CONSTRUCTION OF AN IMPROVED GRAIN STORAGE STRUCTURE IN NIGER STATE.

BY

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DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY FEDERAL UNIVERSITY OF TECHNOLOGY MINNA.

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DEDICATION

This project is dedicated to my parents whose efforts towards the up-liftment of my life cannot be over emphasized.

DECLARATION

I hereby declare that this work is on original work of mine and has never been presented elsewhere for the award of certificate. Information derived from published and unpublished works of others have been acknowledged in the text.

....
Student signature

Date..................................

The above declaration is confirmed

....
Mrs. Z. D Osunde

Date:...................................

CERTIFICATION

The undersigned certify that they have read and recommended to the school of engineering and engineering technology for Acceptance, a project titled **"CONSTRUCTION OF AN IMPROVED GRAIN STORAGE STURCTURE IN NIGER STATE"** submitted by ***KUDU A. MOHAMMED*** in partial fulfillment of the requirement for the award Post Graduate Diploma.

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ACKNOWLEDGEMENT

My unlimited thanks goes to Almighty Allah for giving me strength, courage and perseverance – especially throughout this trying period of my academic pursuance, more importantly in writing this project.

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I wish to extent my thanks to all farmers in my study area for their co-operation.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES/PLATES

ABSTRACT

"Rhumbu" is a local structure use for the storage of threshed and unthreshed Grains by local farmers. Generally, storage structures and products must provide features that are conducive to good preservation. These features which includes structural defects such as leakage and cracking on structures can be traced to the type of materials use for construction. This work which is aimed at improving the local grain storage structure **"Rhumbu"** was approached by surveying three selected local government areas in Niger State; to investigate on the local construction material and the problems associated to the used of them. The study reveals that clay soils in addition to dry grass are the major construction material for "Rhumbu". It was also noticed that the major problem associated to the use of these materials is frequent cracking of the structure. Based on the survey result model of two storage structures were constructed and evaluated. The models are; model of existing local grain storage structure and model of an improved grain storage structure. Evaluation of these two models shows that rice hose ashes (agricultural waste) in addition to clay soil and dry grass eliminates the frequent cracks experienced on the Rhumbu. Based on these discoveries, farmers were advised to adopt the used of rice hose ashes in addition to clay soil and grass for the construction of an improved local grain storage structure (Rhumbu).

CHAPTER ONE

1.0 INTRODUCTION

Grains, otherwise known as "durable commodities" are food products which man has to preserve in order to feed. Compared with other farm produce, grains are easy store provided they are adequately dried before storage. (Olajide 1998)

Most cereals crops are seasonal, which implies that the goods produced in one harvest period which last for few weeks has to be spread out until the next harvest. The grains which are either cereals or legumes can be preserved for several months or even for a number of years if only they are stored in adequate structures. Storage is done to ensure constant supply of high quality food anytime it is needed. The primary aim in any storage system must be to maintain the condition of the crops as long as possible.

Different storage containers and methods are used to store grain. The type of storage structure to be used is largely dictated by a number of factors. Some of these factors are:-

a) Quality of grain to be stored

b) Type and variety of grain to be stored

c) The cost of structure or container.

d) The form in which the grain is to be stored i.e. threshed or unthreshed.

There is a wide range of grain storage structures. However, many of these have limitation particularly in durability. (Osunde et al 1996).

The storage of grains for long periods may not be achieved if there are no adequate or proper storage structures in place. Since inadequate structures for the storage of grains can be responsible for food damage, it is therefore important to bring this to a minimum by improving the existing local structures in places.

1.1 OBJECTIVE OF STUDY

Most farmers store their grains (threshed) in containers like sacks, drums e.t.c and keep them in their dwellings while the unthreshed grains like Guinea corn, millet, paddy rice, are kept in local storage structure called "Rhumbu". This project is aimed at improving the existing local storage structure by making it conducive accommodate all categories of grains by using the available, local and affordable material for construction.

1.2 JUSTIFICATION

Observations have been made that inspite of the increase in production of grains, the benefit of the increase have not been felt. This is because of high level of food damage which occurs during storage. Although grains are lost after harvest and processing but the major reason for food loss as a result of damages is during storage. Storage structures still suffers neglect and this can be attributed to ignorance or inadequate knowledge for the simple, suitable and affordable storage structure.

The justification of this project work therefore, lies in the effort to examine the existing or local storage structures with a view to identify the storage problem areas and suggesting possible solution to grain storage structures.

1.3 LIMITATIONS

This work is limited to grain storage problems, storage condition and storage structures available in Niger State and possible ways of improving on the existing storage structures.

1.4 PROBLEMS ENCOUNTERED:-

This questionnaire approach method was carried out on a small group (sample) of villages chosen at random from large group (sample) of village. It is hoped that the chosen will tend to possess the same characteristics as the larger group of villages. However, two problems were encountered during this investigation.

a. Language:

In some Gwari speaking areas, the illiterates needs or requires an interpreter whom they know very well before co-operating to respond to the questions before them.

b. Photograph:-

Although few pictures can be seen, some villages refuse the taking of photographs.

CHAPTER TWO

2.0 LITERATURE REVIEW:

Storage technology at the grass root otherwise called "subsistence level grain storage", constitute the most popular aspect of food storage methods. Storage at this level could be before and after threshing. The unthreshed grains mainly maize millet, G/corn e.t.c are hung on trees, on raised flat forms, heap on crib or even boundled together and stored in antics or living houses, while the threshed which could be regarded as processed are stored in guards, calabashes, drums, rhumbus, kerozine time e.t.c. (Okusan 1994)

2.1 TERMS:-

1. **Moisture content:-** The moisture content of a product is expressed as the percentage of the wet weight.

   $$\text{Moisture content (\%)} = \frac{\text{weight of water in moist product}}{\text{weight of the moist product}} \times 100$$

2. **Relative humidity:-** The relative humidity is a percentage measurement of the amount of moisture actually in the air as compared to maximum amount of moisture which air could hold at that temperature.

   $$\text{Relative humidity:-} \frac{\text{Amount of water vapour present in the air}}{\text{Max. amount of water vapour that air that temperature can contain.}} \times 100$$

3. **The moisture/dry matter ratio:-** Is the ratio between the weight of water contained in the product and the dry matter weight.

4. **The moisture/wet matter ratio:-** Is the ratio between the weight of water contained in the product and the total weight of the product (or the dry matter weight plus the weight of water).

2.2 STORAGE CONDITIONS:-

Product can be stored in many different kinds of storage containers varying from earthen guards, baskets, cribs and such like, to big metals or cement silos. It is emphasised that every storage container, no matter what it looks like or made if should keep the product dry and cool. That is why in one storage container only uniform batches should be stored.

DRYING / DRYING METHODS

The aim of grain drying is to separate and remove free water from the solid matter. Since moisture is a key factor in the deterioration of grain, it is important both to store grain whose moisture content is sufficiently low and to maintain that moisture content at the same level and even reduce it further, throughout the storage period.

At farm level, drying starts at the "standing crop" stage, applies only to limited quantities, uses rudimentary facilities and involves largely unthreshed crops, while in the modern, centralized storage facilities/drying are carried out on tonnage.

2.2.1 NATURAL DRYING

Natural drying methods use the dehydrating effect of solar heat or dry air, without employing artificial sources of heat. This type of drying is carried out in regions with a dry climate, in which the rainy season seldom exceeds four months, the rest of the year, the sky is clear, daytime temperatures are high, air humidity is relatively low, the crop reaches maturity at the start of dry season, and so drying may begin prior to harvesting and continue in the drying areas. Normally, if the grains have been sufficiently dried and is stored under the right conditions, there is no risk in terms of moisture until the next rain.

2.2.2 ARTIFICIAL DRYING

In moist tropical or equatorial regions, natural drying proves inadequate because the humidity of the air is too high. Thus, source of heat is employ for drying can be lighting fire under grids or the use of dryers.

2.3 METHODS OF FOOD STORAGE:-

Storage methods can be divided into airtight and non-airtight storage. Airtight storage can be achieved sing posts, and gourds that are treated with linseed oil, pitch, bitumen or any thick substance which will stick to it. Other airtight methods include plastic bags, pusabins, oil drums, metal silos, under ground pits and brick or concrete silos which are specially treated with water proof mortar or water proof paints. The lid and out flow opening, should be covered with rubber or sealed with mud, tar, cowling or wax.

This method (airtight) cheaply eradicates insects and prevents moist outside air from gaining access. In this storage process, oxygen is used and carbon dioxide is formed which results in death of insects presents.

Completely airtight storage is difficult to attain because it does not allow:-

1. The weekly inspection of stored product.
2. The regularly use of the stock for food.

2.3.1 <u>FAMILY LEVEL STORAGE SYSTEM</u>

At the family level, the quantity of grains usually stored is not more than 3-5 bags. Maize constitute about 90% of the grains, Guinea corn about 95% of the grains and rice about 60% of grains stored at the family level. Storage at this level is mostly in kerosene tins, big glass bottles or clean drums filled to the brim and sealed off. Grains are also stored in polythene bags with the open and end tied firmly after filling.

To kill any insect already in the grain, on tablet of Aluminium phosphate is enclosed in an enveloped and inserted in the grain before it is sealed off for storage and the content is emptied and exposed to the air for about 24 hours before consumption. (Anonymous 1982)

FARM LEVEL STORAGE SYSTEM

This is the storage technology of the grass root and it constitutes the most popular aspect of food storage methods. Storage at this level is either before or after threshing. The unthreshed grain and legumes mainly maize, G/corn, millet, rice, beans and cow-pea are hung on trees or raised platforms or simply heaped on the ground, either arrange in a special way mostly radially around a shade or just a heap in crib or bundled together and stored in artics of living losses.

The threshed grain could be regarded as processed and these are stored in guards, pots, calabashes, drums, pits, sacks, kerosene tins polythene bags as shown in figure 1 – 4.

FIG. 1 Traditional Pot

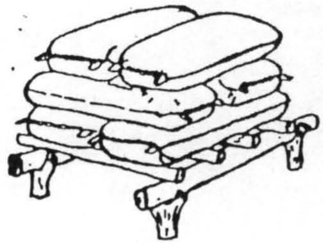


Fig. 2. Traditional Sacks

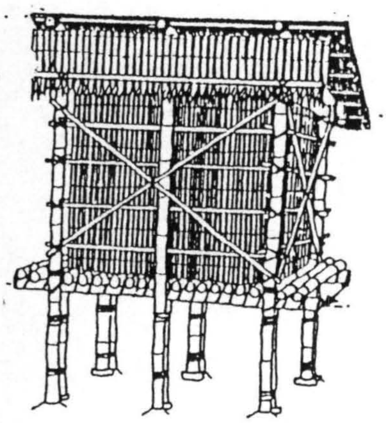


Fig. 3. Maize crib made of Bamboo

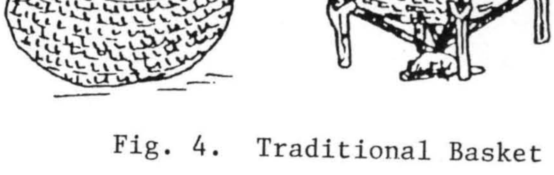


Fig. 4. Traditional Basket

2.4 STORAGE STRUCTURES

In this study, the grain storage structures in Niger State are grouped as follows:-

i) Open structures

ii) Enclosed structures

iii) Containers.

2.4.1 OPEN STRUCTURES

A) **Aerial Storage:-** Unshucked maize cobs and other unthreshed cereals are suspended in bunches using rope or plant materials, from the branches of trees or the top of poles driven into the ground close to the village. The grain usually dry in the air and the sum until it is gradually consumed by the farmer and his family. This simple approach requires no structure but applies only to small quantities of grains. It is also applicable only to cases where there is no theft problem and threat posed by birds and rodents. Jean Appert (1987).

B) **STORAGE ON THE GROUND:-**

This is for temporary storage, following on immediately from harvesting and lasting only a few days, either because the farmer has not had time to bring in what he has harvested or because he wants to let it dry in this manner for a while if there s not prospect of rain. Although, during this period, farmers experience appreciable losses no matter how short (time), it is very much in practice. Jean appert (1987)

C. **PLATFORMS:-** Platforms are four-cornered or circular racks made of branches covered with stem, leaves or grass, usually fixed more than two metres from the ground to post consisting of large branches driven into the ground. On these platforms, the grain is preserved, either in containers placed on top, or bulk unthreshed grains in heaps or regular layers. The platforms which are completely covered with detachable straw root that can be lifted off from time to time serves as a storage structure and dry facility.

D. **CRIBS:-** Cribs are parallelipedal structures with ventilated sides made of bamboo, grass stalks or even wire netting and facing such a way that the prevailing winds blow perpendicular to the length. A corrugated iron roof with a generous overhang protects the whole structure from slanting rain. The floor, which is usually elevated from the ground, is made of wood and attached to the posts. The floor supports the grain and keeps them away from dampness of the ground. Cob maize and paddy rice are usually stored in this structure. Jean appert (1987).

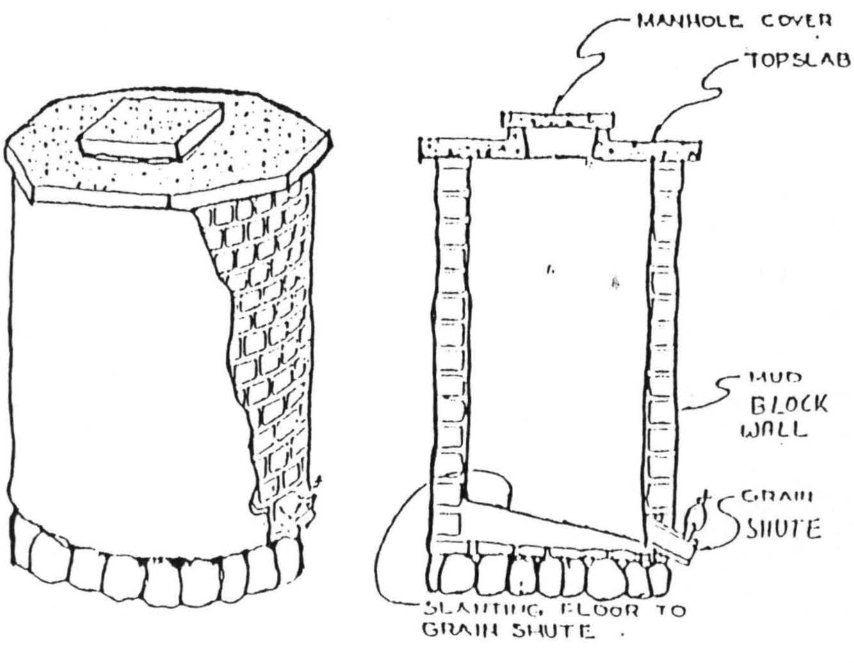
2.4.2 ENCLOSED STRUCTURE:

A) **Rhumbu:-** This are either roughly cylindrical in shape or flask shaped tapering at one end. The floor is usually raised slightly from the ground to prevent it from rain tyrants, rodents, insects, soil moisture and to facilitate the process of unloading the structure, which is normally done by gravity. It is good for storage of both threshed and unthreshed grain.

B) **Ware House:-** These are used mainly for the storage and physical protection of goods. The produce are already bagged before storage in stores or ware houses. The construction of warehouses is a specialized function, which must require the services of skilled engineers.

C) **Silo:-** Silos are of different types but the most common are the inert gas silos, conventional silo in which grains can be stored loosely in bulk without putting them in bags. Other forms of silos are fabricated from metals (aluminium, zinc e.t.c.) on reinforced concrete platforms of various designs and configurations. The silo itself is usually cylindrical in shape but this is not to say that other shapes are not available. (Olajide S. 1998)

Figure 5 and 6 shows an improved mud block silo and sheet metal silo respectively.



a. outside view b. cross section

Fig. 5: Improved mud block silo

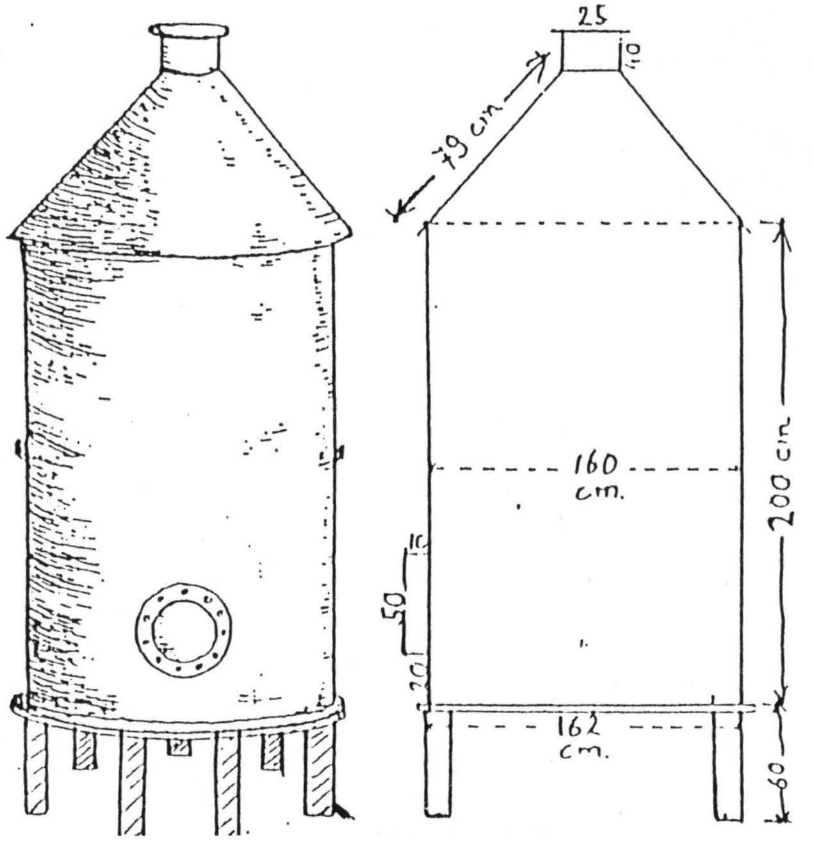
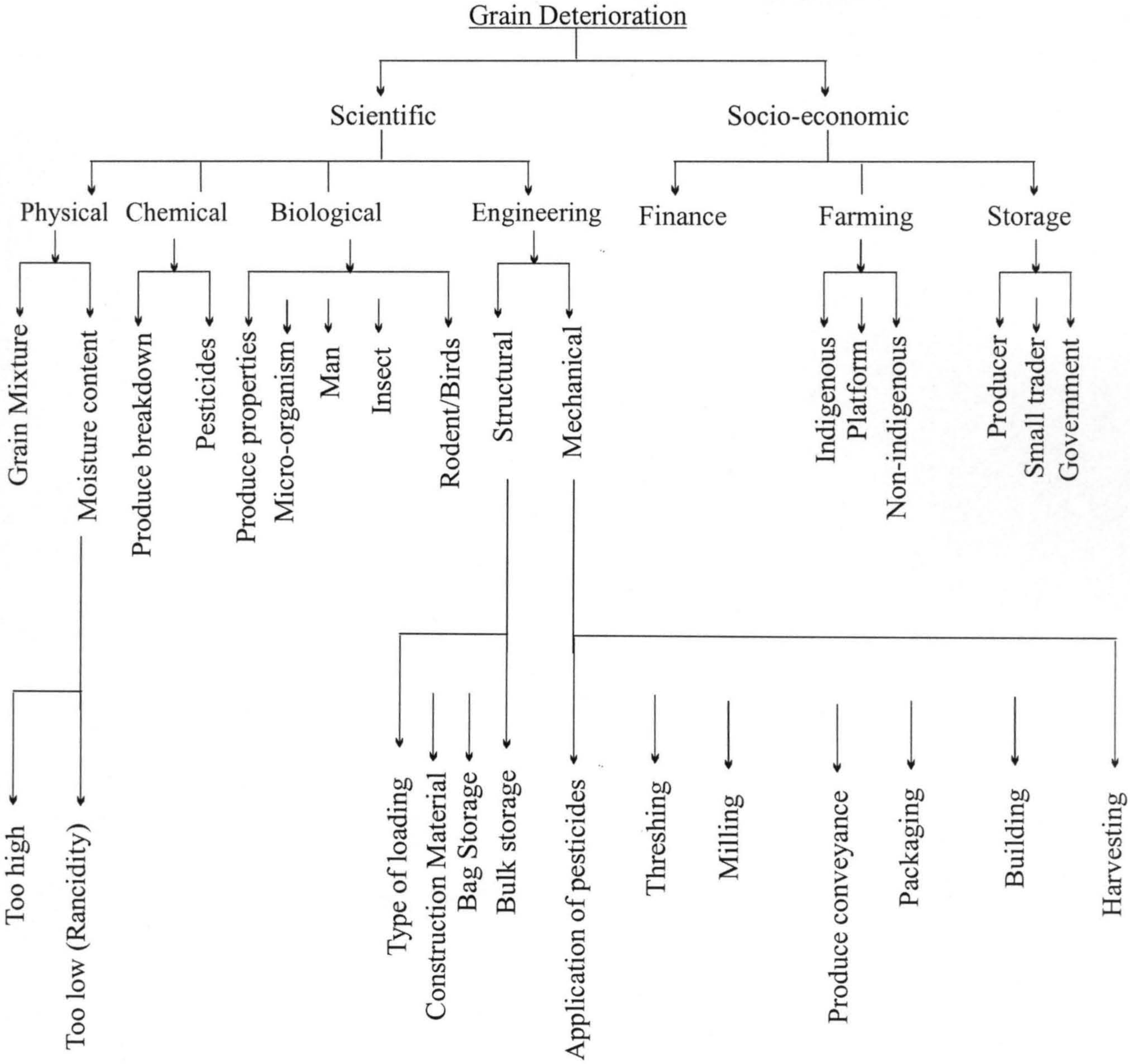


Fig. 6: Sheet metal silo (3 tons)

2.5 STORAGE PROBLEMS

The major problem in all storage operations is the maintenance of product quality during the storage period. The factors responsible for quality deterioration are divided into three major groups. These could be physical, chemical and biological in nature. Each of these groups may be from either internal or external sources. This is represented in the figure 7 below:

Figure 7 Deterioration of Food Stored Product.



Source: AJISEGIRI (2001)

2.5.1 STORED PRODUCT DETERIORATION (AGENCY AND CAUSES)

The rate of product susceptibility to deterioration depends, apart from handling, storage and processing, on man and crop.

The deterioration of stored food stuffs is due to a number of interrelated factors which can be modified by man either by improving their effects, through negligence, ignorance or error, or by limiting or nullifying their impact by prudent measures and good store hygiene. There is a whole range of physical, chemical and biological phenomena which remain constant and with which it is essential to be familiar if an understanding is to be gained of why crops may deteriorate.

Deterioration of stored food stuffs is caused by various factor;-

i) Physical:- Temperature, humidity water and gas.

ii) Biological:- Microflora, (Bacteria) arthropods (insects) vertebrates (birds).

iii) Technical:- Storage (condition, method, duration) and state of the grain.

(A) **TEMPERATURE:-**

Between the water content of the grain and the humidity of the air, there is a constant relationship, which depends on temperature. The effect of temperature is to modify air relative humidity since worm air absorbs much more water than cold air. Thus, when the rays of the sun cause the air in a store to heat up, its relative humidity falls and it therefore absorbs part of the water from the grain, as the grain's mass does not warm up as quickly.

Temperature and humidity affect various biological organisms present in the extent and speed off their development. The thermal optimum for most store insects and micro organisms is around 30ºC below 18ºC, their development slows down or even ceases altogether, and the temperature in excess of 35ºC is lethal for certain species.

(B) **RELATIVE HUMIDITY**

Between the moisture content of grain and that of the air, there is a constant relationship that is a function of temperature. The "moisture content/relative humidity equilibration pattern.

When the air is dry, the grain loses moisture to the ambient air; if it is damp, the grain absorbs moisture from it. These exchanges occur in either direction until a balance is achieved.

The time needed for the balance to establish itself and the direction in which the exchange takes place depends on various conditions, such as the case with which the air can circulate through the grain. If the grain is stored in such away that there is poor air circulation, the balance will be closed to the water content of the grain. Alternatively, if there is good circulation of the air around the product, it is the water content of the grain, which will depend on the relative humidity of the atmosphere.

(C) MOISTURE CONTENT

As moisture content is rarely uniformly distributed in stored products, initiation of decay by degradation agent is very likely for the products not properly dried. An increase in moisture content at a local region may cause pockets of localized increased moisture content regions where decay and growth could start, stabilizes and spread to other regions. In grain storage, moisture content below 10% wet-basis deters most insects from feeding on the grains while the moisture content of 13% and below prevents the growth of most microorganisms and the attack of mites.

2.5.2 FACTORS INFLUENCING MOISTURE CONTENT DISTRIBUTION WITHIN STORED PRODUCE.

One or a combination of the following reasons could cause the inequality of moisture distribution in the bulk storage:-

(i) Variation in absorption/retention capacity among products due to product variation (Aniso tropic nature of biological materials).

(ii) Variation in sizes, porosity, shape and maturity rates. Compactness and bulk density within the same species.

(iii) Peculiarity of the internal composition of each produce due to cell specialization during growth.

(iv) Variation in relative humidity of the system or surrounding.

(v) Generated heat due to bio-activities of both the product and other external sources.

(vi) Condition and orientation of storage or holding structure.

(vii) Segregation of product during loading.

(viii) Variation of thermal conductivity with moisture content.

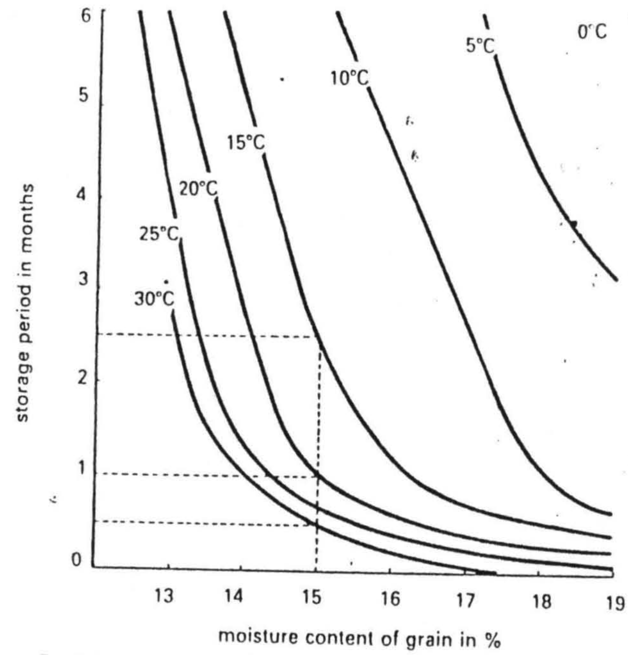
(ix) The non-uniformity of epicarps thickness of most products

(x) Variation in mechanical injuries sustained during processing.

The list given is by no means exhaustive. It could then be realised how sensitive produce is to moisture content and how easily this could lead to product damage. Ajisegiri (2001).

It is essential to know the water or moisture content of each batch of grain entering a store in order to determine whether the produce is sufficiently dry to keep properly or whether arrangement need to be made for drying. Figure 8 below shows storage time as a function of temperature and moisture content of the grain.

Fig (8)



For instance, a grain whose moisture content is 15% will keep for 2½ months at 15°C, but only one month at 20°C and 15 days at 30°C.

Table 1

Maximum Moisture content for long term storage	
Non-oil food products	Oil food products
Rice – 13%	Ground nuts (shelled) – 7%
Maize – 13%	Copra – 7%
Wheat 13%	Palm kernel – 5%
Paddy – 14%	Cotton seed – 10%
Millet - 16%	Soy beans – 13%

Above shows the maximum moisture content for long term storage of non-oil and oil food (grains) product. J. Hayma (1995).

2.6 LOCAL AVAILABLE MATERIALS:-

Local available material for construction of local grain storage structure includes clay soils, stones, rice horse or straws and locally made sun dried bricks.

2.6.1 CLAY:-

A very good quality clay material is available in Niger State and has traditionally been used as a building material. Clay soils locally treated are laid in-situ.

In local construction, the following qualities of clay materials are expected.

i. The clay must be cohesive and have high plasticity
ii. The clay has to be fine smooth and uniform
iii. It should also be free from impurities such as broken titles, roots, leathers e.t.c.
iv. It should be possible to roll it in hands into very thin cylinders, which do not break when bent into rings.
v. Its water resistance must also be satisfactory.

2.6.2 STONE:-

Good quality hard stones are found not only in Niger State but in almost all parts of the country. Stones are used for the construction of foundations for clay/straw silos. (Rhumbu) and other structures as well. It is found to be very expensive to transport when it is not close to the construction site.

2.6.3 STRAW AND FIBRE MATERIALS:-

Straw is an important ingredient in the construction of clay/straw silos. Where straw is normally mixed with clay in weight proportion 1:7 i.e. one part of rice straw to seven parts of clay material.

"Rice straw has a mean breaking strength or tensile strength of 7.6/136kg in 1/20 number of straws. It is mostly used for the construction of silo or (Rhumbu). The strength is sufficient for this purpose. F.A.O (1982).

2.6.4 SUN DRIED BRICKS:-

Bricks are locally manufactured for the construction of clay/straw silos. The clay/straw mixture when treated locally are mould into various sizes and shaped and sun dried for days. The average size is found to be 200 x 120 x 100mm. The quantity to be used per metre square of area usually depends on the brick size.

CHAPTER THREE

3.0 METHODOLOGY

This chapter clearly illustrates the method of data collection through surveys and observations.

3.1 SURVEY WORK:-

A survey conducted using the attached sample of questionnaire (Appendix 1) to find the problems associated with the existing local grain storage structure "Rhumbu" and also to further investigate on the types of local available construction materials used by local farmers. For this work, three local government areas within Niger State were visited and five villages selected in each local government. Two households in each village responded to the questionnaire, which brings to a total of thirty respondents.

Questionnaire were distributed to respondents who were able to read and write while an interpreter assisted those who could not read and write. Questions were read to them and there responses were filled by the interviewer.

3.2 AREA COVERAGE:-

This investigation covers the following local government areas and their respective villages.

A. Minna West Local Government Area:-

1. Gidan Mnagoro
2. Garatu
3. Maraya
4. Padukoi
5. Sabon gida

B. Gbako Local Government Area:-

1. Mungorota
2. Ndakama
3. Ndaruka
4. Ewonko
5. Yabatagi

C. Lavun Local Government Area

1. Sacci
2. Ndawangwa
3. Nnafene
4. Ndaloke
5. Chanchaga

3.3. CONSTRUCTION OF MODEL STRUCTURES:-

Based on observation and surveys work conducted, a model of an improved grain storage structure was built and evaluated along side with a model of commonly used structure.

3.3.1 CONSTRUCTION MATERIALS:-

The major construction material used by farmers for the construction of local grain storage is clay in addition to dry grass or rice horse. The other material added to clay varies from village to village. Addition of dry grass to clay soil was observed as commonly used construction materials.

The above two construction materials seems to play a very important roll, therefore the need to improve on these materials arises. Based on these, two different structures were constructed and evaluated.

3.3.2 RICE HUSK ASHES AS A CONSTRUCTION MATERIAL

Investigations reveals that addition of other materials like rice husk (RH) dry grass DG to clay soils for local construction increase the structural strength. Rice husk is an agricultural waste and available in abundant, which can also be utilized as construction materials. It was used to replace cement in concrete. Amah (1999).

Construction of an improved grain storage structure was based on ideas borrowed from the above-mentioned reference.

3.3.3 MODEL OF LOCAL GRAIN STORAGE STRUCTURE (RHUMBU)

It became very necessary to produce and observe from a model, the actual behaviour of clay materials mixed with dry grass and exposed to certain weather conditions.

Clay soils materials and dry grass are collected from source and clay was soak for about 24 hours with water while the dry grass collected are broken into small pieces. The broken pieces of dry grass are then mixed with soaked clay thoroughly until sign of dry grass are visible in the mixture and then left for another 24 hours. Side by side with water, the mixture was used to cast the base with stone as support and the top cover with an opening. The two units were allow to dry for 24 hours before connecting them together to make a whole and to complete construction. The finished model was expose to sun dry between 1.00am in morning to 4.00pm in the evening for a minimum period of seven days.

3.3.4 MODEL OF AN IMPROVE STRUCTURE:-

Model of an improve grain storage structure was done using additional material that is, clay soil + dry grass + rice husk ashes mixed together in proportion by volume of 1:1:3 ratios. One part of dry grasses to one part rice husk ashes to three parts of clay soil. The construction procedure remains the same but the rice hose ashes were prepared as follows.

Paddy rice waste (Rice husk) was collected from source and arranged in a very clean place in heaps and was set on fine to burn. The material was allow to burn completely to ashes before spreading for cooling and sieved in order to remove the unwanted impurities. These was then collected and batched into ratio as earlier described and the construction of an improve grain structure was completed.

3.4 METHODS

After the construction, the two structures were allowed to dry under the sum for 7 days. During these period the structures were visually evaluated. These evaluations include rate of drying, appearance of cracks, smoothness or roughness of the surface. When the models were fully ready, the temperature and humidity of the two structures were monitored hourly for two days and average of the two days was computed. Guinea corn was later stored in the models and the moisture content was monitored on weekly basis.

3.5 SHAPE AND CAPACITIES OF STRUCTURES

From observations, most of the "Rhumbu" visited in the study area are conical in shape. Capacities of conical structures are computed using the formula below

$$V = \frac{\Pi R^2 H}{3}$$

Where V = Volume
R = radius of the structure
H = Height of the structure.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 PHOTOGRAPHS

Plate 1 and 2 show the commonly used grain storage structures in the study area. All the structures observed have clay as a major construction material, though the finishing varies from village to village. A typical grain storage structure with a doom shape roof and chicken cage shown in plate 1 was taken at Yabatagi in Gbako local Government area of Niger State.

PLATE 1

Local grain storage structure at Yabatagi in Niger State.

The storage structure Plate 2 is use for storing mainly Guinea corn and millet, it has doom shape finish with zinc roof sheet as an additional protector from rain. The Photograph (Plate 2) was at Ndaloke in lavun local government area of Niger State.

PLATE 2

Local grain storage structure at Ndaloke in Niger State

4.2. QUESTIONAIRE ANALYSIS

Question on data collection forms Appendix 1 was analysed based on the information and the results were tabulated as follows:-

4.2.1 MAJOR GRAIN STORED IN PERCENTAGE %

Table 2 shows the major grain stored in the survey area and from the table Guinea corn is the major grain stored with 46.15%, followed by millet, maize and rice on the least.

Table 2 Major Grains Stored

Types of Grain Stored	Guinea Corn	Millet	Maize	Rice
Percentage (%)	46.15%	21.54%	20%	12.31%

Source:- Questionnaire

4.2.2 TYPE OF STORAGE STRUCTURE:-

Table 3 shows the type of storage structures observed majority of which are thatched roof shape which are thatched roof shape which constitute about 62.16%. Most thatched roof structures are use for storage of unthreshed grains followed by doom shape structures mostly use for threshed grain.

Table 3 **Types of storage structure**

Type of structure	Thatched roof shape	Doom roof shape
Percentage (%)	62.16%	37.84%

Source:- Questionnaire

4.2.3 AVERAGE SIZE (CAPACITY)

Table 4 shows the capacities ranging between $1.5m^3$ and $4m^3$ with 66.62 (%) percent followed by $4.0m^3$ and above range with 33.33 (%) percent range.

Table 4 **Average capacities of stores**

Capacity Range	$<3.0m^3$	$>3.0m<4.0m^3$	$>4.0m<5m^3$	$<5m^3$
Percentage	60%	6.67%	20%	13.33%

Source:- Questionnaire

4.2.4. SHAPE

Information about this section was gathered through observation. The observed shapes were analysed as follow. Structures with conical shapes were 73.17(%) percent, circular shape structures 2.95% and square shapes take less than 5%. Table 5 shows the shapes distribution of observed structures.

Table 5 **Observed shape of structures.**

Shape	Conical	Circular	Square
Percentage (%)	73.17%	21.95%	4.88%

Source:- Questionnaire

4.2.5 LIFE SPAN OF THE STRUCTURE:-

Table 6 shows that 36.67(%) percent claims that their structures last more than 10yrs followed by 36.67% percent also claiming 15yrs and 26.67% claim 5years.

Table 6 **Life span of the structures.**

No of years	Above 5yrs	Above 10yrs	Above 15yrs
Percentage (%)	26.67%	36.67%	36.67%

Source: questionnaire

4.2.6 MAIN CONSTRUCTION MATERIALS:-

Table 7 below shows that 63.33% of farmers use clay soil + dry grass, followed by 20% who use clay soil + rice hose (Agric waste) + extract from plant, 13.33% use clay soil + rice hose only.

From table C = clay , DG = Dry grass

RH = Rice hose and P.E = Plant extract.

Table 7 **Construction Materials**

Materials	Clay+D.G	Clay +RH	Clay+RHYPE	Clay+DG+PE
Percentage (%)	63.33%	3.33%	20%	13.33%

Source questionnaire

4.2.7 **PROBLEMS ENCOUNTERED WITH THE STRUCTURE**

Table 8 below shows that 51.52% of structures suffers washout by the effect of rain 30.3% of structure cracks, 9.09% causes food damage when storage exceed one year, 6.06% of structures have short life span and 3.03% of them experience leakage.

Table 8 **Problems encountered**

Problems	**Leakage**	**Wash out**	**Cracks**	**Short life**	**Damage**
Percentage (%)	3.03%	51.52%	30.30%	6.06%	9.09%

Sources: Questionnaire

4.3 **FINDINGS:-**

In the course of my investigations and analysis of questionnaire, the followings were found.

(a) It was evident that local storage structures with average life span of 5 years are mostly constructed with two major materials i.e. clay soil and dry grass.

(b) From analysis, 63.33% of farmers interviewed who embarked on the use clay and dry grass are faced with the problem of:

1. Washout by weather (Rain)
2. Cracks
3. Damage of stored food products that exceed one year of storage.

4.4. EVALUATION OF MODEL STRUCTURES

In evaluating the two constructed mode is the following results in terms of capacities, physical observation and laboratory observation were obtained.

4.4.1 CAPACITY

After construction the two models were measured and the average was recorded in terms of their radius and height. A conical shape was also assumed.

Average radius = 0.15m

Average Height = 0.5m

Using the formular for computing the volume of a conical structure

$$V = 1/3 \pi R^2 H$$

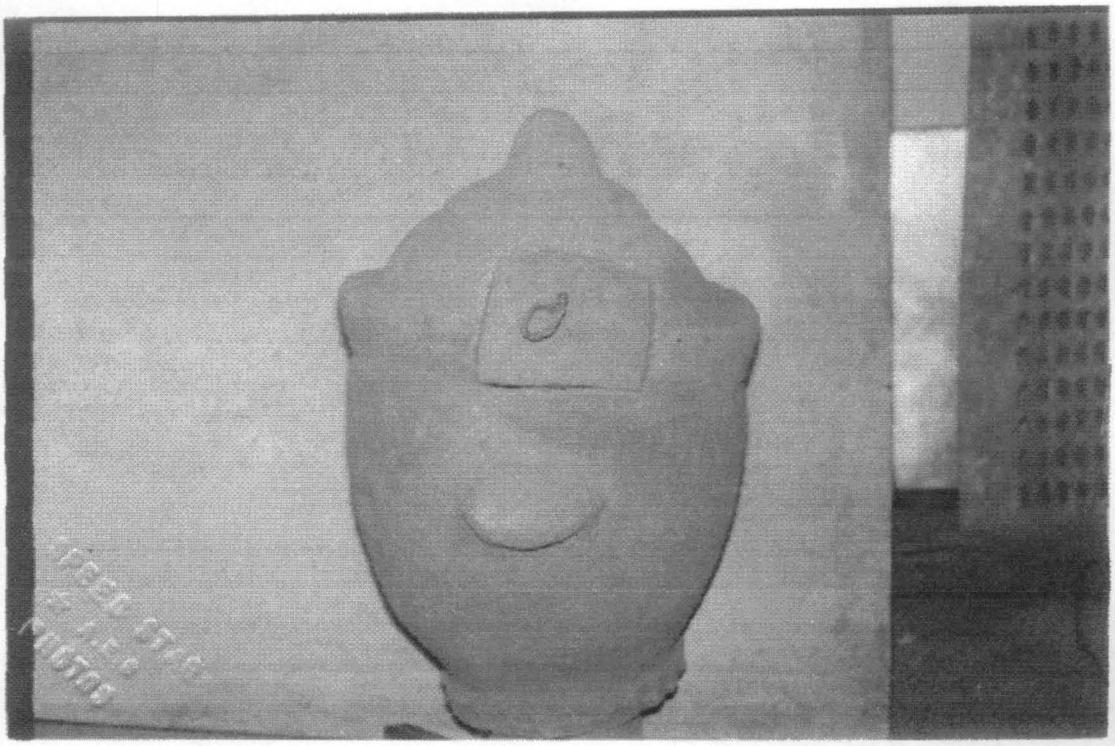
$$\text{Volume} = \frac{1}{3} \times \pi \times (0.15)^2 \times 0.5 = 0.01m^3$$

4.4.2. VISUAL OBSERVATIONS OF THE MODEL

The drying rate in the model of local storage structure is fast while in the model of improve structure was slow. There are visible signs of cracks appearing in the local and no sign of cracks on the improved. The outer surface of the local is rough while that of the improve model is smooth.

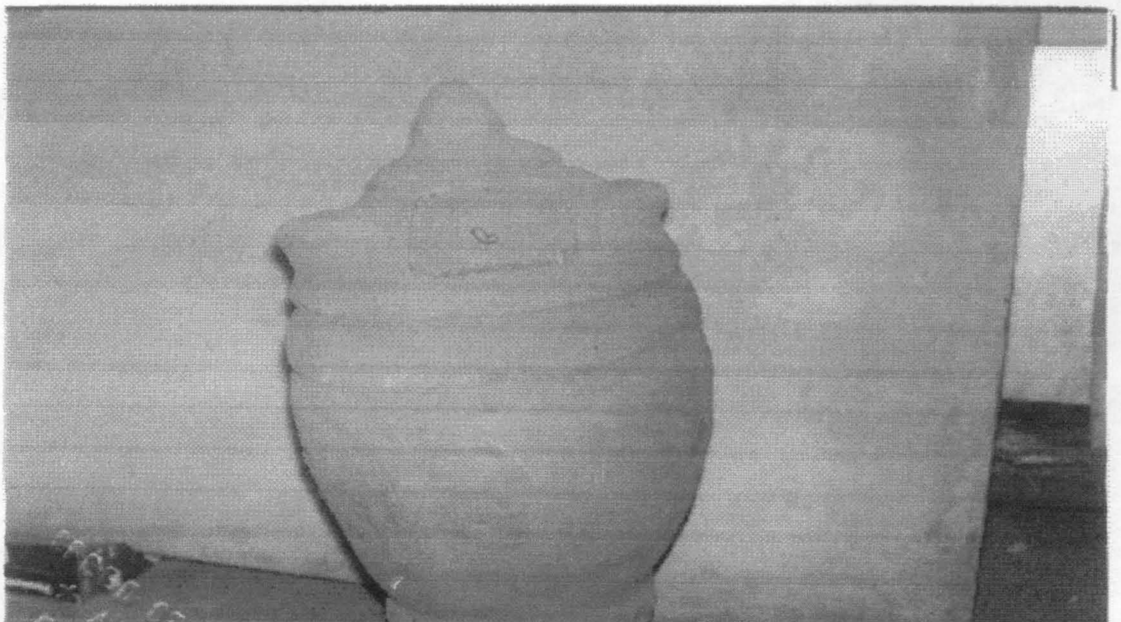
Plate 3 and 4 are photographs of the model of local and improve structures respectively.

PLATE 3



Model of Local grain storage structure

PLATE 4



Model of an improve grain storage structure

4.4.3 **LABORATORY INVESTIGATION**

The temperature and humidity of the models structures were given below in table 9.

Table 9 **Average Temperature And Humidity Readings:-**

Time	**Temperature**		**Humidity**	
Hours	Local	Improve	Local	Improve
8.30am	29°C	28°C	35	29
9.00am	27°C	27°C	40	33
9.30am	27°C	28°C	37	30
10.00am	27°C	28°C	42	34
10.30am	27°C	28°C	38	31
11.00am	28°C	28°C	42	33
11.30am	28°C	29°C	37	31
12.00pm	28.5°C	29°C	41	33

From table 9, significant differences was observed in temperatures of the improved model and that of the local existing structure. The relative humidity in the existing model was higher than the improved model.

The Average of three replication of moisture content of (Guinea corn before storage was 13.93%.

The moisture contents of the grains in the two structures after storage was taken for a period of one month as shown in table 10 below:-

Table 10

Weekly Average Moisture Content Measurement

Week	Average Mc for structure	Average for improved structure
Wk 1	14.2%	14.1%
Wk 2	14.3%	14.1%
Wk 3	14.4%	14.3%
Wk 4	14.13%	14.06%

Appendix II shows the measurement for three replications.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION:-

Guinea corn was found to be highest stored grain in the study area since it constitute about 46.15% of major grain store and thatched roof structures are mostly used for the storage of unthreshed grain.

It was also evident that 73.17% of local storage store capacity of between $1.5m^3$ to $3m^3$. Most of these structure are constructed with clay material mixed with dry grass as it has 63.33% on the table.

Also from surveys, the major problem farmers encounter in using this "Rhumbu" is the frequent cracking of the structure. The improved model showed little or no sign of cracks. Therefore, it is recommended that farmers should adopt the use of rice hose ashes in addition to dry grass for the construction of the Rhumbu.

5.1 REFERENCES

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APPENDIX 1

SAMPLED QUESTIONAIRE FORM

DATA COLLECTION FORM:

TOPIC:- CONSTRUCTION OF AN IMPROVED GRAIN STORAGE STRUCTURE

1. Village name:……………………………………………
2. Name of farmer:…………………………………………..
3. Age of farmer:……………………………………………..
4. Profession:……………………………………………..….
   - A) Fulltime farmer ☐ (C) Business man ☐
   - (B) Public Servant ☐ (D) Politician ☐
5. Major Grain structure……..……………………………………..
6. Types of structure…………….:……………………………………
7. Duration of storage:…………………………..……………
8. Average size:…………………………………………………
9. Shape:
   - A. Conical ☐ (D) Rectangular ☐
   - B. Square ☐ (E) Round ☐
   - C. Cylinder ☐
10. Life span of structure:……………………………………………
11. Main construction material
    - (A) Clay & Dry grass ☐ (C) Clay & dry grass & P/extract ☐
    - (B) Clay & Dry hose ☐ (D) Clay & Rice hose & plant extract ☐
12. Problems encountered with the structure:
    1. ………………………………………
    2. ………………………………………
    3. ………………………………………

APPENDIX II

MOISTURE BEFORE AND DURING STORAGE

BEFORE STORAGE

Sample 1	Sample 2	Sample 3	Average
14.0%	13.9%	13.9%	13.9%

DURING STORAGE

	Structure	Sample 1	Sample 2	Sample 3	Average MC
Week 1	Local	44.2%	14.1%	14.2%	14.2%
	Improve	14.1%	14.1%	14.1%	14.1%
Week 2	Local	14.3%	14.4%	14.2%	14.3%
	Improve	14.2%	14.1%	14.0%	14.1%
Week 3	Local	14.4%	14.4%	14.5%	14.4%
	Improve	14.4%	14.3%	14.3%	14.3%
Week 4	Local	14.3%	14.1%	14.0%	14.13%
	Improve	14.2%	14.0%	14.0%	14.06%