THE EFFECT OF STORAGE STRUCTURES AND PERIODS ON NUTRITIONAL VALUE OF STORED YAMS IN MINNA, NIGER STATE

BY

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) AGRICULTURAL ENGINEERING IN DEPARTMENT OF AGRICULTURAL ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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CERTIFICATION

This is to certify that this project was carried out by **Sunmonu Musliu Olushola** in the Department of Agricultural engineering, Federal University of Technology, Minna.

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DEDICATION

I dedicate this project to Almighty .Allah for his love mercy and for been with me till this very day. To my dearest Dad and Mum, ALHAJI MURTALA SUNMONU and ALHAJA ARINOLA SUNMONU for their understanding, love, care, support and encouragement.

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I give thanks to Almighty Allah (SWT) who in his infinite mercy gave me the strength to complete this research work.

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The contributions of my dear parents, Alhaji Muritala Sunmonu and Alhaja Arinola Sunmonu cannot be quantified. They both laboured hard to see me through by giving me the necessary moral and financial support. May the almighty Allah in his infinite mercy continue to guide and protect them. May he continue to shower upon them abundant blessings both in this world and hereafter.

I must not fail to acknowledge the assistance of Alhaja R. O Sanni who has been just like a mother to me. I am highly indebted to her for her contributions towards my success. I pray Allah to grant her good health, long life and prosperity

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ABSTRACT

The demand placed on yam produces has been on the increases in recent years, but they can't be met due to among other reasons, the loses suffered in storage. The research work in this report was undertaken to understand the behaviours of yams in different storage structures and of course which of the structure will retain a reasonable percentage of nutritional content of the stored yam with minimum weight loss. The storage methods used were the local barn, pit barn and improved barn. Two varieties of yam, ausba and giwa were used for the experiment which lasted for five months. At the end of the experiment, the two varieties of Yam in the pit storage structure recorded the least percentage weight loss followed by the local barn. The yams in the improved barn were losing more weight than others. The nutritional changes in the two varieties of yam were monitored periodically up to five months. The dry matter content was found to increase in the varieties with the asuba variety recording the highest value. The total free sugar was found to increase in the two varieties and the crude protein showed a decrease during storage.

CHAPTER ONE.

1.0 INTRODUCTION

Yam tubers of plant family Dioscoreacae, are the most important food crops in west Africa, except for cereals (Coursey, 1969 and Onwueme, 1978). It also forms an important food source in other tropical countries like East Africa, the Caribbeans, south America. India and south East Asia. The tuber is the economically important part of the yam plant which is extensively used for human consumption (Okonkwo 1985). The shape and size of the yam tuber vary from species to species (Coursey 1967). The tuber shape can be controlled by genetic conditions (Onwueme, 1978). Most yams are cylindrical in shape.

1.1 YAM SPECIES.

According to Ene and Okoli (1985) there are nearly 600 species of yam (Discores species). About 12 of them have edible tubers. Some few species are poisonous. Useful steriods and alkanoid drugs are derived from others.

Six species can be considered to be edible in tropical Africa. They account for 95 or more of the yams eaten here (Ene and Okoli 1985). These species are;

a. D rotundata / D. cayenensis complex

b. D alata

c. D dumetorium.

d. D Buibifera

e. D esculenta and

f. D Trifida.

In west Africa the first three species are widely cultivated. While D rotundata and D cayenensis are said to have originated from west Africa D. alata has its origin from Asia D. rotundata (white yam) is the most sought for it is therefore grown more widely in Nigeria. It is followed by D. alata (water yam) and D. cayenensis (yellow yam).

IMPORTANCE AND USE OF YAM TUBERS IN NIGERIA.

Out of all the tuber crops in Nigeria yam tuber has the greatest demand. It is a major source of carbohydrates, some species that are poisonous have been used as medicines and baits for fish by local inhabitants

TABLE1.2: **SUPPLY AND DEMANDS FOR TUBER CROPS IN NIGERIA**

ROOT -TUBERS	**DEMAND QUANTITY. (METRIC TONS)**			**SUPPLIED QUANTITY. (METRIC TONS)**		
Year	84 - 85	89 - 90	94 - 95	84 - 85	89 - 90	94 - 95
Cassava	5.429	6.643	8.129	4.652	5.272	5.973
Potatoes	0.241	0.293	0.360	0.206	0.234	0.265
Yams	11.353	13.893	17.000	9.730	11.025	120492
Cocoyams	0.545	0.667	0.816	0.467	0.529	0.600
Plantain	0.766	0.938	1.148	0.657	0.744	0.843

SOURCE; Olayide S.O at al 1979. Food production in Nigeria (report of the Agricultural statistics working party), University of Ibadan, Ibadan Nigeria

The edible species of yam are prepared and eaten in different forms such as

a. pounded yam

b. boiled yam

c. yam pottage

d. yam chips

e. yam balls (cakes) or

a. Amala (from yam flour)

Yam cultivation is closely tied to the social customs of the Nigeria people (Banu 1988) its growing is associated with religions cults and many superstition. Annual festivals always set in the planting and harvesting of the yam tuber.

1.3 STATISTICS OF YAM PRODUCTION AND YAM PRODUCING AREAS

Yam are now grown in west and central Africa, south east Asia including adjacent parts of China, Japan and Oceania, the Caribbeans and some parts of tropical south America. It is accorded much importance mainly in west Africa (Ene and Okoli 1985). Annual world production is between 25 and 30 million tonnes.

Over 75% of world yams are produced in west Africa, D. rotundata / D cayenensis. Complex are believed to have been domesticated in the yam zones region of Africa this region stretches from central cote D'ivore through Ghana, Togo Benin and Nigeria to western Cameroon and straddles both the forest and the southern parts of the savanna (Coursey 1967).

Nigeria produce about 15 million tonnes of yams annually (FAO,1984). This is 81% of all the yams produced in west Africa (18.4 million tonnes)

Yam are produced in the rain forest and the guinea savanah regions of Nigeria, where total annual rain fall exceeds 800mm in a month in a month and 4 month in duration. A minimum rainfall of 800mm for a period of at least 4-5 months is needed to increase the productivity of yams Also the financial input labour requirements and timely weeding and harvesting are important factors to be considered to increase the production of yam.

1.4 PRESENT YAM STORAGE METHODS

Despite the greatest importance of yams in the food economy of Nigeria only one crop is grown in a year yams are planted in the months of November to early January and harvested from July to December. This makes it imperative to store them for six to eight months.

Storage of yams is not an easy task as high losses could be suffered if the wrong technique is used. Yams in storage are susceptive to attack by insects, rodents, micro-organisms and could even be stolen by thieves.

It is therefore essential to find the best methods for storage. The practices of yam tuber storage vary between the various producer countries of the world. Various techniques may be in use within just one district. Yams are mainly grown by the peasant farmers. This makes their storage to be in small quantities, except for the middlemen who buy and store for sale at a later date. Since most farmers have limited supply of capital the methods used will generally be simple, with very little or no cost. According to Coursey, 1967, some of the storage methods are follows;

(A) Yams are stored in some localities simply by leaving them in the ground till they are needed for sale or food. This system has many defects. It is inconvenient for large quantities. The tubers are exposed to attacks by pests, such as yam beetles, termites, rodents or monkeys. Harvesting will be difficult when the soil becomes hard. This can even lead to bruises and cuts on the tuber. This tuber may become rotten if and whenever heavy rains set in

(B) Another simple method is the stacking of the tuber after lifting into small heaps. This is done in sites where there is protection from sun and flooding such as on out crops of rock or between buttresses of large trees.

There are few dozens of yams in each stack though this system protects the yams from exposure to elements, they can be attacked by rodents, termites or even stolen by thieves.

(C) Yam may be kept in ordinary huts or sheds, within any special care being taken, similarly, they can be stored in the spaces beneath houses that are built on piles or stilts. In this case, the yam tubers may be stacked in heaps on the floor or supported on shelves or racks.

(D) Yams can also be stored in pits. This technique is sometimes called underground silo (Igbeka, 1985).

A trench is dug with sides and bottom mulched with palm leaves. The yams are arranged horizontally in the pit and them covered. The defect of this system has been found to be the speeded deterioration rate due to high temperature and humidity. The tubers are also susceptible to heavy rains and attacks by rodents termites etc.

(E) By far the most widely used and probably the best traditional storage method for yams in west-Africa is the shaded, well ventilated outdoor yam barn the design and construction vary from one area to another, but in principle all consist of more or less vertical frame work of poles preferably live poles. Live poles are preferred so as to provide shade for the barn the vertical poles, whose heights vary between 1-2m, are spaced about 50cm apart and held togther by rigid horizontal wooden sticks are tied individually to the frame work in a horizontal position by means of local twines. The barns are usually covered with thatched roof for shade, though the shade may be provided only the leaves of the live poles. The disadvantages of this system is that the yams may be bruised by the twines used in tying. The improvement on this is to use shelves the yams are placed side by side on the shelves. The shelves may be constructed from wooden bamboo or from any other wood source. Apart from storing yams wholly, they may be processed in yam chips or yam flour and then stored About 20-25% of yam harvested in Nigeria are stored this way (NSPRI,1982). Whenever the method is to used, it should be borne in mind that loses should be minimised. These losses can be weight moisture content and even charges in the palabity value.

(F) In some localities shelters are built in the shade of trees and the yam tubers are carefully stacked on top of each other within the shelter (Banu, 1988). It has been observed that this method is suited to cultivars that do not bruises easily.

1.5 OBJECTIVE

The objective of this project is to observe the Nutritional change that occur in yam under the three storage methods the methods are:

(a) Local yam barn

(b) Improved yam barn.

(c) pit yam barn

The properties of the yam tubers to be observed in the storage are the changes in the nutritional values (free sugar, crude protein and dry matter)

1.6 JUSTIFICATION OF THE EXPERIMENT.

It has been observed that the total demand for yams throughout the year has not even been met. The main cause of this problem is the heavy losses suffered in storage of yams in the tradition al methods including weight loss. It then becomes necessary to study the behavior of yams in storage. This is done to ascertain the right atmosphere for their storage. This is to reduce or even eliminate the losses suffered every year.

The justification of this experiment is to know the best storage structure that will record the least amount of weight loss of the stored yam and that will retain a reasonable percentage of nutritional value of the stored yam.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 PHYSIOLOGY OF YAM TUBERS IN STORAGE

The argument is often made that proper understanding of the physiological processes occurring in the yam tuber from harvesting through dormancy and senescence is essential for an efficient and economical planning of yam storage and utilization (Ikediobi, 1985).

2.1.1 DORMANCY

Dormancy in yams is a state in which the tuber are metabolically quiescent and spans the period between harvest and sprouting (Ikediobi, 1985). Ikediobi (1985) stated that two measurable parameters of importance in a discussion of dormancy in yam are

- Length of dormancy and,
- Depth of dormancy.

The length of dormancy is simply the period between harvest and first visual evidence of sprouting while depth of dormancy refers to the difference in metabolic activity as measured by the respiratory rate (e.g. CO_2 evolution) between the freshly harvested tubers and the tubers in their dormant state. According to Ikediobi (1985) dormancy is critical to yam storage for two reasons.

Firstly it determines the length of storage life of the tuber since sprouting marks the beginning of tuber senescence which leads to tuber disintegration and tissue necrosis..

Secondly the suppression of endogenous metabolism during dormancy reduces the rate of loss of storage carbohydrates.

2.1.2 RESPIRATION

Yam tubers are alive after harvest, hence their metabolic process continue during storage but in a lesser rate respiration happen to be one of these metabolic processes. During respiration the carbohydrates in the tubers are converted to carbon dioxide and water, both of which are lost to the atmosphere.

Work on the respiration of stored yams by Hayward and walker. (1962). Showed that the principal sources of weight loss in yams during storage arose from the respiratory activity of the living tuber. Control of these respiratory activities will invariably lead to the reduction of dry matter loss in stored yam

2.2.3 SPROUTING

Sprouting or germination mark the termination of dormancy in the tuber this characterised by increased metabolic activity it has been shown that once sprouting sets it will be difficult to half the loss in dry matter content of the tuber. This is because of the biochemical and physiological processes taking place controlling the lifespan of the tuber is best done by controlling sprouting.

Adesuyi (1976) Carried out a research on the effect of manual removal of sprouts at the time of first development on losses in stored yam. He found out that by removing the sprouts as soon as they developed, reduced loss in weight of stored yam by more than half, reduced incidence of rot loss of moisture content and loss of carbohydrates food reserve with improved palatability of the yams after storage.

NSPRI handbook on yam storage (1982) list the effects of sprouting as follows:

- Reduction of food reserves in yams through the translocation of carbohydrates from the tubers into sprout for metabolic purpose.
- Increase in the rate of respiration, thereby increasing the rate of dry matter loss.

2.2 CHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF YAM

The chemical composition of yam is characterised by a high moisture content and dry matter the dry matter is composed mainly of starch, vitamins as well as sugars and minerals. Nutrient contents vary with species and cooking procedure. Cooking with the peel intact helps retain vitamins .

2.2.1 PROXIMATE COMPOSITION OF YAM TUBERS.

Table 3.2 shows the proximate composition and food energy of yam tubers in grams per 100 grams edible portion as reported by FAO (1968,1972) and also by Watson (1971, Eka (1978). It can be seen from the table that yam tubers in general are high in moisture content and low in dry matter content the moisture content ranges between 60% and 85% (Table 2.2.1). The observed high moisture level may influence the keeping quality of the tubers adversely. In terms of the protein level the yam tubers cannot be considered as very rich source of protein. The protein content is lower than that in most cereals except in the case of D. dumetorum. The total carbohydrate (table 2.2.1) is high in yam making it is very good source of carbohydrate the yams have low content of fat and low in fibre content. They have moderate ash content.

TABLE 2.2.1: PROXIMATE COMPOSITION OF YAM TUBER (In mg/100edible portion

Yam species	Food Energy Cal	Moisture %	Protein (gm)	Fat	Total Carbohydrate	Fibre (gm)	Ash (gm)
D. Alata	135	65.1	2.3	0.1	31.8	1.5	0.7
D.armata	118	68.4	3.0	0.1	27.0	10.0	1.5
D. bulbifera	78	79.4	1.4	0.2	18.0	1.2	1.0
D.Cayenensis	71	80.8	1.5	0.1	16.4	0.6	1.2
Ddumetorum	124	68.3	3.2	0.1	28.3	0.8	1.1
D. esculenta	112	70.2	3.5	0.1	25.2	0.5	1.0
D. hastifolia	-	-	-	-	-	-	-

SOURCE FAO (1968,1972).

2.3 EFFECT OF STORAGE ON NUTRITIONAL COMPOSITION OF YAM.

The effects of storage on changes in nutritional composition vary from one specie to another in yam. Yams may be normally stored during dormancy for about 3-6 months until sprouting sets in (Passam and Noon,1977, Ikediobi and Oti 1983, Mozie 1988).

Traditionally yams are stored buy leaving the tubers in the ground until required. Other methods used include storage in trenches, heaps or platform storage and barn storage (Igbeka 1985, Onayemi and Idown 1988, Ajayi and Madueka 1990, Nwakiti Etal 1988).

Improved techniques of storage of yam have been introduced and include curing treatment (Martin 1974, Passam et al Okoro 1990). Use of chemicals and germination inhibitors (Ogundana 1972 Ogundana et al 1981) and building of special well designed stored houses (Igbeka 1985, Ezeike 1987, Osuji 1987).

Storage of yam tubers can in some cases result in up to 25% loss of edible material (Coursey 1983) Ikediobi and Oti (1983), showed that contents of various enzymes ascorbic acid and lipids increased during storage and peaked at sprouting the content of sugar also increased near the end of the dormancy (Coursey 1983). More work is required to be carried out to determine the effects of storage on nutritional composition of yam tubers (Onayemi and Idowu 1988) cooking may results in the conversion of starch into sugars in the case of sweet potatoes.

TABLE 2.3 **NUTRITIONAL COMPOSITION OF ROOT AND TUBERS ON FRESH WEIGHT BASIS**

	YAM	**CASSAVA**	**SWEET**	**TANNIA**
	D. alata	D. esculanta	Potato	Cocoyam
Moisture (%)	77.3	62..8	71.1	67.1
Energy (kJ\100g)	347.0	580.0	438.0	521.0
Protein (%)	2.2	0.5	1.4	1.6
Starch (%)	16.7	31.0	20.1	27.6
Sugar (%)	1.0	0.8	2.4	0.4
Fat (%)	0.1	0.2	0.2	0.1
Ash (%)	0.8	0.8	0.7	1.1

Source modified from Bradbury and Holloway (1988) using available data from literature

2.4 SUMMARY OF NUTRITIONAL COMPOSITION OF ROOTS AND TUBERS

1. Yam (discorea specie): The tuber contain 15-25% starch and 2-5% protein on fresh weight and 4-12% protein on dry weight basis Protein and moisture levels increases from proximal (head) to distail (Tail) end of the tuber. The peel contains much more

fibre, ash, proteins, calcium, iron than the edible part of the tubers (Oyenuga 1968, FAO (1978,1976 Eka 1985,Eka and Aliu 1974).

2. Cassava; fresh root contain about 30-35% starch, less than 70% protein it has the highest energy and starch contents it is high in directory fibre and low in protein peels are richer in protein and ash than the edible portions (Oyeunga 1978, FAO 1968, 1972, Coursey 1973 and Eka 1984).

Source: Bradbury and Holloway (1988) and Literature survey.

2.5 MAJOR COMPONENT OF YAM

2.5.1 CARBOHYDRATE

The carbohydrate content of the yam tuber varies from 16-31 percent on a fresh weight basis this represents the major dry matter component of yams;yam carbohydrate may be classified as starch and sugars .

2.5.2 STARCH

The amount of starch in the tuber depends principally on the age of the tubers the percentage starch of mature tubers range from 20 to 31 percent. Lower percentage often reported in the literature are associated with lack of maturity (martin 1979). The starch of yam tubers is deposited in typically multilayer grains that vary in size and shape with the species. The main constituent of yam, starch is amylo pectin. Amylose occurs as 10 to 28 percent of the starch and influence the properties of the starch.

2.5.3 SUGARS:

Starch in yam tubers is frequently converted to sugars probably as a result of stresses experienced during growth and /or storage. The content of sugars in the yam tuber is influenced by variety location and cultural treatment in the matured stored tuber sugars and starch exist in a state of dynamic equilibrium which could be represented as:

$$\begin{array}{ccccc} \text{SUCROSE} & \rightleftharpoons & \text{GLUCOSE} & + & \text{FRUTOSE} \\ & & \downarrow\uparrow & & \downarrow\uparrow \\ & & \text{STARCH} & \rightleftharpoons & \text{GLUCOSE} \end{array}$$

Source Ketiku and Oyenuge 1973

The free sugars consist mainly of sucrose and glucose with predomination. Traces of fructose and mannose have also been detected (Ketiku and Oyenuga 1973). Most yam tuber are not sweet. An exception is D. esculenta whose tubers contain enough sugar to give them a positive sweet taste. The sugars identified in D esculenta include large amounts of maltose (Kouassi et al 1990)

2.6 NITROGENOUS SUBSTANCES

2.6.1 PROTEINS

As earlier stated that carbohydrates constitute the major dry matter component of yam tubers.

However, considerable attention has been paid to the proteins of yam tubers because of the critical role fairly low concentrations of proteins can play when tubers and roots are used as dietary staples Although the protein contents of yams is lower than that in most cereal yams can provide more protein per hectare per year than maize, rice, sorgham and soyabeans (Idusogie 1971). The value of cooked yam as a source of protein is limited by its bulk, the water content being so high.

It is suggested that in screening tubers for protein content, the soluble coagulable protein should be determined as this is more closely related to the true nutritional value. Also the distribution of nitrogen within the yam tuber is not homogenous (Ferguson et al, 1980), decreasing from head to tail end of the tubers; higher in the peel than in the pulp.

2.6.2 PROTEIN CONTENT;

Published protein contents of yam tuber vary very considerably between both species and between cultivar of a particular species ,this variation depends on various factors including cultural practice, climate and edaphic factors under which it was grown its maturity at harvest and the length of time for which the tuber has been stored. However it appears that high protein content is a characteristics of very vigorous varieties with large tubers (Martin. 1979)

Table 2.6.2. **TABLE OF CRUDE PROTEIN IN VARIOUS SPECIES OF YAM**

DISCOREA SPECIES	OYENUGA(1959)	BARQUAR & OKE (1976)	MARTINS (1979)
D alata	7.26 -8.10	3.8 -9.6	6.6 -15.5
D dumtorum	11.73 -12.58	4.9 -14.0	-
D cayenensis	5.44 -6.15	4.0	-
D rotundeta	4.42 -5.87	3.2 -13.9	6.3 - 8.1
D esculenta	7.73 - 8.73	5.5 - 5,9	7.8 -13.4
D bulbifera	-	7.9 - 9.6	6.7 -11.1

Literature Source

However, for the analytical results to be nutritionally meaningful, it is necessary to convert samples into a form comparable to that in which yams are actually consumed so that planners may correctly assess intake of nutrient in order to provide a balanced diet i.e. boiled yam (Francis et al 1975) or converted into flour and fufu (Bell and Favier 1981). On the average D. alata tubers have the highest protein levels among the edible yams.

2.7 EFFECT OF STORAGE ON YAM NUTRIENT

Yam tubers under storage condition exhibit considerable physiological activity: respiratory, enzymic and biosynthetic. The physiological change affects the internal composition of the tuber. Respiratory results in steady loss of carbohydrate as carbon dioxide and water while at the same time a transpiratory loss of water occur. These transpiratory and respiratory losses result in a destruction of edible material which under normal storage conditions can often reach 10% after 3 months and up to 25% after 5 months (Coursey 1967: Passam et al 1978). Relatively little changes occurs in the actual nutritional value of the material remaining after this metabolic loss take place (Gonzalez and Collazo de rivera 1972).

The dry matter portion of yam tubers is mostly composed of carbohydrates which exists primarily in the form of starch and sugars. Ikediobi and Oti (1983) attributed the steady decline in starch which they observed in stored D. rotundata tubers to the respiratory loss of sugars as carbon dioxide. Starch is located in amyloplasts within the cell vacuole. During storage of the tubers, parts of the starch is converted to sugars by a mechanism which is probably similar to senescent sweetening in potato tubers (Burton 1978, Bailey et al 1978). As a result, stored yam tubers assume a sweetish taste. The mechanism of starch breakdown and its conversion to soluble sugars is completely understood. As observed that both α -amylase and starch phosphorylase are present in high amounts in mature tubers throughout storage, although levels increases somewhat as sprouting begins (Dipoh and Kamenen 1981). Presumably starch granule breakdown involves both enzymes.

Sweetening in stored yam tubers might be due to an increased fragility of the amyloplast membrane and increased vulnerability of the starch granule to degradative enzymes from outside the amyloplasts.

Table 2.7: **CHANGE IN THE LEVEL OF SOME NUTRIENTS IN THE WHITE YAM DURING PROLONGED STORAGE. (IKEDOBI AND OTI 1983).**

Age of Tubers Weeks	Starch (g/ 100g fresh weight)	Total Free Amino Acid (g/100g fresh weight)	Crude Protein (g/100g dry weight)	Total Lipids (g/100g dry weight)	Total Carotenoid (g/100g fresh weight)	Ascorbic Acid g/100g fresh weight
1	29	0.29±0.009b	0.980±0.361	0.225	3.000±0.03b	82.2±0.075b
5	28.88	0.27±0.007	1.860±0.026	0.175	2.9±0.098	82.4±0.045

9	28.28	0.12±0.003	2.590±0.048	0.135	1.65±0.061	94.6±0.044
13	25.18	0.09± 0.009	5.450±0.005	0.132	0.55±0.073	95.8±0.078
17	23.24	0.35±0.09	4.110±0.049	0.145	0.93±0.012	199.3±0.066
21	21.89	0.42±0.007	3.030±0.054	0.155	2.04±0.014	45.9±0.009
25	21.14	0.36±0.009	1.040±0.50	0.170	1.15±0.010	39.2±0.100
29	20.15	0.40±0.009	4.010±0.032	0.200	1.22±0.009	30.2±0.083

Ikediobi and Oti (1983), found that the content of free amino acids, total lipids and Carotenoid decrease sharply during the pre-spouting period of D. roundata tubers and then showed a fast increase in the case of total amino acids and a rather slow increase for total lipids and Carotenoids as shown in table 2.7. The level of crude protein maintain an increase right from the onset of storage, peak during the sprouting period and declined gradually thereafter.

2.8 BIOCHEMICAL CHANGES IN YAM TUBERS DURING STORAGE

The various biochemical parameters monitored during storage of D. rotundata is given in Table 2.8. The results indicated that the starch content decreased in a faster rate in D. rotundata tubers on storage. A decrease of nearly 21 percent starch was observed after 4 months of storage. Significant decrease was observed even after 10 days of storage. The free sugar showed an increase during storage. The crude protein content of the tubers showed a gradual decrease on storage. Nearly 43 percent of the crude protein was found to be lost after a storage life of 120 days.

The data presented here clearly indicate that yams stored at ambient condition undergo significant changes in their major constituents. The reduction in starch content during storage of D. rotundata have been reported by several workers (Ikediobi and Oti, 1983; Onayemi and Idowu, 1988). On a fresh weight basis the starch reduction comes nearly to 7 percent. A reason for a faster depletion of the reserve carbohydrate in D. rotundata may be the early sprouting character.

A steep reduction of protein was observed in D. rotundata after 30th day of storage of storage and then the decrease was slow. The steep fall in protein during storage of D. rotundata have been reported by Onayemi and Idowu (1988). According to these workers 50 percent crude protein was lost by the end of 150 days storage.

TABLE 2.8: **CHANGES IN THE NUTRITIONAL COMPOSITION OF D. ROTUNDATA ON STORAGE.**

STORAGE PERIOD (DAYS)	STARCH (%)	FREE SUGARS (%)	CRUDE PROTEIN (%)	MOISTURE (%)
0	73.82 ± 0.92	4.62 ± 0.07	3.52 ± 0.04	67.1 ± 1.50
10	68.40 ± 1.05	5.02 ± 0.12	3.42 ± 0.06	61.4 ± 1.42
20	64.35 ± 1.02	5.08 ± 0.21	3.35 ± 0.04	58.5 ± 1.10
30	63.12 ± 0.94	6.25 ± 0.20	2.47 ± 0.09	56.60 ± 0.85
40	59.71 ± 0.90	6.39 ± 0.13	2.45 ± 0.06	56.40 ± 0.85
60	56.12 ± 1.12	6.43 ± 0.10	2.32 ± 0.13	49.45 ± 1.40
80	54.21 ± 1.06	7.09 ± 0.25	2.29 ± 0.12	47.20 ± 1.40
100	53.07 ± 0.92	7.16 ± 0.17	2.10 ± 0.08	44.20 ± 1.40
120	52.70 ± 0.86	7.85 ± 0.22	2.00 ± 0.04	43.10 ± 1.38

(Values are on dry weight basis)

(Source: S. Sundaresan et al.

CHAPTER 3

3.0 MATERIALS AND METHODS

Before the selection of materials for this project was made, certain factor were put into consideration.

a. LOCAL AVAILABILITY : Materials that could easily be procured locally were used for the construction though efficiency was not sacrificed for this choice.

b. ECONOMIC CONSIDERATION; The economic position of the various levels of Nigerian farmers in relation to the farming area level of development was given special consideration.

c. COST: The project aimed at minimum cost

d. EASE OF CONSTRUCTION AND MAINTENANCE : The ease of construction and maintenance of the storage structures was also given special consideration.

For any storage system to be effective, certain principles or guidelines can be enumerated as follows:

- Adequate shade should be provided
- Good ventilation
- Security against pests
- Security against thieves
- Good sanitation of the storage site and
- Storage of sound tubers

3.1 STORAGE SYSTEMS AND STRUCTURES

On the course of this experiment, three methods of storing yams were adopted. The systems were:

- Local yam barn
- improved yam barn
- Pit yam barn

The interior and the exterior view of the barn is as shown in PLATE 1 - 4

3.1.1 Local Yam Barn

The material used for the construction of this barn were:

a. Guinea Corn Stalks: These were used in constructing the entire structure after they have been cut down to equal size in height.

b. Twines: They were used in tieing the guinea corn stalks together

c. Long and Hard sticks: they were used as frame for the entire structure

The local barn has a rectangular shape with dimensions 2m wide, 3m in length and 1.8m in height. The local barn was constructed with long and hard sticks that were used as frame for the entire structure. The guinea corn stalks was than used for the roof of the barn and the wall. The entrance door was made with guinea corn stalks

3.1.2 Improved Yam Barn.

The materials used for the construction of this barn were:

a. Guinea Corn stalks: these were used in constructing the entire structure after they have been cut down to equal size in height .

b. Twines: They were used in tieing the guinea corn stalks together.

c. Hard and long sticks: they were used as frame for the entire structure.

d. Rice Straws: they were used in lining the wall and the roof of the structure.

The improved barn has a rectangular shape with dimensions 2m wide 3m in length and height of 1.8m. The improved barn was a modification of the local barn it was constructed with hard and long sticks that were used as frame for the entire structure. The guinea corn stalks were used for the roof and the wall of the barn. The rice straws were then used in lining the wall and the roof. The entrance door was made with guinea corn stalks

3.1.3. The Pit Barn

the materials used for the construction of this barn were:

a. Guinea Corn Stalks: these were used in construction the entire structure after they have been cut down to equal size in height.

b. Twines: they were used in tieing the guinea corn stalks together

c. Hard and Long sticks: they were used as frame for the entire structure.

d. Ladder: The ladder was placed inside the pit for climbing up and down the pit.

The pit barn was made simply by digging a rectangular pit with dimensions 2m wide, 3m in length and 1m deep. The height of the barn above the pit was also 1m.

The structure above the pit in the pit barn was constructed with long and hard sticks that were used as frame for the entire structure the guinea corn stalks was then used for the wall and roof of he barn. The entrance door was made with guinea corn stalks the barns were

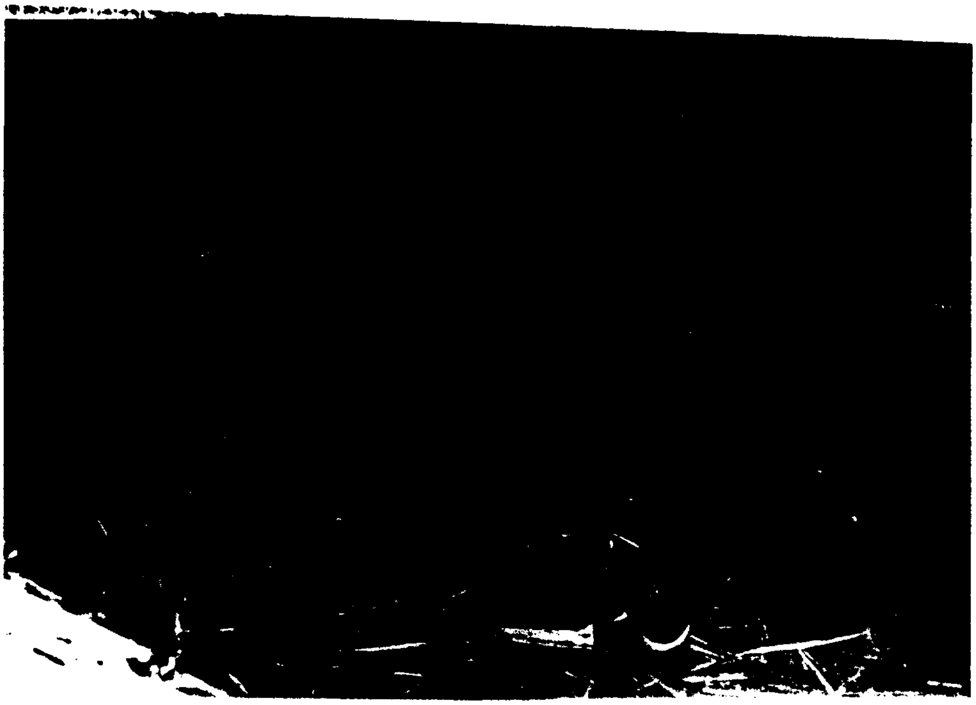

PLATE 1: INTERIOR VIEW OF PIT STORAGE BARN.

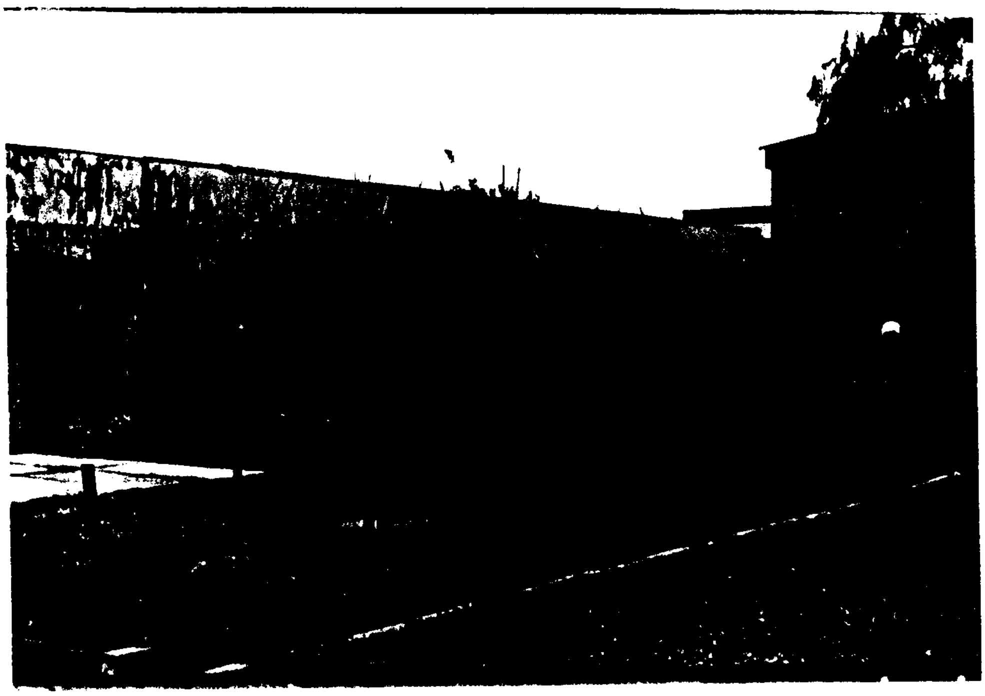

PLATE 2: EXTERIOR VIEW OF THE STORAGE BARN: LOCAL IMPROVED AND PIT BARN.

PLATE 3: INTERIOR VIEW OF THE LOCAL STORAGE BARN.

PLATE 4: INTERIOR VIEW OF THE IMPROVED STORAGE BARN.

constructed within a given experimental area in the school and fenced round with barn wire for protection against thieves and pests.

Two replace of each storage structures was built and two varieties of tuber (asuba and giwa) were purchased directly from the local farmers and were stored from February to June. The yams were sorted into different size categories and heaped at different position in the barn

3.2 EXPERIMENTAL PROCEDURE.

Above six hundred and twenty yam tuber freshly harvested were used for this experiment. One hundred and three tubers were stored inside each barn. Two varieties of yam tubers were used and they were the giwa, white yam (D. Rotundata) and the asuba.

3.2.1 Storage Measurement

Weight Measurement: Twenty yam tubers were selected in each structure and numbered from one to twenty and these tuber were weighed-by weekly using a top load weighing balance. Weighing commenced from the first day of storage till the end of the experimental period.

Temperature and Humidity Measurements: The temperature and relative humidity of the barn were measured using digital temperature and humidity recorder. The temperature and humidity readings was in degree Celsius and percentage respectively and they were measured on Mondays, Wednesdays and Fridays at 8.00am, 12pm, 4pm and 7pm each day.

3.2.2 Nutritional Value Analysis

The Nutritional quality of yam may be evaluated by chemical analysis of the food. The nutritional qualities analysed were the crude protein, free sugar and dry matter composition of the tubers. This chemical analysis was carried out in the laboratory.

3.2.3 Procedure for Dry Matter Determination

The dry matter content in yam was determined using oven method as outlined by the food and agriculture organisation (FAO) 1981. This method involves cutting thin slices of yam to know their fresh weight and then oven dried to know their final weight.

Apparatus: Six standard petri dishes, oven and electronic weighing balance

Sample Preparation: the sample preparation for the determination of dry matter content involved cutting of thin slices of yam at different portions of the yam. That is at the head, middle and tail. Thin slice are required so that they can dry quickly.

Procedure: six clean petri dishes were weighed and their weight (wi) was noted. A required gram of the prepared samples was put into each of the six petri dishes and their content was weighed (w_2). They were then put into an oven dried at 50 for 24 hours and allowed to cool. The dried sample were then weighed (w_3). The procedure for the dry matter determination was carried out in March, April, May and June.

The two varieties of yam in each barn, asuba and giwa were used in preparing the sample

CALCULATION.

$$\% \text{ Dry matter content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100\%$$

3.2.4 Procedure for the Determination of Crude Protein Content

The protein content in yam sample was determined using Kjeldahl method. This method involves three process. The digestion process to obtain a clear content of the mixture, distillation process to obtain nitrogen gas and titration process to know the volume of acid consumed.

Apparatus: kjeldahl flask, electric heater, volumetric flask, pipette, conical flask and burrette.

Reagents: Concentrated H_2SO_4, sodium hydroxide, mixed indicator, hydrochloric acid boric acid and ammonia solution.

Sample preparation: The sample preparation for the determination of crude protein content involved cutting of thin slice of the yam and placing them on a cardboard paper which has been numbered accord to the yam variety, that is A1, to A6 and G1 to G6 and were sun dried for a period of 24 hours. They were then grinded using grinding mill.

Procedure: Into a 100m Kjeldahi flask, 0.50g of the prepared samples of yam together with 20ml concentrated H_2SO_4 was measured the mixture was digested over an electric heater in a hood initially with low flame until frothing subsides and then at higher temperature until content was clear greenish the digestion was continued for further 60 minutes. The content in the flasks was allowed to cool and 15ml of water was added to it. The content was transferred carefully into a 50ml volumetric flask.

The Kjeldaj; flasks was rinsed out with distilled water the water poured into the 50ml volumetric flask.. The volume of the solution in the volumetric flask was made up to the 50ml mark with distilled water 10ml of the digest was transferred with a pipette into the Markan semimicro-nitrogen still apparatus 10m,l of 40% sodium hydroxide solution was added to the digest. A steam distilled ammonia was liberated into a 5ml boric acid solution containing 4 drops of mixed indicator taken in the conical flask. The indicator turned green and distillation was continued for 2 more minutes.

The distillate was removed and was titrated against a standard hydrochloric acid the end point was reached as the indicator changed from green through grey to definite pink. The acid consumed was noticed. A blanc was run through the whole procedure and the burrette reading was subtracted from above to get a correct volume of standard hydrochloric acid.

The fresh sample were taken for nutritional analysis on March, April and June.

CALCULATION OF % NITROGEN

$$\text{Nitrogen } \% = \frac{(v_1 - v_2) \times 14 \times 5 \times 100}{1000 \times 70 \times \textit{sample weight } (g)}$$

where V_1 is the volume of the hydrochloric acid at which the indicator changes colour with sample and ' v_2 is the volume of the acid remaining in the burrette without sample.

The percentage crude protein was calculated by multiplying % N_2 by a factor of 5.90.

3.2.5 Procedure for the Determination of Free Sugar by Benedicts Titration

The fire sugar content in yam samples was determined using Benedicts reagent method. This method involves observing the colour change when the benedict qualitative *Reagents* is added to the prepared samples.

Apparatus: Conical Flask, Filter paper, burette, pipette, porcelin dish, spatula

Reagents: Acetic acid, distilled water, benedicts qualitative reagent, sodium carbonate.

Sample Preparation: The sample preparation for the determination of free sugar content involve squeezing out the juice of fresh yam tubers into a crucibles which has been number red according to the yam variety that is A_1 to A_6 and G_1 to G_6.

Procedure: Into a clean conical flask, 10ml of prepared samples of yam together with 10ml of water and 10ml of 2% acetic acid were measured. The mixture was allowed to stand for 5 minutes. The total volume was made up to 50ml by the addition of 20ml of distilled water. The contents were mixed and filtered. The filterate was taken into the burette after which 10ml of benedict's quantitative reagent was pipetted into a porcelin dish. A spatula full of solid sodium carbonate was added to the benedict's quantitative reagent.

The mixture was heated to boiling and titrated against the filterate of prepared yam samples while continuing boiling. The blue colour gradually disappears and develops a while precipitate. The end point is when the blue colour disappears and white colour appears.

The fresh samples was taken for analysis on March, April and May.

CALCULATION:

$$\text{Percentage of Sugar} = \frac{0.050 \times D \times 1000}{y}$$

D is 20ml of distilled water added and

Y is the titre value.

3.3 NUMERICAL ESTIMATION OF WEIGHT LOSS:

Linear regression analysis was used to find an equation that best fits the measured data. To regress y on x connotes the formulation of a regression line equation of which y is the subject or is the dependent variable and x is the independent variable. The regression line equation of y and x is given by $y = a + bx$

Where b is the regression coefficient of x: a and b are constants obtained from the solution of the simultaneous equation:

$$\sum y = na + b\sum x$$

$$\sum xy = a\sum x + b\sum x^2$$

Y is the percentage weight loss and X is the storage period.

A graph of weight loss against storage period was drawn for the two varieties of yam for the three structures using the calculated values and measure values using the regression line equation.

3.4 STATISTICAL ANALYSIS

The following methods were used for the statistical analysis:

3.4.1 The Arithmetic Mean:

The arithmetic mean was used to calculate the averages in the weight of the two varieties. The means of a set of parameters $x_1, x_2, x_3, \ldots\ldots. x_n$ is denoted by $\bar{x}$

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \ldots . x_n}{N}$$

$$\frac{\sum_{j=i}^{N} x_j}{N}$$

Where N is the number of Parameter (weight).

$\sum x_i$ = Summation of individual data together.

3.4.2 **Least Significant Difference Method:**

This is the common procedure for making pair comparisons. The procedure for applying the LSD test to compare any two treatments involve the following steps:

Step 1: Compute the mean difference between the varieties / methods

$$d_{12} = \bar{x}_1 - \bar{x}_2$$

Step 2: Compute the LSD value at α level of significance as :

$$LSD_\alpha = (t_\alpha)(s\bar{d})$$

Where $s\bar{d}$ is the standard error of the mean difference and t_α is the tabular t value, from Appendix C, at α level of significance and within n = error of degree of freedom.

Step 3: Compare the mean difference computed in step 1 to the LSD value computed in step 2 and declare the varieties/ methods to be significantly different at the α level of significance if the absolute value of d_{12} is greater than the LSD value, otherwise it is not significantly different.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 WEIGHT LOSS

The percentage weight loss in each of the storage structure for the two varieties were recorded every two weeks for a period of five months. The average result is as shown in table 4.1

TABLE 4.1: **THE PERCENTAGE AVERAGE WEIGHT LOSS IN THE YAMS STORED IN THE LOCAL, IMPROVED AND PIT STORAGE STRUCTURES USING THE TWO VARIETIES**

WEEKS OF STORAGE	LOCAL BARN %WT. LOSS		IMPROVED BARN % WT. LOSS		PIT BARN % WT. LOSS	
	asuba	giwa	asuba	giwa	asuba	giwa
2 Weeks.	0	0	0	0	0	0
4 Weeks.	2.2	1.7	1.1	2.7	0.8	1.2
6 Weeks	3	3.4	2.8	5.5	3.3	3.9
8 Weeks	4.5	5.3	6.5	8.3	4.2	5.4
10 Weeks	6	7.5	7.1	9.5	5.8	7.3
12 Weeks	9.7	11.6	9.4	11.5	10.8	9.3
14 Weeks	13.4	14.1	13.6	13.1	14.2	12.4
16 Weeks	18.7	17.9	20.8	18.4	18.3	14.9
18 Weeks	18.7	20.2	21.8	21.8	21.7	21.4

From the table it can be seen that the asuba variety of yam in the pit storage structure recorded the least percentage mean weight loss for the first ten weeks. After the tenth week, yams in the local barn recorded the least weight loss value.

For the giwa variety, it can be seen that the yams in the pit storage structure recorded the least percentage mean weight loss from the first week of storage up to the end of the eighteenth week. The difference in percentage weight loss may be due to the respiratory act of the living tubers.

The average biweekly weight loss is generally higher in the giwa variety at the beginning of the storage period in the three structure while at the latter stage, the asuba variety recorded the highest biweekly weight loss.

At the end of the eighteenth weeks of storage period the tuber has lost between 18 - 22% of its initial weight. This loss is attributed to respiration, transpiration and sprout growth. Other causes of loss in yam are:

1. Losses due to insect and nematode attack and also
2. Losses due to microbiological attack

there is a linear relationship between weight loss and storage period. A linear regression equations for the three barns and the two varieties were obtained using regression analysis method.

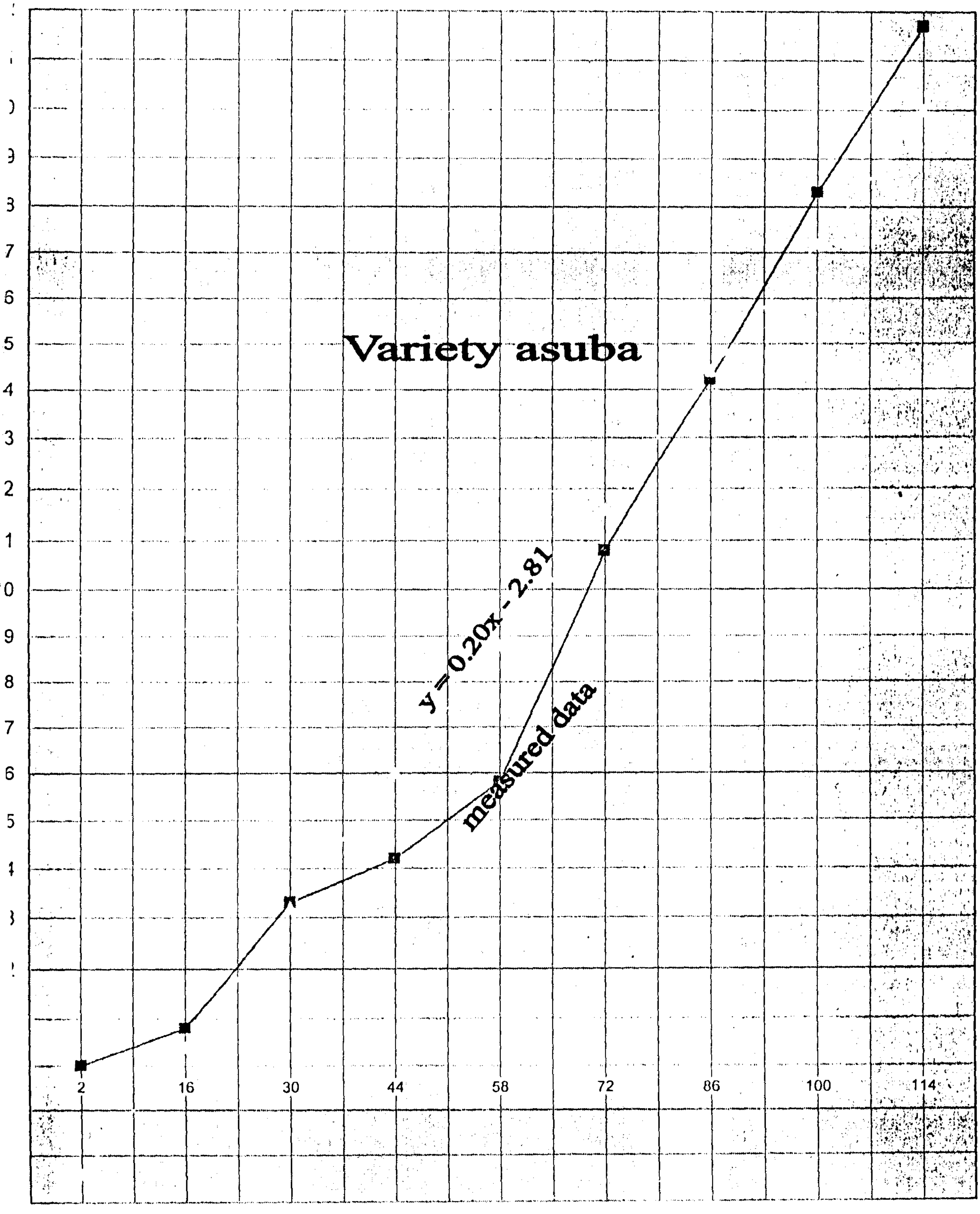

FIG 4.1: PERC. WEIGHT LOSS VERSUS STORAGE PERIOD (MEASURED AND CALCULATED VALUE)

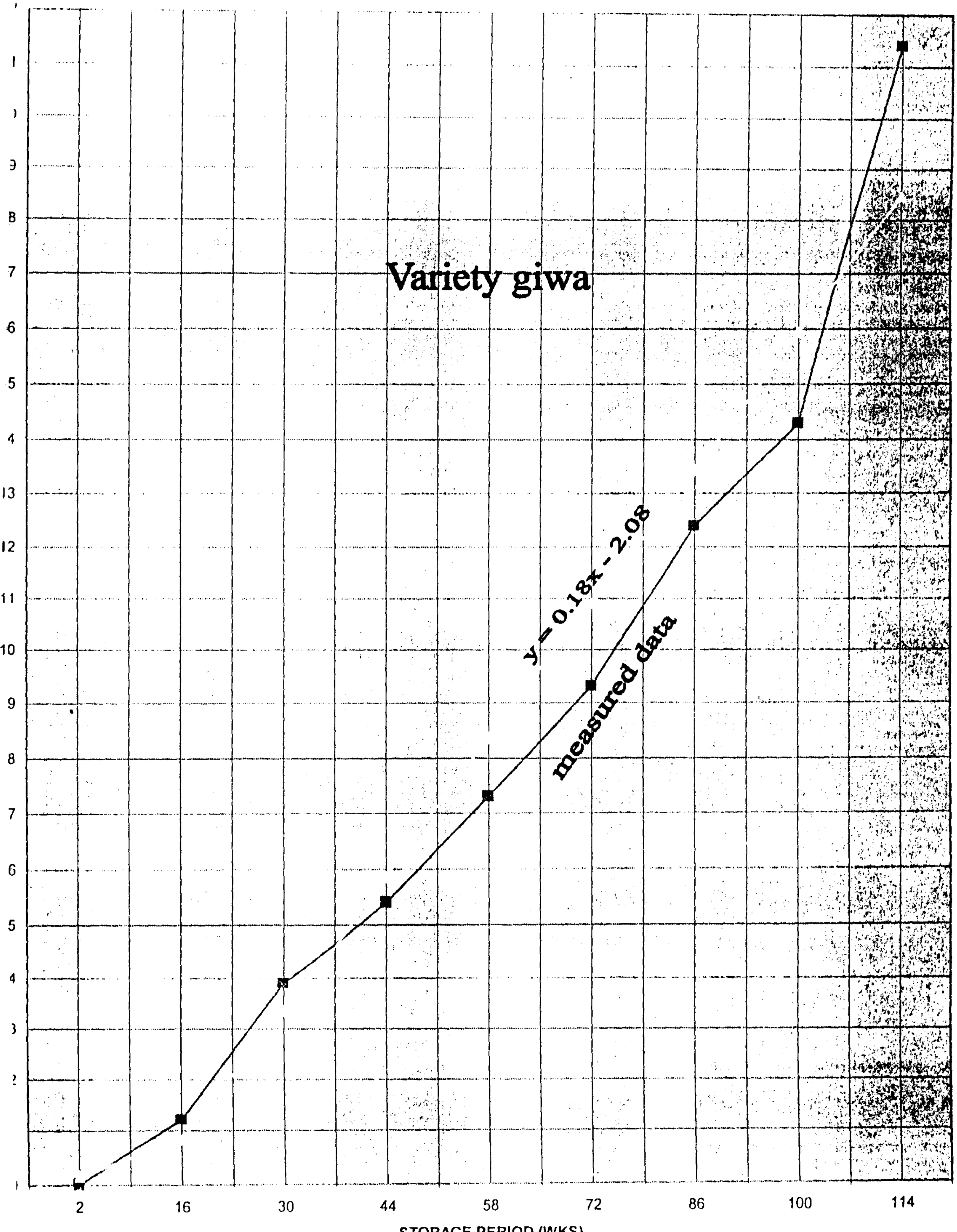

FIG 4.2: PERC. WEIGHT LOSS VERSUS STORAGE PERIOD (MEASURED AND CALCULATED VALUE)

Table 4.1b. **EMPIRICAL FORMULA FOR PREDICTING THE WEIGHT LOSS IN STORED YAMS IN DIFFERENT STORAGE STRUCTURE**

VARIETY	IMPROVED BARN	LOCAL BARN	PIT BARN
asuba	Y 0.114X + 2.62	Y 0.816X - 13.19	Y 0.20X - 2.81
giwa	Y 0.16X - 0.35	Y 0.190X - 1.94	Y 0.18X - 2.06

Figure 4.1 and 4.2 showed that there is a close relationship between the measured and calculated data and the weight loss values can be predicted using the empirical formula as given above in table 4.1b.

4.2 NUTRITIONAL CHANGES

The protein and free sugar content of the yam tubers in each storage structure was determined at the beginning at the middle and at the end of the storage period while the dry matter content was determined in the month March, April, May and June. The results is as shown in table .

Table 4.2a. **PERCENTAGE REDUCING SUGAR CONTENT FOR ASUBA AND GIWA**

PERIOD	LOCAL BARN %		IMPROVED BARN %		PIT BARN %	
	asuba	giwa	asuba	giwa	asuba	giwa
March	3.605	3.535	3.575	3.91	3.985	3.845
April	4.57	4.17	4.82	4.27	4.8	4.115
May	6.65	9.355	3.935	6.625	5.395	5.51

Table 4.2b **PERCENTAGE CRUDE PROTEIN CONTENT FOR ASUBA AND GIWA**

PERIOD	LOCAL BARN %		IMPROVED BARN %		PIT BARN %	
	asuba	giwa	asuba	giwa	asuba	giwa
March	2.23	3.48	2.02	2.271	2.64	2.933
April.	1.99	2.40	1.48	2.56	1.908	2.73
May	0.94	2.23	0.91	1.57	1.20	2.07

Table 4.2c **PERCENTAGE AVERAGE DRY MATTER CONTENT FOR ASUBA AND GIWA**

PERIOD	LOCAL BARN %		IMPROVED BARN %		PIT BARN %	
	asuba	giwa	asuba	giwa	asuba	giwa
March	44.75	38.90	44.175	41.65	40.8	40.15
April.	44.55	39.2	46.05	42.85	45.05	42.20
May	48.40	41.80	51.05	43.80	50.10	41.15
June	45.40	42.60	46.70	44.15	49.80	45.21

From the table it can be seen that the percentage reducing sugar in the two varieties is increasing every month in each storage structure except in the improved barn in which the free sugar percentage in asuba decreased from 4.82% in April to 3.935% in June.

The percentage crude protein in the two varieties is decreasing every month in each storage structure. This decrease is in accordance with the work carried out by Onayemi and Idowu (1988). According to these workers 50% crude protein was lost at the end of storage period.

It is also observed the giwa generally has higher percentage crude protein compared to asuba variety. This shows that the nutritional content of yam tubers differs in different variety. This is in agreement with the work carried out Oyenuga (1959) and Martins (1970).

The percentage dry matter in the giwa variety increases every month in the three structures. This is not in agreement with the work carried out by Ikediobi and Oti 1983,Onayemi and Idowu: 1988. According to these workers, the dry matter reduction comes nearly to 7 percent on a fresh weight basis for the asuba variety, the trend in the dry matter content was increasing every month and a fall in the value was noticed in the last month of the storage period in all the three structures. This may be due to the vigorous sprout growth in this month. Also in this month, rainfall has started and so the dry matter content decreases. The trend in this variety is partially in accordance with the work carried out by Ikediobi and Oti; 1983, Onayemi and Idowu: 1988. The findings of these workers shows a decrease in dry matter content right from the onset of storage while the trend in the dry matter content showed an increase right from the onset of storage and then a decline is noticed thereafter.

Generally the amount of dry matter content in asuba variety is higher than that giwa variety. This may be due to the smaller size of asuba and its lower amount of moisture content.

4.3 STATISTICAL ANALYSIS OF VARIANCE IN THE NUTRITIONAL CONTENT FOR THE VARIETIES OF YAM AND THE STORAGE STRUCTURE.

The statistical analysis of variance for the percentage dry matter, protein and free sugar content for the varieties and for the storage structures were analyzed using the least square difference method. The result is as shown in table 4.3.

TABLE 4.3 STATISTICAL ANALYSIS FOR THE VARIATION IN THE NUTRITIONAL VALUE IN THE VARIETIES AND FOR THE STORAGE STRUCTURES.

	DRY MATTER				CRUDE PROTEIN			FREE SUGAR		
VARIETY	Marc	April	May	June	March	April	June	March	April	June
asuba/giwa	ns	ns	xx	xx	ns	ns	xx	ns	xx	ns
local improved/pit	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

xx = Significant at 5% level ns = Not significant

from the table, it shows that is a significant difference between the varieties in their dry matter content. This happened in the month of may and June. The mean difference calculated in the dry matter content is greater than the LSD value at 5% level. The value did not show any statistically significant difference in the month of March and April.

A significant difference was observed between the varieties in their crude protein content. This happened in the month of June. The mean difference calculated in crude protein is greater than the computed LSD value at 5% level. The value did not show any significant difference in the month of March and April.

The free sugar content also shows a significant difference between the varieties. This happened in the month of May. The mean difference calculated in the free sugar is greater than the LSD value at 5% level. The value did not show any significant difference in the month of March and June.

CHAPTER FIVE

5.1 CONCLUSIONS

This project focused on the behaviour of stored yam tubers under the local, improved and pit barn storage methods. This was done to compare their results so as to know the best conditions to store the yams for them to lose veery little of their qualities.

It was observed that a lot of losses in weight occurred in all the storage methods though in variable proportions. For the first ten weeks of storage, asuba variety of yam in the pit storage recorded the least percentage mean weight loss compared to the improved and local barn. Its percentage weight lost after the tenth week was 5.8 which was 1.3 less than the improved barn and 0.2 less than the local barn. Considering only the weight losses, it is better to store in the pit for the first ten weeks or storage than any of the other two methods.

After the tenth weeks of storage up to the end of the eighteenth weeks storage period yams in the local barn recorded the least weight loss value while the weight loss in the pit increased tremendously. This could be attributed to the effect of sprouting. For the giwa variety under the same environment yams in pit storage method recorded the least percentage mean weight loss from the first week of storage up to the end of the eighteenth weeks of storage. It is therefore adviceable to store in the pit barn for a longer period of time than in any other methods considered if only loss in weight is under consideration. The weight loss recorded in both varieties for the improved barn was generally higher compare with either pit or local barn.

The nutritional changes in the two varieties of yam were monitored periodically up to five months. The dry matter content was found to be increasing except for the asuba where there was a decrease during the last month of storage. The asuba also recorded the highest value in the dry matter content. The total free sugar was found to be increasing in the two varieties except for the asuba in the improved barn where there was a decrease during the last month of storage. The crude protein showed a decrease during storage in both varieties.

Based on the findings of this project , the followings are recommended

1 Further study should be done to improve the ventilation of the improved barn.

2 In all, the behavior of stored yams in the local, improved and the pit barn was studied and compared. If yam tuber is to be stored for about five months pit method of storage is recommended. This is because the pit method of storage lose very little of their qualities.

3 Further study is to be recommended to know the nutritional qualities contained in each variety of yam so as to know which of them is good for consumption and also which is to be recommended for the farmers.

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APPENDIX A

ANALYSIS OF VARIANCE FOR PERCENTAGE PROTEIN CONTENT (VARIETIES)

MONTH	SOURCE OF VARIATION	SUM OF SOURCES	DEGREE OF FREEDOM	MEAN DIFFERENCE	LSD VALUES	REMARK
March	Between varieties	1.46	6	0.59	0.75 1.13	ns
April	Between varieties	1.09	6	0.77	0.81 0.87	ns
June	Between varieties	1.50	6	0.94	0.90 1.47	xx ns

ANALYSIS OF VARIANCE FOR PERCENTAGE FREE SUGAR CONTENT (VARIETIES)

MONTH	SOURCE OF VARIATION	SUM OF SOURCES	DEGREE OF FREEDOM	MEAN DIFFERENCE	LSD VALUES	REMARK
March	Between varieties	0.15	6	0.04	0.21 0.32	ns
April	Between varieties	0.44	6	0.54	0.37 0.59	xx ns
June	Between varieties	16.52	6	1.83	2.19 3.32	ns ns

ANALYSIS OF VARIANCE FOR PERCENTAGE DRY MATTER CONTENT (VARIETIES)

MONTH	SOURCE OF VARIATION	SUM OF SOURCES	DEGREE OF FREEDOM	MEAN DIFFERENCE	LSD VALUES	REMARK
March	Between varieties	25.87	6	3.05	3.66 5.54	ns
April	Between varieties	30.4	6	3.82	3.95 5.99	ns
May	Between varieties	94.05	6	7.61	7.60 11.60	xx ns
June	Between Varieties	30.13	6	3.41	3.40 5.20	xx ns

ns = Not Significant
xx = Significantly different at 5% level

APPENDIX B

ANALYSIS OF VARIANCE FOR PERCENTAGE PROTEIN CONTENT (STRUCTURE)

MONTH	SOURCE OF VARIATION	SUM OF SOURCES	DEGREE OF FREEDOM	MEAN DIFFERENCE	LSD VALUES	REMARK
March	Between local and improved	1.32	2	0.71	2.65 6.12	ns
	Between pit and improved	0.49	2	0.64	1.95 4.49	ns
	Between local and pit	0.82	2	0.07	1.43 3.29	ns
April	Between local and improved	0.69	2	0.18	1.29 2.63	ns
	Between pit and improved	1.01	2	0.3	0.96 2.22	ns
	Between local and pit	0.44	2	0.12	0.68 1.57	ns
June	Between local and improved	1.16	2	0.35	1.39 3.22	ns
	Between pit and improved	0.94	2	0.4	1.22 2.81	ns
	Between local and pit	1.2	2	0.05	0.53 1.22	ns

ns = Not Significant

APPENDIX C

ANALYSIS OF VARIANCE FOR PERCENTAGE FREE SUGAR CONTENT (STRUCTURE)

MONTH	SOURCE OF VARIATION	SUM OF SOURCES	DEGREE OF FREEDOM	MEAN DIFFERENCE	LSD VALUES	REMARK
March	Between local and improved	0.06	2	0.17	0.53 1.22	ns
	Between pit and improved	0.05	2	0.18	0.61 1.40	ns
	Between local and pit	0.13	2	0.35	1.05 2.43	ns
April	Between local and improved	0.25	2	0.18	0.53 1.22	ns
	Between pit and improved	0.34	2	0.01	0.61 1.41	ns
	Between local and pit	0.27	2	0.19	0.43 0.99	ns
June	Between local and improved	14.62	2	2.72	8.25 19.04	ns
	Between pit and improved	3.00	2	0.17	3.07 7.09	ns
	Between local and pit	10.17	2	2.91	17.62 20.08	ns

ns = Not Significant

APPENDIX D

ANALYSIS OF VARIANCE FOR PERCENTAGE DRY MATTER CONTENT (STRUCTURE)

MONTH	SOURCE OF VARIATION	SUM OF SOURCES	DEGREE OF FREEDOM	MEAN DIFFERENCE	LSD VALUES	REMARK
March	Between local and improved	21.05	2	1.08	5.69 13.13	ns
	Between pit and improved	2.90	2	2.38	3.04 7.02	ns
	Between local and pit	19.08	2	1.30	8.71 20.08	ns
April	Between local and improved	26.05	2	2.57	8.83 19.19	ns
	Between pit and improved	9.86	2	0.82	2.55 5.87	ns
	Between local and pit	21.43	2	1.75	6.54 15.08	ns
May	Between local and improved	53.46	2	2.33	7.15 16.49	ns
	Between pit and improved	69.61	2	1.8	6.055 13.97	ns
	Between local and pit	62.08	2	0.53	3.88 8.96	ns
June	Between local and improved	9.20	2	1.43	4.35 10.02	ns
	Between pit and improved	18.11	2	2.08	7.04 16.25	ns
	Between local and pit	26.73	2	3.51	10.60 24.45	ns

ns = Not Significant.