OTHER☐

ESTIMATED NUMBER OF TUBERS DAMAGED IN YEAR----------------------TO--------------- ----------------

YEAR	L.G.A	NAME OF TUBER GROWN	AMOUNT OF TUBER STORED	LOSS DUE TO RODENTS	LOSS DUE TO INSECTS	LOSS DUE TO MOULD	LOSS DUE TO ROTTING	LOSS DUE TO THIEVES	LOSS DUE TO MECHANICAL DAMAGE	LOSS DUE TO FIRE

INFORMATION ON THE TUBER STORAGE STRUCTURE

NAME OF STRUCTURE	NAME OF TUBER STORED	LIFE OF SPAN STRUCTURE (YEAR)	NUMBER OF STRUCTURES	EFFECT OF RAIN FALL HIGH/LOW/MED	EFFECT OF NAMED PEST ON STRUCTURE HIGH/LOW/MED	CAPACITY OF STRUCTURE	DURATION OF TUBERS STORED MONTHS / YEAR	MATERIALS USED FOR CONSTRUCTION	NUMBER OF STRUCTURE IN VILLAGE	COST OF CONSTRUCTIO N OF ONE UNIT
PIT STORAGE										
HANGING										
BARNS										
WAREHOUSE										
OTHERS (SPECIFY)										

EVALUATION OF TUBER STORAGE AND PROCESSING IN FEDERAL CAPITAL TERRITORY AND NASSARAWA STATE

BY

ABIADE OLANREWAJU ADEKUNLE

97/5888EA

PROJECT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE IN AGRICULTURAL ENGINEERING

NOVEMBER, 2004