EVALUATION OF YAM STORAGE METHODS AND STRUCTURES IN THE EASTERN PART OF NIGERIA

BY

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DEDICATION

This project is dedicated to God Almighty who is the author and finisher of my life; for his protection, guidance and blessings throughout my course of study.

CERTIFICATION

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ABSTRACT

Eastern part of Nigeria is known for the production of yam tuber. However there is dearth of data on the quantity produced and on the storage methods and storage structures used.

Three eastern states of Nigeria namely Rivers, Enugu and Anambra and three L.G.As in these states where chosen as a case study.

A survey therefore was conducted to evaluate the yam storage methods and structures in the three selected yam producing states in the eastern part of Nigeria. The result shows that the type of yam grown are white yam, water yam and yellow yam their production rate is Rivers has the highest production rate, followed by Enugu state and then Anambra state. Their total production per annum are River state produce 12.042×10^6 tonnes Enugu state produce 7.125×10^6 tonnes and Anambra state 6.47×10^6 tonnes. Percentage losses per annum is for Rivers, State 31.35% Enugu State 34.2% and Anambra state 29.5% losses.

It was also observed that the most widely used yam storage structure in the states is the yam barn, which are made essentially of bamboo, sticks, palm fronds and other materials. Other storage method used in the states is heap storage. The causes of losses encountered are due to rot and theft which gave the highest loss followed by rodents and sprouts.

The survey shows that farmers in the region harvest yams from August to December, and store it for an average of five to six months.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 IMPORTANCE OF YAM

Food yams have a major importance in the diet and economic welfare of millions of people in tropical Africa, Latin America and Caribbean Island. The annual global out put of yams in West Africa, where Nigeria is the major producer, accounts for more than 7 percent of the annual world production.

Yam is a nutritious, high fibre food, which is also important in household food security. It is prized for its excellent eating qualities and has potential as an export crop to Europe and North America.

Yam is also an indispensable part of the bride price among the Yoruba and Igbo in Southern Eastern Nigeria. (Orkwor, 1992). Compared to other tropical food crops, researches on yam have been limited. In spite of this neglect, yam production has increased steadily seven percent per annum (Orkwor and Asiedu,1992b).

This project aimed at evaluating the yam storage, methods and structure in Eastern part of Nigeria.

The three Eastern State that were put into consideration are Anambra, Enugu and Rivers States studies conducted in Eastern Nigeria showed that yams consist an average of 30% of farmers' (Lagemann,1977). Gross income derived from arable crops (Ugwu, cited by Green and Florini,1996). Not only is yam an important staple food, yam is considered a man's crops and has ritual and socio cultural significance it is the food of choice at many ceremonies and festivals, and an indispensable part of bride price (Hahn et al.,1987).

New yam festivals are celebrated annually, during the month of August and September, in Eastern Nigeria (Coursey and Coursey, 1971).

The major food component in yam is carbohydrate, which constitutes the main dry matter part of the tuber in Cross River and Akwa Ibom State of Southern Eastern Nigeria, however D.Alata is an important food, where it is eaten in boiled roasted form or in a special mashed preparation.

In eastern part of Nigeria, yam are processed into various food forms, which include pounded yam (from D. rotundata, and sometimes D. Cyenesis), boiled yam roasted or grilled yam, fried yam slices and yam balls mashed yam chips and flakes. Fresh yam tubers are also peeled, chipped, dried and milled into flour. This flour is cooked in boiling water and turned into a thick paste similar to fufu and eaten with soup. Among the eas' of the River Niger it is called "akwunaji"

1.2 SOCIO-CULTURAL SIGNIFICANCE: -

In eastern Nigeria, the cultivation and consumption of yam dates back several centuries. In this area yam is a totem of masculinity and the center of annual harvest celebrations..

In many riverine town of the River Niger, yam is a calendar crop around which the Igbo farming season and annual Festivals revolve. The antiquity of these festivals in Ogbaru, Aguleri; Otuocha, Anam, Enugu-out and Omo in Anambra State provides one of the reasons for researchers belief that D. rotundata probably originated in this area. Successful farmers in these areas who produce the requested number of yam tubers (running to several thousand) in one cropping season are conferred with the title "Ezeji" (king of yams) or "Ofieluji" depending on the area.

Ezeji titleholders usually do not eat cassava; they consume only pounded yam. The Ezeji chief in collaboration with the traditional ruler and the elders in with the traditional rulers and the elders in the community also set the date for the celebration of the annual New yam festival between August and October.

Until this is done, it is forbidden for the Ezeji chief and traditional rulers to eat the newly harvested yams.

1.3 OBJECTIVE OF THE STUDY

This research work is carried out to achieve the following objectives

1. Collect storage data in the area, which covers Enugu, Anambra and Rivers State.
2. Identification and evaluation of different storage methods in the area.
3. Estimation of the quantity of yam lost annually.
4. To evaluate yam losses using the method of storage and suggest ways to control it.

1.4 JUSTIFICATION

Although some reduction in crops losses after harvest have been noted in the country, a major reason for the losses still suffered has been identified as ignorance or inadequate knowledge of the suitable techniques available for storage and pest control has long over due n the country.

It is therefore important to continue to examine present storage techniques and strategies with a view to isolating problems areas suggesting possible solutions to this problem. In this lies the justification of the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 METHODS OF YAM STORAGE

2.1.1 Underground Storage: Unharvested.

The crops are simply left underground, unharvested after maturity until required for immediate consumption or sale. Under this condition. Full physiological activities are in progress and the tuber remains intact so long as the aerial part remains unwitted. This type of storage saves labour and inputs for storage. However, the practice for yams is only for a limited period. (Coursey et al, 1966).

2.1.2 STORAGE IN BARNS

This is by far the commonest method of yam storage, especially among the traditional farmers in West Africa.

A yam barn is essentially a framework of vertically arranged wooden poles, each about three meters high.

These poles are often made from the mid-rib of oil-palm leaves. They are arranged about fifty centimeter apart and are held together by more rigid horizontal wooden sticks, as well as by occasional stout vertical logs that have been dug into the ground. Logs which will root when set in the ground are preferred. Thus the basic framework of the barn can survive and be used for several years; only the more fragile vertical poles need be replaced each year. The yam tubers are tied to the vertical poles of the bam, the yam tuber being placed with its long axis horizontal.

The method of tying is such that the same piece of rope or twine is used to tie all the tubers on the same pole, starting from the bottom and working upward.

The barn is an outdoor structure and it is essential to shade the store tubers. Palm fronds are often used for this purpose, but other material may serve as well. The barn should be located in a well-ventilated area.

The Ventilation Serves Two Purposes: -

Preventing the build up of high humidity, which favours rotting and preventing the tubers from heating up owning to their own respiratory activities.

Barn are effective for yam storage during the dry season but once the rainy season starts, tubers stored in barn tend to deteriorate rapidly. The constantly moist environmental apparently enhances the rotting of the tubers, and of the framework of the barn. Also technique demands inputs for trying and high man-hours.

1.3 STORAGE IN HEAPS AND CRIBS.

Yams are often stacked in small groups under shades for storage. They are shielded form excessive sun heat but adequately ventilated. Water yams (D.Alata) can be stored under this condition for long periods up to three months.

Cribs are rural structures. They may be huts or wooden structures with thatched roofs. The floor of the cribs may be the ground covered with leaves or the floor may be raised above ground. No special storage structures are needed and it can be used as a short-term measure prior to marketing.

4 STORAGE IN DITCHES

The storage of yam in ditches is also practiced. The pit may be lined with straw before the tubers are packed in it and then covered over with soil. Shading materials then placed over the soil.

Indications are that this method of yam storage is very poor. Ventilation is inadequate, and constant inspection of the tubers is difficult. Moreover, rodents usually do extensive damage to tubers that are stored in ditches.

COLD STORAGE

Much of the hope for the future storage of yam tubers is now placed on cold storage.

Essentially, this involves storing the tubers on shelves in rooms maintained at about 15°C (Adesuyi,1973). The use of air conditioners for such rooms has been found effective, since they reduce both temperature and humidity at the same time and can provide a continuous exchange of air in the room. However, the temperature should not be reduced below 10°C, since yam stored at such low temperatures tend to become brown and unsuitable for consumption. Because of the humidity factor, it is important that the air conditioner should be left running continually. If power to it is interrupted and or is turned off, moisture may condense on the tubers and cause widespread rotting.

Young (1923), indicated that freezing temperature must be avoided in storage of yams and suggested 12 to 16°C as the optimum rang of storage temperature.

Irreversible damage to the respiratory metabolism of tubers tissue of Dioscorea rotundata caused by holding the tuber at 5°C but not at 10°C was reported by (Coursey et al,1966). Dioscorea rotundata was found to be susceptible to low temperature injury, and temperature higher 12.5°C were necessary for its safe storage and transport.

The storage of yam tubers at lowered temperature has the advantage of reducing the tubers rate of respiration, sprouting, and rotting, all of which are major sources of storage loss.

RADIATION PRESERVATION

At the experimental level, gamma, radiation has been successfully used to suppress sprouting of yams.

It is reported that at does in the range of 7 to 15 krads, sprouting was effectively inhibited. The most effective does was found to be 12.5 krads for yams.

Quality indices of yams after radiation were found acceptable (Adesuyi, 1975).

SOURCES OF STORAGE LOSSES.

General Consideration.

Since the preservation of food is simply a matter of perverting or retarding deterioration and spoilage regardless of the method used, a good knowledge of the causes of deterioration and spoilage is a pre-requisite to the study of preservation methods.

On the basis of food storability; tubers are classified as "perishables". Their botanical entities, structures and water content make them unsuitable for long-term storage as primary commodities.

It should be recognized at the outset that there are degrees of quality and that all perishable foods pass through various stages of deterioration before becoming unfit for consumption. In most cases, the objective in the preservation of food is not only to preserve the foodstuff in an edible condition but also to preserve it as nearly as possible at the peak of its quality with respect to appearance, odour, taste and vitamin content.

Except for a few processed foods, this means maintaining the foodstuff as nearly as possible in its original fresh state.

Any deterioration sufficient to cause a detectable change in the appearance, odour or taste of fresh foods immediately reduces the commercial value of the product and thereby represents an economic loss (Dossat, 1961).

For the most part, the deterioration and eventual spoilage of perishable foods are caused by a series of complex chemical changes, which take place in the foodstuff after harvesting. These chemical changes are brought about by both internal and external agents.

The former are the natural enzymes, which are inherent in all organic m iterials, whereas the latter are micro-organisms, which grow in and on the surface of the foodstuff. Although either agent alone is capable of bringing about the total destruction of a i.:od product, both agents are involved in most cases of food spoilage.

ın any event, the activity of both of these spoilage agents must be either eliminated or effectively controlled if the foodstuff is to be adequately preserved.

In spite of traditional methods except possibly processing of preservation of the roots and tubers, these commodities suffer spoilage and losses ranging 10% to 60% (Ayernor, 1981).

The yams which demonstrate a relatively appreciable storability even undergo marked weight losses with prolonged storage time. The impact of food losses, in Nigeria, a Country where roots and tubers play a very important role in the food economy, according to Idosugie and Olayide (1977), amounted to about 90 million united state Dollars, of which roots and tubers constituted a large fraction. Of the world cup (f about 20 million tons, about one million tons are lost annually by bio-deterioration in storage (Coursey, 1967).

These storage losses constitute a major economic problem in districts where yam is a staple food.

Food losses have wider implications than the cash value of the lost material. In nutritional terms, the amount of protein lost, grammes of fat lost, the total food energy lost in calories in relation to the total energy expended in producing the lost material should be considered.

It is more than apparent that there is a great need to minimize food losses as part of the total effort to increase the quantity of food supply. Some of the primary problems are the gaps in the knowledge of the estimates of degrees of food losses along the food supply "pipeline" as well as the degree of damage or less inflicted by each causative agent or factor.

Knowledge of the various cause and estimates of food losses at every stage of the food supply line does not directly prevent food losses but provides the ground on which preventive measures can be taken. The functional relationships between production storage and consumption is shown in fig 2.0.

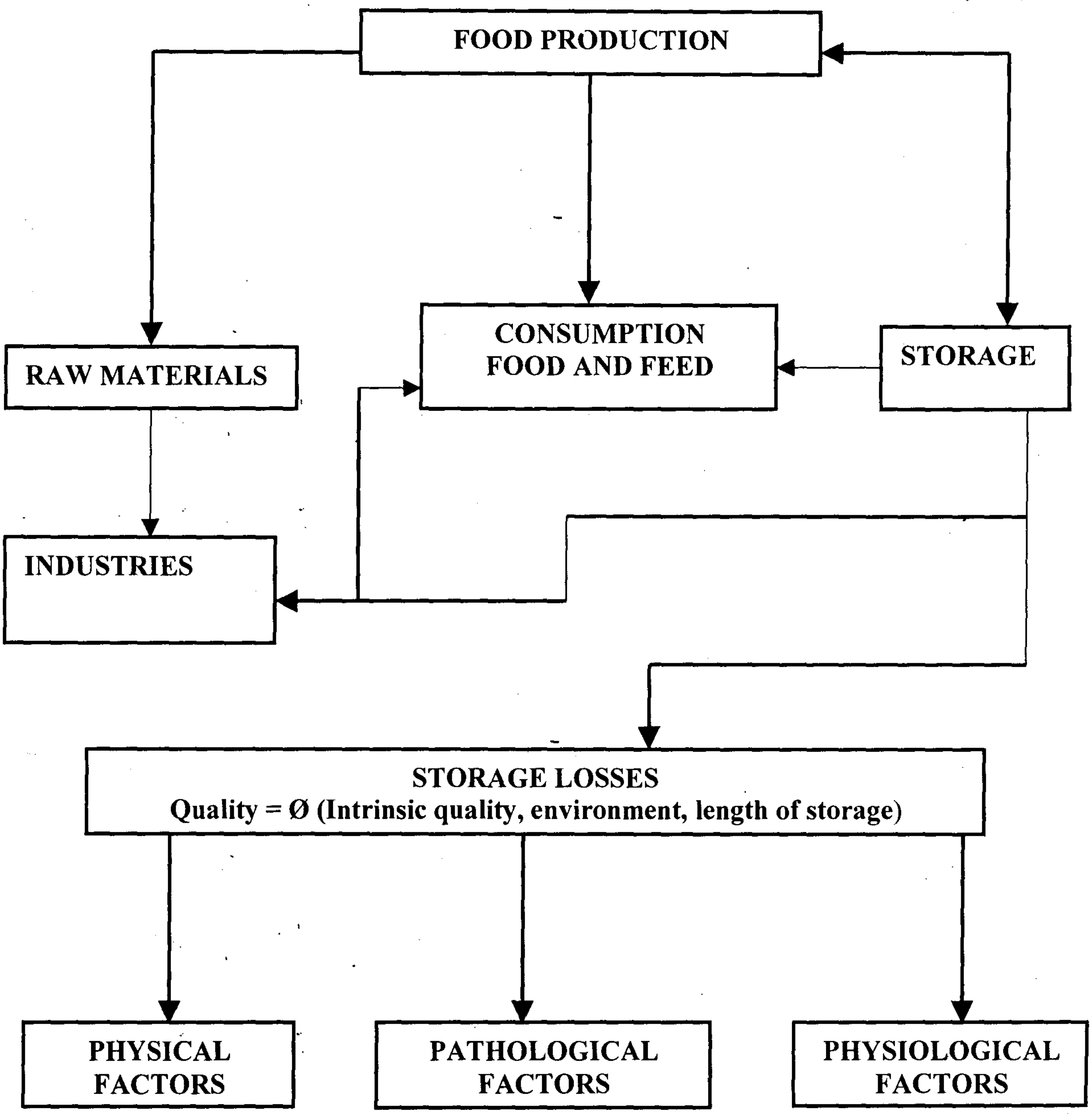

Fig2.0 FLOWCHART SHOWING FACTORS OF PRODUCTION, STORAGE AND CONSUMPTION

Source: Coursey(1967)

PHYSICAL SOURCES

!.1 Mechanical Injuries

One by-product of mechanization in production and bulk handling of agricultural products is mechanical damage (Ezeike, 1982). Damaged tubers are particularly susceptible to water loss. Badly damaged tubers may dry out during storage, but often become rotten, so that in this instance the problem of water loss does not arise.

When the skin of the yam tuber is broken, the barrier against loss of water and entry of fungi and bacteria, comprising a well-formed periderm (cork) layer beneath the suberin layer, is greatly reduced.

Mechanical damage in agricultural material arises from either eternal forces under static or dynamic conditions or internal forces. Damage arising from internal forces can result from physical changes such as thermal or moisture gradients as well as chemical and biological changes. These defects show up as skin cracks in yam tubers.

.1.1 TYPES OF MECHANICAL DAMAGE.

.1.2 Damage Under Dead Load

Due to economic considerations, it is often imperative farmers and entrepreneurs to use bulk transportation and storage systems, in handling agricultural products. Consequently, when such materials are exposed to high dead weights, they are subjected to excessive pressures resulting in external and internal injuries as distortions, cracks and internal bruises.

Because during bulk handling, dead wrights are applied over a long time, it has been found that force-deformation relationships of bulk stored agricultural products are of creep phenomenon. If the allowable maximum values of bruise volume and deformation are known for a given material, it will be possible to design containers to satisfy critical dimensions according to the procedure of Ross and Isaacs (1961) and Holt et al (1981).

!.1.3 Vibration Damage

Vibration damage often arises during the transport of agricultural products. Following repeated forces of vibration of tubers in transit, defects generally classified as "roller bruising" often arise. Damages of this nature are related to fatigue of the biological tissue in much the same way as a loaded shaft will fail after a large number of cycles of operation. For biological materials the results are cell rupture beneath the skin. The magnitude and duration of vibration will determine the severity of damage.

The natural frequency of a product is important in the design or selection of suspension system for vehicles used in carrying agricultural materials. The vibration characteristics of the transport vehicles should be such that the resonance frequency of the vehicle does not coincide with the range of product resonance frequency (Ezeike, 1982).

:.1.4 Impact Damage.

Shock the impact during mechanical handing of agricultural products often results in me hanical damage.

This can occur during loading and unloading of tubers either as piles or in wooden pallets. Each agricultural materials possesses a certain degree of resistance to impact damages.

In order to reduce the magnitudes of impact damage, certain cushioning materials can be employed. The ability of a cushioning material to reduce product celebration is measured in terms of the fragility factor, G which is given as

$$G = F/W$$

Where F is the peak force applied, and

W is the weight of the impacting body

.2.2.2 PESTS.

Loss of stored yam to pests is substantial. The major problem here is with rodents and insects. The attack of rodents is not very frequent but damage is often extensive when it occurs. Tubers stored on the ground or underground are more prone to rodent attack. Among the insects, termites and scales are the most common pests.

The main steps that can be taking against rodents are to fence the barn or storage area securely, and to kill the by means of traps and poison baits.

2.2.3 DESICCATIONS

Evaporation of water from sound yam tubers is dependent upon two main factors:

1. The permeability of the tubers surface to water this being largely dependent on maturity that is on the degree of skin setting and on whether or not sprouts development during spoilage and.
2. The ability of the air to absorb moisture, this being influenced by the temperature and humidity of the store atmosphere, and by the rate of ventilation.

It is know that the capacity of dry air to take up water vapour becomes rapidly greater the higher its temperature. Completely dry air never occurs in agricultural practices and for tubers, it is necessary to takes account of both temperature and relative humidity of air when considering its drying potential. Temperature considered alone or its percentage relative humidity alone, is of little significance. The drying potential of air is commonly expressed ass water vapour pressure deficit measured in milli bar.

Perhaps a more understandable interpretation of the situation is to use the direct term "drying potential" and to express it as grammes water evaporation per kilograms dry air.

Once the freshly harvested crops is placed into storage the air surrounding the tubers becomes rapidly charged with water vapour from the respiring tubers, and thereby loses its drying potential. Within a few hours of storage the relative humidity can rise to near the point of saturation. Highly humid conditions are very desirable in the first instance, because the greater the humidity the greater will be the rate of cell wall suberization and periderm (cork) formation and hence wound-healing or "curing".

These conditions are temporary, however, and except in a completely enclosed environment the storage atmosphere will become somewhat drier within 2 to 3 weeks of storage, owning to draughts of air from outside.

During storage, the yam tuber continues to lose water so that its fresh weight continues to decrease. Weight loss arising from dehydration in a 5 month storage period may be as much as 20% of the original weight (Coursey and Walker , 1960). Dehydration loss during storage is different from the other kind of storage loss because there is no loss of edible dry matter. All the same it is important to keep dehydration loss to a minimum because dessicated tubers may loss viability, deteriorate and become unpalatable. Also, since yams are normally sold by fresh weight, it is important for the farmer to maintain as high a fresh weight as possible. Shading during storage helps to keep dehydration loss to a minimum. Also during cold storage in enclosed rooms, the humidity should not be allowed to become too low although it should be low enough to discourage microbial rotting.

2.2.3 PATHOLOGICAL SOURCES.

By far, the greatest amount of loss of dry matter in yam storage is a result of rotting. This rotting is due mostly to the effects of fungi and bacteria. Usually the cork layer surrounding the tuber serves as an effective shield against bacterial and fungi attack; but whenever the tuber is wounded, the rot-causing organisms can readily enter the tuber through the wound. It has also been reported attack the tuber may sometimes-create wounds through which bacterial and fungi may enter the tuber.

In his study of the losses due to decay of five species of yam stored in a yam barn or stack-piled on the floor or on shelves, Adeniji (1970a) found that decay was greater in yams stacks-piled on the floor of a hut than those tied up on stacks in a barn.

Table 2.0 incidence of Decay in yam (Dioscora) species. Stored in a barn or stack pile for five months.

Species of Yam	No of Tubers Stored	Percentage Decay	Type of Storage
D. Alata	166 182	9.0 52.2	Barn Stack-piled
D. Cayanensis	200 180	6.0 42.2	Barn Stack-piled
D.Dumetorun	110 198	1.8 11.1	Barn Stack-piled
D. Esculenta	120 288	20.0 59.3	Barn Stack-piled
D. Rotundata	150 122	20.7 39.5	Barn Stack-piled

Source: Adeniji (1970a)

The most important measure in the prevention of rotting during storage is to ensure that the tubers are not wounded during harvesting and handling. In order to ensure that the protective layer is adequate after harvesting, it may be necessary to cure the tubers for a few days before they are stored.

Curing is the conditioning of tubers to heal bruise and wounds caused during harvesting and material handling. It is affected by natural development of a corky layer under the skin it can only be achieved under the right temperatures and humidity.

Hudson (1975). Indicated that the depth of bruising is correlated with cell size, intercellular space and specific gravity of roots. (Ezeike,1979b), showed that the length of curing period for whole yam (D. rotundata), tubers at 25^{0}C and Rivera (1972), have suggested curing at 29 to 30^{o}C at 90 to 95% relative humidity for 4 days. While Adesuyi (1973) has used 25 to 30^{o}C at 55 to 62% relative humidity for 5 days. Thompson et al (1973) used 38^{o}C and 95% relative humidity for 24 hours.

Each of these treatments was effective in decreasing the incidence of rotting during storage.

The curing process should however, be used with some caution since the same high-temperature and high humidity conditions used for curing also favour rapid microbial activity and rotting.

2.4 PHYSIOLOGICAL SOURCE

2.4.1 Respiration

Although yam tubers are natural storage organs, being organs both of perennation and propagation (Passam and Noon, 1977), nevertheless considerable losses occur during storage.

Apart from decay brought about by fungal or bacteria pathogens, a principal cause of loss is thought to be the high metabolic activity (especially respiration), that occurs endogenously within the tubers (Coursey, 1967).

Ambient temperatures for yam storage are often around 30°C, internal temperatures in tubers in traditional stores in Nigeria usually averaging between 27 and 37°C (Coursey and Nwankwo, 1968). At these temperatures metabolic activity, and hence respiratory losses of carbohydrate would be expected to be high (Coursey, 1967).

Passam <u>et al</u> (1978), carried out experiments in which the respiration of whole or bisected tubers was monitored using a flow–through apparatus incorporating an infrared gas analyzer. Temperature was maintained at 25 to 35°C and a constant flow rate of air (about 31/hr) was passed through the system. In internal temperature of the tubers was measured by insertion of hypodermic thermistor thermometers into the tubers, and temperature and respiration were then monitored simultaneously. For calculation of the contribution of respiration to total weight loss during storage it was assured that carbohydrate was the sole substrate of oxidation.

Measurements of Co_2 evolution were converted to standard temperature and pressure and correlated with weight loss determination

The respiratory activity of yam tubers during the long term storage at 25°C and 35°C is shown in Fig2.1 After harvest, the rate of respiratory was high (about 15 and 29ml Co_2/Kg fresh weight per hour at 25°C and 35°C respectively). As tubers became dormant, so the rate of respiration declined to a minimum (3 and 8ml Co_2/kg fresh weight per hour at 25°C and 35°C respectively), followed by an increase to above 20ml Co_2/kg fresh weight per hour on breakage of dormancy. Passam et al (1978)

Hayward and Onyearu (1962) showed that although respiratory activity during the initial post harvest period is greatest at the distal (tail) ends of the tubers, which constitute the most recently formed tissues, after the dormant period Co_2 in mainly evolved from the proximal (head) ends at which sprouting primarily develops.

During storage, tubers lost weight at rate, which varied, according to the stage of dormancy, between 0.15 and 0.22 percent per day at 35°C. These rates when compared with the losses which can be attributed to respiration, calculated from the respiratory measurement on which Fig 2.1 is based indicate that the contribution of respiration to tubers weight loss is between 7 and 35% at 25°C and between 10 and 30% at 35°C. The assumption is made that carbohydrate (the principal constituent of yam tubers) is the only substrate for respiration and that the respiratory end products, Co_2 and water, are lost to the atmosphere. Passam et al (1978)

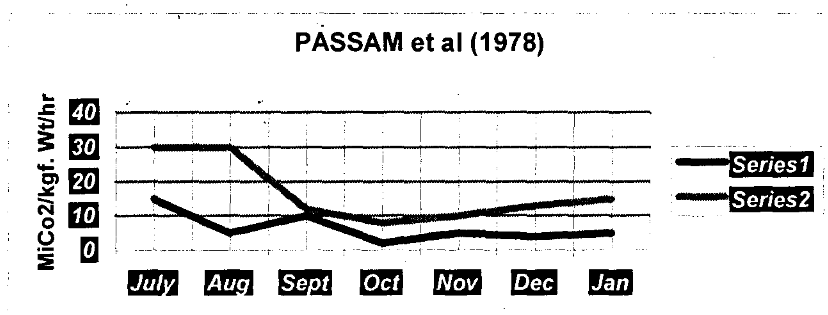

Fig 2.1 RESPIRATION OF YAM TUBER DURING STORAGE
SOURCE: PASSAM et al (1978)

This respiratory contribution varied between about 7 and 35% (at 25°C) and between 10 and %, (at 35°C) of the total with the stage of dormancy of the tubers. Losses due to respiration were greatest shortly after harvest and on breakage of dormancy. During the dormant stage the weight loss due to respiration was equal to or less than, 10% of the total. Hence, although respiration may contribute to the weight loss of the tuber and, more importantly, cause reduction in actual carbohydrate, the major source of weight loss would nevertheless appear to be loss of water. Passam et al (1978).

Only intact, undamaged tuber were used in these experiments, although it has previously been shown that abrasion of yam tubers increases water loss without a concordant increase in respiration. Generally, however, wounds in-curded during harvest and handily add to respiratory losses during storage, particularly if the wounds do not heal completely and become infected by rot causing organisms. Passam et al (1976a,b) showed that when yams are injured by cutting or bruising that rate of respiration is enhanced and, if prolonged, this may cause a significant loss of carbohydrate.

It is important; therefore, that wounds should be healed quickly because if a high rate of respiration continues over a long period, much carbohydrate will be lost considerable variability was found in the susceptibility of individual tubers to chilling injury. Some tubers becomes chilled by storing at 5°C for 8 days, become chilled by storing at 5°C, or even 1 °C for similar length of time has not produced detectable hilling even 18 days after being returned to ambient temperature.

.4.2 Sprouting

It was formerly presumed that the yam tubers was similar to the potato in possessing buds at various points on the tubers surface, and that sprouting simply involved the breaking of these buds and their subsequent elongation.

However, Onwueme (1973) reported that, at harvesting the yam tuber surface is normally devoid of buds. Later on during storage, one more buds may develop from the head-region of the tuber, or from the corn.

The process of sprouting in budless tubers-pieces has been described by Onwueme (1973). First the layer of meristematic cells just beneath tubers surface begins active cell division, and produces a large mass of undifferentiated cells. This mass of cell soon becomes organized and a shoot apex becomes differentiated within it.

At this stage the overlying tuber skin has ruptured, revealing, on the surface, the glistening mass of cells produced by theē meristematic activity. Such a point of skin rupture and exposure of the underlying cells during yam sprouting is called a sprouting locus.

Soon the growing point begins to push through the overlying mass of cells, and later it becomes visible from the surface as a small bud. The whole process from the onset of cell divisions till the bud is externally visible lasts 1 to 2 weeks.

Temperature affects sprouting of yams (Onwueme, (1975c) while sprouting occurs at 35oC and it s considerably delayed at 35oC or 15oC.

Lack of water supply does not affect the rate of bud formation on the subsequent elongation of the bud is showed by moisture stress.

Increases in weight loss occur with sprouting since sprouts are more permeable to the flow of water vapour than the unsproted portion of the tubers. Also total surface area increases due to sprouting.

The readiness with which a yam tuber will sprout depends on the physiological age of the tuber, which is to say how long ago the tuber was harvested.

When a yam tuber sprouts in storage, it mobilizes the food material stored in the tuber and uses it to produce a sprout. - The conversion of edible tuber material to inrdible sprout is considered a storage loss.

In present production practices, it is not possible to prevent or delay the production of sprouts, except perhaps by storage at reduced temperature. The most common resort is to break off the sprouts before they become long. Several chemicals and other treatment have been tried for their possible effects in preventing yam sprouting during storage. However, it will require a considerable amount of research and refinement before any of these methods becomes commercially exploitable.

The problem of providing food and feed materials in Nigeria is twofold. To maintain a certain level of agriculture output that is proportional to the number of hungry mouths that must be fed, presents problems that interrelates agriculture, economic and engineering. The other component is the ability to store what cannot be consumed immediately or what must necessarily be stored in order to maintain continuity in other related industries (Coursey 1967).

Very often farmers are forced to sell almost all the food stuffs they harvest in order to avoid very heavy losses due to deterioration of produce soon after harvest.

Thus the function of storage is an important one and serves to form a vital link in the chain of food demand and supply.

In order to design storage structures and to stipulate environments or storage conditions, fundamental studies must be carried out on the crop concerned so as to determine its post-harvest behaviour or characteristics.

Post – harvest behaviour of yams (D.S.S.P) has lither to present a major storage problem due to the losses that occur. Coursey (1967), estimated that as much as 60% loss may occur for a storage period of six months. When it is realized that this storage loss has qualitative, qualitative as well as economic dimensions, the seriousness of the problem can then be viewed in its proper perspective. The quality of yam tubers at any time during storage depends partly on its intrinsic quality (condition at harvest) and/or partly on the environmental and physiological factors to which it is exposed.

PRODUCTION AND DISTRIBUTION OF YAM

Yams are used as an important source of carbohydrate. They are stem-tuber crops indigenous to the humid tropical southern part of West Africa. Yam is also believed to be one of the oldest crops cultivated in West Africa (Oyenuga,1967). They are monocots belonging to the family within the other Dioscoreales which also includes the families stenomeridiceae, Trichopodace and stemonace (Ayensu, 1972). Yam are believed to be Angiosperms or flowering plants and are monocotyledons, belonging to the family Dioscoreales, which contains about 600 species (Coursey, 1967). Favourable condition for yam cultivation occurs in fertile, well-prepared, loamy soil and well drained. Closely packed soil do not allow the tuber to grow larger. Yams are usually planted in mounds ridge or holes in a flat surface.

There are many varieties of yam as earlier mentioned which are differentiated by varying characters such as the direction of the stem twines (Clockwise or counter Clockwise), the shape and colour of leaves, stem and tubers, the cooking quality of the tubers, their palatability and use of early or later maturity. But six out of these numerable species are quite common and cultivated under Nigeria context and these include:

Dioscorea	rotundata	(White yam)
Dioscorea	alata	(Water yam)
Dioscorea	cayenensis	(Yellow yam)
Dioscorea	dumetorium	(Trifoliate yam)
Dioscorea	esculenta	(Chinese yam)
Dioscorea	bulbifera	(Bulbli or Potato yam).

Dioscorea rotundata poir (white yam) is almost popular type in Nigeria and many subvarities within this group are widely grown in the different parts of the country.

Subvarieties are classified as to the nature of the starch suitable for use as pounder yam or to be eaten as such when boiled and also to different shape and sizes. Dioscorea rotundata is said to be originated in West Africa, and has some cultvors like Awada, Fela, and Etenta which trigenated from Nigeria (Olayide and Idusogie, 1977).

(i) Dioscorea alata lim (water yam) originated from South East Asia, probably in Burna (Onwueme,1975), and was brought to East Africa coast by the Portuguese round the cape of West Africa and from there spread in land (Coursey et al, 1966). It is quite different from both the white or yellow man both in the character and use of the tuber.

This variety normally yields more heavily than the white and yellow yam and can do better in poor soils. It contains a higher proportion of water and the tuber may be white, yellow, brown or almost red in colour.

(ii) Dioscorea cayenensis lam (yellow yam) is a native of West Africa from where it was taken to America in slavery times. It was introduced into West Indies from west Africa during the 16th centuries (Onwueme, 1975c). The tubers of these varieties have a yellow colour when peeled and this is the main difference from the white yam. In addition, yellow yam possesses short broad, heart-shaped, deep green leaves. It does not keep for as long as the white yam.

(iii) Dioscorea dumetorium pax (trifoliate yam) originated in tropical Africa, and occurs there in both wild and cultivated from (Onwueme, 1975c). Some of the tubers of the wild forms are highly poisonous and they are used in southern Africa to prepare poisons for hunting and other purposes. The cultivated form may be yellow, white or pale yellow in colour and taste quite differently from yam with a fairly high proportion of sugar. They are relatively low in protein.

(vi) Dioscorea esculenta Burkill (Chinese yam) originated in Indo-China and has been cultivated in china since at least the 2nd century (Lawton and Lawton J.R.S, 969). This variety produces a number of small tubers, which we shallow in the soil. The vine and roots are spiny. The tubers are numerous but small and sweet to the taste. This is not common in Nigeria and matures 12 month after planting.

(v) Dioscorea bulbifera lim (bulbil or potato yam). This variety is not widely used in Nigeria since it is not popular as food except in the rural, yam-growing areas where it is used on the farm itself; during cultivation it is either burned or cooked. The varieties is not of much economic importance in West Africa.

The tubers have strong cooly skin, which enable them to store well for long periods.

2.2.4 CHEMICAL AND NUTRITIONAL COMPOSITION OF YAM

Carbohydrate and moisture are major constituent of yam tubers, others such as fat, crude protein, crude fibre and Ash contents are relatively low. The newly harvested fresh yam and tuber has a high moisture contents of about 55-75% wet basis (wb) (Ezeilke, 1984). While the dry matter of the tuber is about 30 to 40% of the weight of the tuber and is composed mainly of carbohydrates (65 to 80%,).

However, the tail end of each tuber has a higher moisture content than the head, and there is a gradient of increasing percentage of moisture from head to tail (Coursey and Walker, 19960).

Carbohydrates in yam accounts approximately one quarter of the fresh weight and most of it starch. The starch itself is mainly amylopectin (branched chain starch) and exists in the cells in the form of starch grains. The starch grain varies depending on the species and the smaller the size of the grain, the better the quality of the starch. Furthermore, sugar are present in yam tubers in the form of sucrose and glucose. The sugar content of the yam tubers increases during or just before sprouting, given the tubers abnormal sweetish taste. The protein contents of yams are considerably low and ranges from 1 to 2% of the fresh weight depending on both species and cultivars. Investigations carried by Ezeike (1979) estimated that crude protein content of yam tubers ranges from 6.3 to 13.4% dry weight. Yams contain also some enzymes which account for starch conversion, respiratory processes and wound repair.

TABLE 2: SUMMARIZED PROXIMATE ANALYSIS OF YAM TUBER

(Blank spaces indicate where no figure is available).

SPECIES	Moisture content (%)	Carbohydrate (%)	Fat (%)	Crude protein (%)	Crude fibre (%)
D.alata	'65 –73	22 – 29	0.03 – 0.27	1.12 – 2.78	0.65 – 1.40
D.rotundata					
D.Cayenesis	58 – 80	15 – 23	0.05 – 0.12	1.09 – 1.99	0.33 – 0.79
D.Opposita	70 – 80	16 – 29	0.06 – 1.10	1.11 – 3.10	0.33 – 1.00
D. esulenta	67 – 82	17 – 25	0.04 – 0.29	1.29 – 1.87	0.18 – 1.51
D.bulbifera	63 – 67	27 –33	0.04	1.12 – 150	0.70 – 0.73
D. dumentorum	79	17	0.28	2.78	0.30
D. trifida		38	0.44	2.54	
SPECIES					**Ash (%)**
D. alata					0.67 – 2.06
D. rotunda					
D. Cayenesis					0.68 – 2.56
D.Oposita					0.69 – 1.10
D. esulenta					0.50 – 1.24
D.bulbifera					1.08 – 1.51
D.dumentorum					0.72
D. trifida					

Source: Coursey (1960)

ECONOMIC AND SOCIAL IMPORTANCE OF YAMS

Recently, yam production is still at subsistence level in Nigeria. In the world today the estimation of yam production is about 20 million tones per year (Coursey,1969). Nigeria alone, is said to produce about 76% of the total production recorded throughout the world per year . (Onwueme, 1975). The southern part of Nigeria produces more than half of the total yam crops in the country.

The largest production of annual produces (yam) is sent to the market unprocessed while the processed products represent only but a few fraction of the entire produce. Evidently, most of yams produced are consumed and very little enters into international trade. As such the economic importance of yam, therefore, lies in its utility as a carbohydrate food rather than in any ability to earn foreign exchange.

Not m.ny significant advance have been made in recent year with respect to the technological aspect of yam storage. As a result, the rate of sprouting and weight loss during storage in the conventional barn continue to pose serious problems. The Nigeria conventional barn consist of the harvested tubers being commonly stored by tying them horizontal position on vertical poles in yam storage sheds which are built off the ground with roofs and sides of for protection from sun rain and rats.

Previous studies (Coursey, 1961, 1963) have revealed that relationship exist between sprouting of yam tubers and the level of weight losses that occur during storage in the conventional barn. However, controlled environmental factors such as rate of airflow humidity and temperature of the conventional barn were not evaluated in term of their effects on either rate of sprouting or weight loss.

ORIGIN AND CLASSIFICATION OF YAM

Yams planted are members of the genus Diocorea and produce tubers, bulbils, which are of economic importance. They are monocots belonging to the family Dioscorealea within the other Dioscorealea (Ayensu, 1972) which also includes the families stenomeridicease, Trichopodacesae and stemonaceae. It is generally agreed that yam are monocosty ledonous plants despite occasional evidence (Lawton and Lwaton, 1969) for the existence of a second cotyledon.

Taxonomically, the genus Diocorea is sub-divided into sections within which the specie fall. The section Enantiophyllum contains most of the economically important yam species (rotundata, alata, Cayenensis, opposita and joponica), and is characterized by the fact that the vines time to the right i.e in a clockwise direction when viewed from the ground upwards. Species in section lasiophyton (dumetorium and hispida), opsophyton (bulbifera). combilium are macrogynodium (trifida) twine to the left. The preceding are the species of Dioscorea whose tubers are used extensively for food and are therefore called yams. Numerous other species of Dioscorea exist which are only eaten occasionally or are not used for food at all.

Important among the latter group are D. Mexicana, D. Composital, and D. Floribunda from wich pharmaceutical (diosgenis are grown commercially in Mexico and other places for use by the pharmaceutical industry.

STRUCTURE AND ANATOMY OF THE YAM TUBER.

The structure of the yam tuber is highly variable, depending on the species. Both genetic and environment play significant roles in determining tuber shape and size. Sizes of individual tubers may range from a few grams to over 50kg, and tuber length of 2-3 meters have been recorded (Coursey, 1967).

Most commercial yam tubers are more or less cylindrical in shape and covered by a thick layer of cork. Crack are often present on the tuber.

The yam tubers grow from a massive, corn-like structure located at the base of the vine. The corn is present very early in the life of the plant, being formed shortly after sprouting occurs. The main feeder roots, and later the tuber arise from it.

It is well know that some of the factors that determine the quality of stored yams are:-

(i) Physical factors, such as mechanical damage, desiccation and high or low temperature.

(ii) Physiological factors such as natural metabolism

(iii) Pathogenic factors resulting in Micro-biological proliferation. An attempt to solve the problem of yam storage should recognize the biological as well as the engineering properties of this root crop. The solution to the overall problem of yam storage should therefore be derived from it's Anatomy physiology and hygroscopicity.

2.3.2 ANATOMY

The yam tuber is know to be covered by a protective outer skin know as the periderm. Structurally, the periderm consist of three parts namely (a) the phellogen or cork cambium, which is the merstem that produces the periderm, (b) the phellem, commonly called cork produced by the phellogen centrifugally and (c) the phelloderm, consisting of the inner derivatives of the phellogen.

At this time of harvest, this skin is unavoidably broken and removed in varying degrees. Such skin breaks may also occur during handling and transportation and are know to be responsible directly and indirectly for substantial storage losses by encouraging dehydration and by providing an easy path for invasion by micro-organisms (Hudson 1975), indicates that depth of bruising corrected with cell size, intercellular space and specifies gravity of root of various varieties. It is suggested by Hudson (1975), that in sweet potatoes presence of an active cork cambium together with skin shipping and that a curing procedure hastens the maturity of the cork cells. Working with potatoes, bruise susceptibility is shown to be highest for tubers having low specific gravity =, large cell size and high intercellular space.

2.3.3 CHEMICAL COMPOSITION OF THE YAM TUBER

The tuber is the main economically utilized part of the yam plants. The chemical composition of the tuber varies with species and cultivar, even within the same cultivar, it may vary depending on the environmental conditions under which the tuber was produced.

By far the largest component of the fresh tuber is water, which accounts for about two-third of the fresh weight. The dry matter of the tuber is therefore only one-third of its weight.

However, the tail end of each tuber has a higher moisture content than the head (coursey and walker, 1960) and there is a gradient of increasing percentage of moisture from head to tail.

Carbohydrates bare the major dry-matter component of yams. They account for approximately one-quarter of the tuber fresh weight most of this carbohydrates is starch.

The starch itself is mainly anylopectin (branched chain starch) and exist in the cells in the form of starch grains. The size of each individual starch depends on the species, but the smaller the starch grain, the better the quality of the starch.

Sugars are only present in minute quantities in yam tubers. For most species, they account for less than 1% of the fresh weight, but in D. escullental, which is sweet, the percentage of sugar may be high as 2-4% on a fresh-weight basis. It seems, too, that the sugar content of yam tubers may increase during or just before sprouting. As a result, tubers that have been stored for very long period may develop a sweetish taste. The sugar present in yam is mostly sucrose, but small traces of glucose and fructuose may also occur. The protein content of yam is rather low, ranging from 1-2% of the fresh weight. The protein in yam appears to be low in sulphour containing amino acids.

Most of the soluble amino acids in yam are lost when the tuber is chilled (Oke, 1973). Mucilages which exude when the yam tuber surface is cut are mostly glycoproteins.

Vitamins band mineral (ash) are also minor components of the yam tuber. Significant amount of vitamin C are present, traces of Vitamins A and B are also present. Calcium, Iron, and Phosphorus are among the components of the mineral fraction of the tubers.

As has already been mentioned, certain yam species may contain quantities of alkaloids (e.g dioscorine) and steroid derivatives (e.g diosgenis). The former are extracted for use as a poison, while the latter is extracted for pharmacentical use.

2.3.4 UTILIZATION AND ECONOMIC IMPORTANCE OF YAMS.

By far the largest proportion of yams produced annually is marketed as the fresh **tuber.** Only a very small fraction goes to market in processed forms. Yam are used for food in the form of boiled yam, pounded yam, mashed yam, baked yam, yam flour, yam flake and yam chips. Yam tubers make good feed for livestock, but are not normally used for that purpose because of the availability of much cheaper alternatives. In rural settings yam peels are often fed to domestic animals such as goats and sheep. The use of yam as a source of industrial starch is not widespread, probably because cheaper alternatives sources exist. Most of the yams produced in various parts pf the world are consumed within the country of production.

Very little enter into international trade. The economic important of yams, therefore, lies in its utility as a carbohydrate food for producing region, rather than in any ability to earn. Foreign exchange.

For several decades before the introduction of maize and cassava, yam was probably the main sustenance of the peoples of the west African yam zone. During that time, considerable importance must have been attached to the success or failure of the yam crop. It is not surpassing therefore that a considerable amount of rutualism, such as the new-yam festival, developed around the production and utilization of yams.

The new-yam festival marks the earliest date on which new yams may be harvested or eaten. It ensures that the new crop is ushered in formally, and that its consumption does not occur until the community as a whole gives thanks to the gods and celebrates the event.

No other crop has a taboo and festival connected with the date when its harvesting may commence.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Evaluation Of Yam Production, Storage and Losses

In this chapter, the methodology and technique employed to evaluate yam production, storage and losses in the eastern states is explained. Also the nature of the questionnaire and its administration. In this research study three states in the eastern part of Nigeria were taken into consideration namely Enugu, Anambra and Rivers state

3.2 METHODS OF DATA COLLECTION; ORAL INTERVIEW, QUESTIONNAIRE AND VISUAL OBSERVATION.

In order to collect data a method known as simple random selection was used to cover the local Government Area (LGA) in each state. This method eliminated discriminating and favouring some sets of people. Three states were visited namely Anambra, Enugu and Rivers state and in each of the three states, three Local Government Areas were visited. A total number of five villages were visited in the three local government areas. In each of the five villages, six farmers were selected randomly. Apart from farmers, the questionnaires were also given to Agricultural Development Programme workers, Ministry of Agricultural workers and Extension workers in each state. The total number of questionnaires administered in River State comprises of three to Agricultural Development Programme workers and two Ministry of Agricultural Staff and thirty five to farmers. In Anambra and Enugu States the total number of questionnaires administered were five to Agricultural Development Programme workers, five to Ministry of Agricultural Staff and five Extension workers and thirty to the farmers. All the questionnaires distributed were returned in Enugu and Anambra states.

It's worth mentioning that only a greater proportion of the questionnaires distributed were returned by the farmers in Rivers state under study.

Table 3.0 : shows data collected using oral interview and questionnaire methods:

STATE

	RIVER	ENUGU	ANAMBRA
Number Of Local Government Areas Visited	3	3	3
Number of villages visited	5	5	5
Number of farmers interviewed	6	6	6
NUMBER OF QUESTIONNAIRES TO:			
A) Agricultural Development Programme workers	3	5	5
Number returned	-	-	-
B) Ministry of Agricultural staff	2	5	5
Number returned	-	-	-
C) Extension workers	-	5	5
Number returned	-	-	-
D) Farmers	40	30	30
Number returned	35	30	30
Total Number Of Questionnaires Distributed were	40	45	45

The questions were formed or constituted in this pattern: -

i. The Background Information: - Here the Age of the farmers, traders etc was indicated to get the size of the people that can farm very well and their village.

ii. Yam Production/Planting: - This shows the variety of Yam Planted in each state and their planting

iii. Yam Harvesting: - This gives the harvesting time, method of harvesting, problem encountered and the size of yam harvested.

iv. Storage Losses: - This is the most important aspect because it gives the percentage loss and causes of the loss.

v. Storage Methods: - This gives the best storage method that is practiced in the eastern state and from the storage losses you will confirm which is the best method of storage.

Generally the evaluation was conducted using three different methods. The first method is the distribution of the questionnaire. Where already prepared questionnaire was given to respondent to fill and was returned back. The second method was oral interview from where the researcher got more information on the subject under study. The last one is the visual observation to evaluate the structures on ground and the tubers stored in it. The oral interview method was taking into consideration because it involves the unskilled farmers and traders; the information was able to pass across using this method because the respondents are asked questions or are engaged in verbal discussion to extract information. The advantage is that detail information can be gathered and the respondent cannot misinterpret questions and the disadvantage is that data coding and analysis will be difficult and response may be influenced by the presence of the interviewer. The visual observation method was also considered because the researcher can visually inspect the storage structures, see the quantity and quality of yam stored and also inspect damage tubers. The advantage is that this enhances confidence of the researcher in the quality of the data and the observer may not influence observations and the disadvantage is that the observer may influence the respondent.

The Questionnaire Method: - The Questionnaires are distributed to the respondent to be collected later by the researcher with the assistance of some people. This gives the respondents enough time to fill the Questionnaire. The only problem is that, the Questionnaire could be misinterpreted, it could get lost and response rate was very how.

3.3 METHOD EMPLOYED IN ESTIMATING STORAGE LOSSES

Storage loss was estimated based on the response of farmers to questionnaire. The yam was visually assessed and also weighed to find the weight of different size categories of yam tuber. This percentage loss could be as a result of quantity or quality losses. Because the farmers had been handling yam for a long time especially those farmers who store and sell yams were in better position to tell the percentage loss correctly.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 BACKGROUND INFORMATION:-

The Questionnaire was distributed to, three local government areas in each of the three states. A total number of 130 persons were interviewed, the breakdown of this figure showed that there were forty five persons in Enugu State, forty persons in Rivers State and forty five persons in Anambra State. Out of the 150 questionnaires administered in the three states, 130 copies were recovered and twenty were not recovered. Fifty questionnaires were administered in each state: Thirty were recovered from the farmers, in Enugu State, five from Agricultural Development Programme, five from Extension worker, five from Ministry of Agric; the same method of collection went for Anambra; in Rivers state, thirty five were recovered from farmers, two from Agric Development programme and three from Ministry of Agric there was no response from the extension workers. The farmers generally practice large scale farming and their age range is 50% of the farmer falls between 30 and 35 years. 30 % falls between 36 and 44 years and lastly 20% falls between 45 years and 50 years

4.1.1 YAM PRODUCTION

The farmers in these area planted yam every year and they plant the yam to make maximum output; the variety planted are mainly white yam, water yam and yellow yam the planting time is between January and March .

During the process of research it was observed that most of the farmers cultivates mostly white yams though water yams and others could be planted but white yam is the main types they cultivate because it is best for pounded yam, good when boiled and fried.

4.1.2 YAM HARVESTING

The yam is ready to be harvested between September and December, because they are large scale farmer they don't harvest all at once, they harvest yam within a period of one to two month depending on the quantity.

Their method of harvesting is with the aids of hoes, some of then use spade and even digger, their final harvesting is done in December, they harvest yam within a period of one to two month depending on the quantity.

They are faced with the problem of rot, rodent, thief, breakages, bruises and cuts during harvesting. Some claim to harvest as much as 500,000 tubers yearly and some harvest 25,000 tubers and below.

These farmers don't leave their yams underground after maturity because by so doing they said they will encounter much losses due to heat i.e lack of aeration and rodent attack.

4.1.3 STORAGE METHODS OF YAM

There are different kinds of storage method such as barn, Heap, Crib, Ditches and Underground but the most practicing and common one is Barn method there in the east they have two different ways of barn storage known as:-

4.1.3.1 **Traditional Yam Barn**:- They can be stored in open traditional barns where they are tied in columns and supported with bamboo and palm fronds. Live plant that demarcate and sometimes serve as columns in the yam barn provide shade protects the tubers from excess direct sunshine and lower the temperature.

4.1.3.2 **Improved Yam Barns**:- The root is made of corrugated iron sheets, while the wall are made of steel mesh with holes sufficiently large to provide aeration, but small enough to prevent rodents from penetrating the barn. The improved barn, seed yams are stored on racks and bins with wire gauze floors. The technical efficiency of the improved barn over the traditional open barn has been rated very high.

There is need to improve the aeration in the modern barn to reduce the high ambient temperature from January to March.

Some farmers tried storing yams in the soil, and these attempts to store yam in dig out ditches have not proved successful as the yams are prone to rot and decay.

4.1.4 **Pretreatment Before Storage**:- Tubers are selected and grade according to size normal-sized seed yams and micro tubers. The tubers are cured for 2 to 3 days and subsequently tied and placed on racks in the barn.

The reconstruction of storage structure varies among farmers, some reconstruct every harvesting period once in two years and others regularly, depending on the condition of the structure. They make use of materials like wood, bamboo sticks, thatch, palm fronds e.t.c.

The storage of yam lasts for as long as 6 month and are checked weekly or biweekly. When sprouting is noticed, they are cut off immediately.

4.1.5 DISTRIBUTION OF STORAGE LOSSES

The farmers in these area were able to give the percentage losses they encounter every farming season; some said they are not usually faced with much loss except that the land is not large enough and retains water, some equally said their percentages loss is through rot and rodent but very minimal generally, they encounter losses but minimal through rot, thief, rodent and sometimes sprouting they less than 1/3 percentage loss.

4.2 DETAILED DISCUSSION

Tables 40 – 42 shows the response of farmers on the quantity of yam produced in each L.G.A. Ogoni in Rivers State has the highest production rate followed by Enugu and Anambra State. Table1 shows that 66.67% of farmers claims to produce greater than 2,500 yam tubers in a year, because they are large scale farmers, in Oyigbo L.G.A. 50% of the farmers claims to produce between 1000 to 2,500 tubers of yams and in Etche 75% of the farmers claims to produce above 2,500 tubers; the case is different in Enugu and Anambra State. In Enugu state, 57.89% of farmers in Isuizo L.G.A. claims to produce ≤ 1000 tubers and in Udenu L.G.A and Ezeagu L.G.A. 45% claim to produced ≤ 1000 tubers and 66.67% of farmers claim to produce ≤ 1000 tubers. The farmers that claims to produce 1000 – 2,500 are 27.3% and in Udenu L.G.A. In Ezeagu L.G.A the production for the farmers above 2,500 is13.3% while in Isuizo L.G.A. 26.32%. of farmers claim to. produces above 2,500 tubers in Ezeagu L.G.A 57.8% of farmers claim to produce ≤ 1000

It is also observed in Anambra state that 50% of farmers in Aguata L.G.A. claims to produce ≤ 1000 tuber of yam while 52.63% of farmers claims to produce ≤ 1000 tubers in Aguleri. The least production for those above 2,500 is Aguler 21.05% of farmers while the highest production for the farmers that produce 1000-2,500 tubers of yam is Aguler 26.32% of farmers while least for 1000 to 2,500 production of yam is Aguata giving 21. 43% of farmers.

The data for the total number of farmers were obtained from Agricultural Development Project and Ministry of Agriculture and used for the computation of the total production assuming 75% of the farmers produce yam per year.

From the calculation Rivers state has the highest production followed by Enugu state and the least production is Anambra state. It is observed that the farmers produces yam in different sizes, small, medium and big and each of the farmers gave the amount of tubers they produce every year beginning from Small, Medium and Big sizes of ≤ 1000 tubers, 1000 to 2,500 tubers > 2,500 tubers and this was worked with weight claimed for yam produced, Small sizes 1.5kg, Medium 3kg and Big 5 to 6kg .

Table 4.3 shows the approximate amount of tuber produced per farmer per L.G.A. and respective states. In Rivers State, Ogoni L.G.A. has the highest followed by Etche and the least is in Oyigbo L.G.A. In Enugu State, Isiuzo L.G.A. has the highest amount of tuber produced per farmer per L.G.A. followed by Udenu and Ezeagu L.G.A. In Anambra State, Idemili has the highest followed by Aguleri and least is Aguata, L.G.A.

Figure 4.0 to 4.2 show the bar charts of "amount of yam tubers harvested" against "percentage of farmers that produced them" in Rivers State, Enugu State and Anambra State. The amount of yam produced is in three categories of < or = 1000, 1000 – 2500 and > 2500. These categories of output classify the farmers that responded.

In Rivers state: For the first category, Oyigbo has the highest percentage of farmers with this output while Etche has the least; for the second category, Oyigbo also has the highest while Etche has the least; for the third category, Etche has the highest while Oyigbo has the least. The final analysis of all the categories shows that Ogoni L.G.A. has the highest followed by Etche and the least is in Oyigbo L.G.A.

In Enugu State: For the first category, Ezeagu has the highest percentage of farmers with this output while Udenu has the least; for the second category, Udenu has the highest while Isiuzo has the least; for the third category, Udenu has the highest while Ezeagu has the least. The final analysis of all the categories shows that Isiuzo L.G.A. has the highest amount of tuber produced per farmer per L.G.A. followed by Udenu and Ezeagu L.G.A.

In Anambra State: For the first category, Aguleri has the highest percentage of farmers with this output while Aguata and Idemili have the least; for the second category, Aguleri also has the highest while Aguata has the least; for the third category, Aguata has the highest while Aguleri has the least. The final analysis of all the categories shows that Idemili has the highest followed by Aguleri and least is Aguata, L.G.A.

Table4.4Shows the response to storage losses of the harvested tuber, 50% of the farmers claim < ¼ losses, 37.5% of the farmers claim 1/3 losses and 12.5% of the farmers claim 0.5 losses in Rivers state. For Enugu state 40% claim ¼ losses 33.33% of the farmers claim 1/3 losses and 26.67% of the farmers claim 0.5 losses and in Anambra state57.78% of the farmers claim ¼ losses, 35.56% of the farmers claim 1/3 losses and 6.67% of the farmers claim 0.5 losses.

Table4.5shows the total amount of yam produced per state and storage losses per state Rivers state has the highest production amount of yam followed by Enugu state and then the least yam production state is Anambra and however the percentage losses for the three states are Anambra state has 29.5% which is the least, Rivers state has 31.25% and Enugu state has the highest loss of 34.3%.

Table4.6shows the variety of yam planted in the eastern part of Nigeria. They are white yam, water yam, and yellow yam. White yam is the most commonly grown variety of yam followed by water yam and yellow yam, white yam is frequently grown because it is most prefered it is good when boiled, roasted or grilled, it is also best when pounded in Rivers is called Akwunaji and the production is Known as Ibiekeji in Enugu state and Awaji in Anambra state.

Table4.7shows problems encountered during storage. in Rivers state 35% of loss is due to Rot, 30% of loss is due to thief while 20% of loss is due to rodent and 15% of loss is due to sprout. In Enugu state 44.44% of loss is due to Rot, 22.22% of loss is due to thief while 20% of loss is due to rodent and 13.33% is due to sprout. In Anambra state 20% of loss and thief 10%, 20% said rodent and 13.33% said sprout. In Anambra state 33.33%

of loss is due to rot, 26.67% of loss is due to thief while 20% of loss is due to rodent and 20% of loss is due to sprout.

Table 4.8 shows the types of storage structure used in the states. In all the L.G.A.'s visited the most popular storage structure is the yam barn. The yam barn is surveyed and seen that the technique was the most widely practiced method through out the three states. It varies in design and structure from area to area but they all have the same basic features. The barn consist of vertical frame work. To these vertical sticks are tied the yam tubers, individually by means of twines. The framework is made from vertical poles preferably live, 5-10cm and set 1m apart. The height of the poles varies from 6 to 7m cross members are usually of bamboo or raffia, palm leaf mid-ribs. The tuber is fastened to the poles using twine. The yam barn is not a permanent structure. When there is rain during the wet season, the tubers are hurriedly taking into the improved yam barn. Another method practiced is heap through it is observed that they encounter much losses during storage due to heat, and not enough ventilation.

Table 4.9 shows the storage period the longest storage period is 5 to 6 month. In Rivers state 50% of the farmers store for 5 months and 12.5% of the farmers store for 3 months and 37.5% of the farmers store for 5 months.

Enugu 24.44% of the farmers store for 5 to 6 months, 33.33% of the farmers store for 3months and 17.78% of the farmers claim to store for 2 months. In Anambra state 22.22% of the farmers store for 5 to 6 month 33.33% of the farmers store for 3 months and 22.22% of the farmers claim to store for2 months.

Table 4.10 shows pretreatment done to the tubers before storage. In Rivers state 50% of the farmers said grading, 30% of the farmers said sorting and 20% of the farmers said curing.

Enugu state, 44.44% of the farmers claim grading, 35.56% of the farmers said curing and 20% of the farmers said sorting while in Anambra state 40% of the farmers claim grading, 40% of the farmers also claim sorting, 11.11% of the farmers said curing and 8.9% of the farmers said others.

TABLE 40: AMOUNT OF YAM TUBERS HARVESTED IN RIVERS STATE

STATE	L.G.A	Amount of Tuber	Number of Respondent	% of Respondent
RIVERS	OGONI	≤1000	2	11.11
		1000 – 2,500	4	22.22
		> 2,500	12	66.67
	OYIGBO	≤1000	2	20
		1000 – 2,500	2	50
		> 2,500	3	30
	ETCHE	≤1000	1	8.33
		1000 – 2,500	2	16.67
		> 2,500	9	75

TABLE 41 AMOUNT OF YAM TUBERS HARVESTED IN ENUGU STATE

STATE	L.G.A	Amount of Tuber	Number of Respondent	% of Respondent
ENUGU	ISIUZO	≤1000	11	57.89
		1000 – 2,500	3	15.79
		> 2,500	5	26.32
	UDENU	≤1000	5	45.5
		1000 – 2,500	3	27.3
		> 2,500	3	27.3
	EZEAGU	≤1000	10	66.67
		1000 – 2,500	3	20
		> 2,500	2	13.33

TABLE 4.2 AMOUNT OF YAM TUBERS HARVESTED IN ANAMBRA STATE

STATE	L.G.A	Amount of Tuber	Number of Respondent	% of Respondent
ANAMBRA	AGULERI	≤1000	10	52.63
		1000 – 2,500	5	26.32
		> 2,500	4	21.05
	AGUATA	≤1000	7	50
		1000 – 2,500	3	21.43
		> 2,500	4	28.5
	IDEMILI	≤1000	6	50
		1000 – 2,500	3	25
		> 2,500	3	25

TABLE 4.3 APPROXIMATE AMOUNT OF TUBERS PRODUCED PER FARMER PER LOCAL GOVERNMENT AREA

STATE	L.G.A	Amt/Farmer/ L.G.A	Amt/farmer x No of (tonne) farmer	
RIVERS	ETCHE	14329.17		12.042×10^6
	OGONI	22881.50	25161.24	tonnes
	OYIGBO	13645		
ENUGU	EZEAGU	4733.33		7.125×10^6
	ISIUZO	8376.39	19932.39	tonnes
	UDENU	6822.67		
ANAMBRA	AGUATA	5153.6		6.47×10^6
	AGULERI	6039.47	18480.57	tonnes
	IDEMILI	7287.5		

TABLE 44 THE STORAGE LOSSES OF THE HARVESTED TUBERS

STATE	LOSES	Number of Respondent	% of Respondent
RIVERS	< ¼	20	50
	⅓	15	37.5
	½	5	12.5
	> ½	-	-
ENUGU	< ¼	18	40
	⅓	15	33.33
	½	12	26.67
	> ½	-	-
ANAMBRA	< ¼	26	54.78
	⅓	16	35.56
	½	3	6.67
	> ½	-	-

TABLE 45 TOTAL AMOUNT OF YAM PRODUCED PER STATE AND STORAGE LOSS PER STATE

STATE	RIVERS	ENUGU	ANAMBRA
Amount produced	12.042×10^6 tonnes	7.125×10^6 tonnes	6.47×10^6 tonnes
Amount lost	3.76×10^6	2.443×10^6	1.9×10^6
Percentage loss	31.25%	34.3%	29.5%

TABLE 4.6 VARIETY OF YAMS PLANTED

STATE	LOSES	Number of Respondent	% of Respondent
RIVERS	White Yam	30	75
	Water Yam	10	25
	Others	-	-
ENUGU	White Yam	45	100
	Water Yam	-	-
	Others	-	-
ANAMBRA	White Yam	40	88.9
	Water Yam	5	11.1
	Others	-	-

TABLE 4.7 PROBLEMS ENCOUNTERED DURING STORAGE

STATE	Problems Encountered	Number of Respondent	% of Respondent
RIVERS	Rot	14	35
	Thief	12	30
	Rodents	8	20
	Sprout	6	15
ENUGU	Rot	20	44.44
	Thief	10	22.22
	Rodents	9	20
	Sprout	6	13.33
ANAMBRA	Rot	15	33.33
	Thief	12	26.67
	Rodents	9	20
	Sprout	9	20

TABLE 4.8 TYPE OF STORAGE STRUCTURE

STATE	Yam Barn	% of Respondent	Heap	% of Respondent	Ditch	P it	Underground	Others
RIVERS	40	100	-		-	-	-	-
ENUGU	42	93.3	3	6.7	-	-	-	-
ANAMBRA	43	95.5	2	4.4	-	-	-	-

TABLE 49 SHOWING PRETREATMENT BEFORE STORAGE

STATE	PRETREATMENT	Number of Respondent	% of Respondent
RIVERS	Curing	8	20
	Grading	20	50
	Sorting	12	30
	Others	-	-
ENUGU	Curing	16	35.56
	Grading	20	44.44
	Sorting	9	20
	Others	-	-
ANAMBRA	Curing	5	11.11
	Grading	18	40
	Sorting	18	40
	Others	4	8.9

TABLE 4.10 SHOWING THE STORAGE PERIOD

STATE	STORAGE PERIOD	Number of Respondent	% of Respondent
RIVERS	2 months	-	-
	3 months	5	12.5
	5 months	15	37.5
	6 months	20	50
ENUGU	2 months	8	17.78
	3 months	15	33.33
	5 months	11	24.44
	6 months	11	24.44
ANAMBRA	2 months	10	22.22
	3 months	15	33.33
	5 months	10	22.22
	6 months	10	22.22

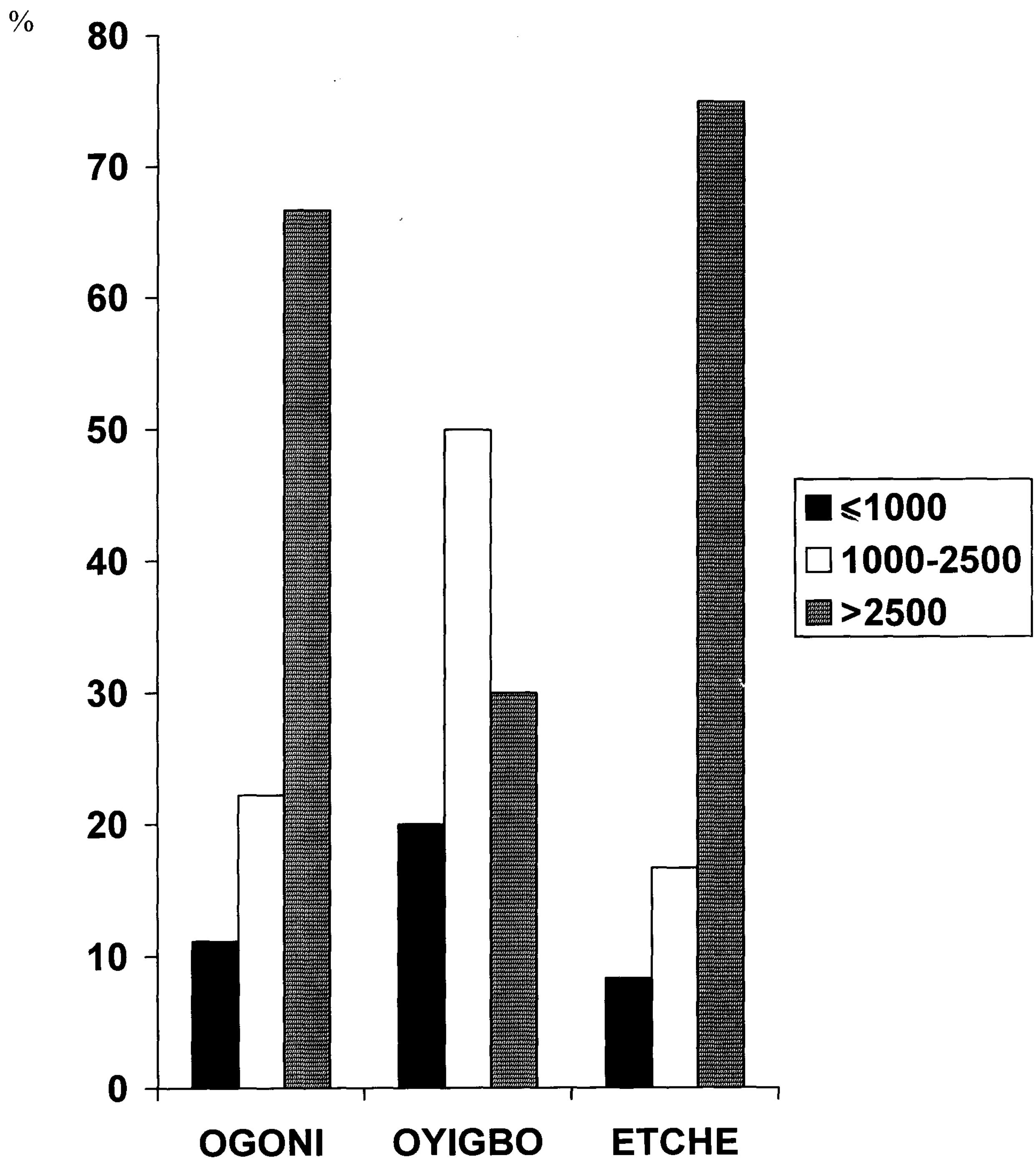

Figure 4.6: Amount of Yam Tubers harvested in Rivers State

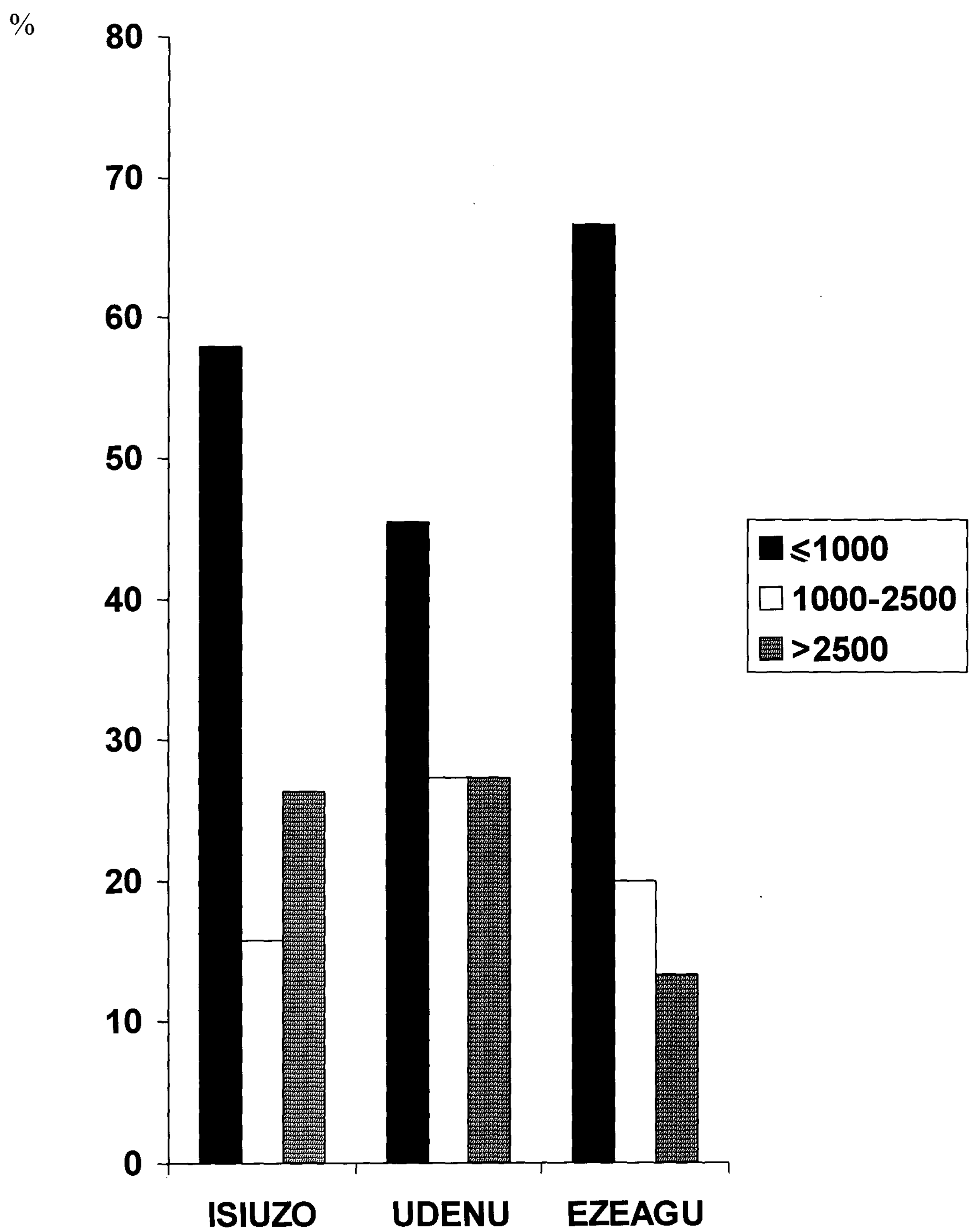

FIGURE 4.1: AMOUNT OF YAM TUBERS HARVESTED IN ENUGU STATE

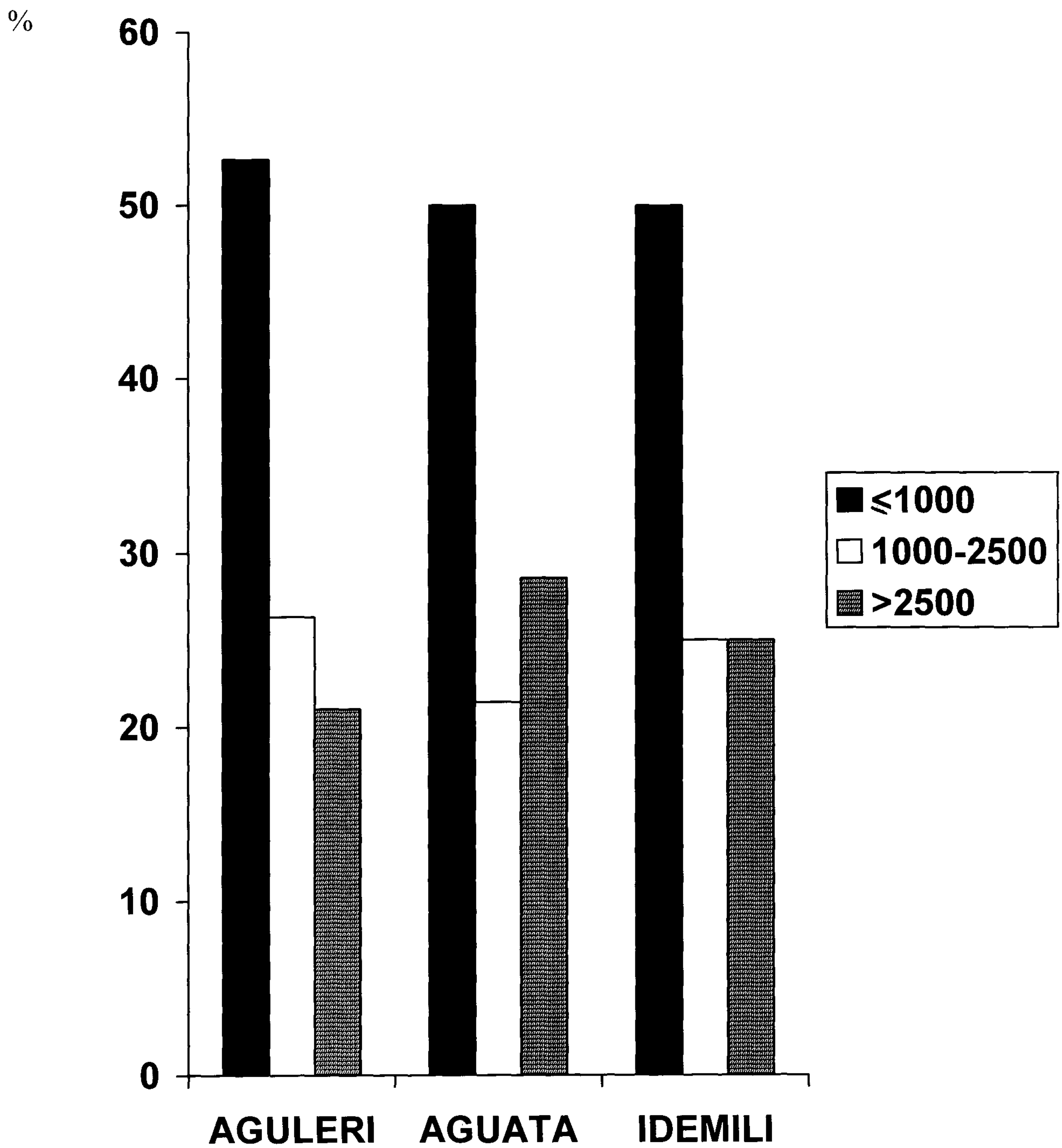

FIGURE42: AMOUNT OF YAM TUBERS HARVESTED IN ANAMBRA STATE

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

A survey was conducted to evaluate yam production, storage methods, structures and storage losses in the eastern state namely River, Enugu and Anambra.

The survey shows that each farmer from each of the L.G.A. produces quite a large number of yams, it is observed that Ogoni L.G.A has the highest number per farmer in River state, Isuizo L.G.A has the highest in Enugu state and Idemili L.G.A in Anambra state.

Production per state is given as Rivers state farmer has 12.04 x 10^6 tonnes annually. Followed by Enugu state farmers 7.12 x 10^6 tonnes annually and the least production state is Anambra having 6.47 x 10^6 tonnes annually. Out of these yams produced in each state, the total loss is: Anambra state has the least percentage loss as 29.5% followed by Rivers state 31.25% loss and Enugu state has the highest total loss of 34.3%.

The survey also shows that there is 50% storage period from 5 to 6 months. The main storage method is yam barn, the yam is made of wood, thatch, palm fronds bamboo sticks.

5.2 RECOMMENDATIONS

The piece of work is hoped at arousing greater awareness of the importance of yam storage in man's constant effort to obtain his primary need, that is without undue wastages. Since the farmers encounter much losses due to heat and not enough ventilation during in heap storage method, farmers should find a way to curtail the losses the encounter during storage.

Though some other states in the eastern part of Nigeria are also known for yam production, it will be also be of scientific significance to evaluate the total number of production in the whole eastern parts of Nigeria that are known for yam production.

In view of the high losses recorded during storage further studies would be required to determine the causes of these losses.

Ways to control yam losses using the method of storage are pre-harvest fumigation of yam barns and storing only uninfested tubers reduce the chances of an outbreak in storage. There is a need to inspect stored yam periodically for the early detection of incipient infestation.

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APPENDIX

QUESTIONNAIRE

This questionnaire paper is strictly for a project work and any answer given in this questionnaire will not be used against you.

Background Information

1. Name of Farmer: ________________________________

2. Name of village: ________________________________

3. Age:______________ [a] 30 years [b] 35 years [c] 40 years [d] above

4. Profession:______________ [a] trader [b] farmer [c] teacher [d] others

Yam Production/Planting

5. Do you plant yam every year:________ [yes/no]
   If yes,
6. How often____________
7. Variety planted:_________ [a] white yam [b] water yam [c] others [specify]
8. Planting time:_____________________

Yam Harvesting

9. When is the yam ready for harvesting:_________________________
10. Harvesting time:____
11. Do you harvest all at once:________________ [yes/no]
12. Method of harvesting:__________[a] hoe [b] cutlass [c] others [specify]
13. When do you do final harvesting:___________________________
14. For how long do you harvest:_______________________________
15. Problems encountered:___________________________________
    [a] rot [b] rodent [c] thief [d] breakage [e] bruises [f] cuts

15[b] How many big:__________ medium:___________ small:_________

16. How many yams do you harvest per year:______________________
    [a] 1000 [b] 1500 [c] below [d] above
17. Do you leave them underground after maturity:_____________ [yes/no]
    If yes then, for how long:______________________________

Storage Losses

18. What is the percentage loss:________________ [a] 1/3 [b] ¼ [c] ½
19. What are the causes:________ [a] rot [b] thief [c] rodent [d] sprouting

Fig a Yam barn storage

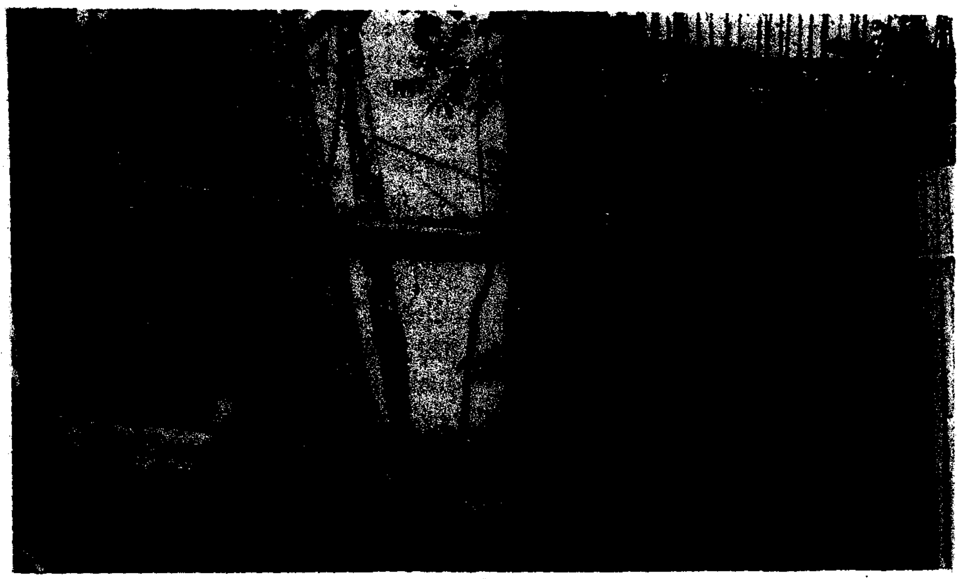

Fig b Yam barn storage.