ASSESSMENT OF SOME QUALITY PARAMETERS OF MAIZE (Zea mays), STORED IN A WOODEN SOIL

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CERTIFICATION

This is to certify that this project was carried out by Oramulu Chinedu in the Department of Agricultural Engineering, Federal University of Technology , Minna.

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DEDICATION

To God almighty who sustained me through out this programme.

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I wish to use his medium to express my profound gratitude to almighty God, who out of his endless love cared for me throughout this programme. I will not fail to say a big thanks to Engineer Dr. B. A. Alabadan (my project supervisor) who made some high level of sacrifice to ensure the successful completion of this work. Sir, I say a big thanks to you and may God continue to improve your life and that of your family.

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ABSTRACT

Considerable wastage of grains occur between the time of harvesting and consumption in the tropical countries of the world, and this in turn result in appreciable loss of quantity and quality of the community for processing and construction. The major reason for this is the lack of efficient storage facilities to reduce bacterial; insect and fungi attack on the grains. The study looks into how maize quality changes with storage period, using wooden silo. Changes in the nutrient content of maize (crude protein, crude fibre, lipid, carbohydrate,ash) stored in the wooden silo were investigated. Slight reduction in some nutrient content (crude protein, crude fibre, lipid, carbohydrate) of stored maize grains was observed at three months of storage period. This reduction resulted from the combined effect of termite attack and heat damage of the germ portion of some kernels. Slight difference in Ash was only observed at specific month of storage and not with months i.e the difference in value is between 1.60 ± 0.07^{b} for top sample to 1.56 ± 0.07^{b} for the bottom sample at the first month of storage as seen from table 4.6. This finding shows that the use of wooden silo can be of tremendous advantage if proper construction and management procedures are practiced. From this investigation, it has been found that maize grains can be stored for even up to 3 months without serious deterioration under tropical conditions.

CHAPTER ONE

INTRODUCTION

Grain silo is a storage tower or structure used for the storage of agricultural produce such as maize and guinea corn. Some of this grains after harvest will be stored commercially, while others will go to the market for sale as well as stored on the farm.

For any nation to achieve self-sufficiency in food supply, not only must crop yields be increased, but regular returns must be ensured. Improvement in agricultural production without the solution of the associated problem of safe storage and preservation of grains that must be harvested in a short period of time, will have little or no effect on increasing the quantity available for human consumption and livestock feeding (Lasisi, 1975).

Nigeria produces a wide variety of agricultural products ranging from cereal grains (such as rice, maize, sorghum) to roots and tuber (such as cassava and yam) to vegetables and fruits and a host of dairy products (Ashafa, 1986). In the tropics, there are serious losses of farm produce particularly, grains before, during and after harvest as well as during storage. The major reason, in addition to others for the shortage of food grains in the tropical countries, is lack of adequate storage facilities to cope with the environmental conditions unique to the tropics. This situation forces the farmers to keep a small portion of their grains and dump the rest in the market at a reduced loses of stored agricultural produce, to enhance marketing efficiency and to meet demand, which is evenly spread throughout the year (Igbeka, 1983). Attempts have been made in the past

(O'Dorid, 1971; Igbeka, 1982; Aderibigbe et al, 1985; Mijingawa, 1989) to develop suitable storage structures using locally available materials for the construction of such structures. Some measures of success have been achieved.

Grain as a major part of food consumed by livestock and man in Nigeria plays a vital role in the life of the people.

The demand for grain which is produced within a certain period of time during the year is all year round and so to assure the continuous or constant supply for the people, there is need for the storage of the grains.

Farmers looses much of their grains all over the world after being harvested through attacks by birds, insects and rats. In Nigeria, grain losses are most critical because products are stored traditionally in structures like bags and earthen pots (indoor storage) by farming families, these types of structures are exposed to risk like fire incidents, insect, Infestation which leads to great loss in the available grain quality and quantity.

1.1 Statement Of Problem

The use of the metal silo made from different materials like Aluminum, concrete or steel is one of the method used for the storage of grain on a large scale. Excessive heating on the metallic silo roofs and walls and its distribution with the bulk grain as well as moisture condensation is as a result of wide diurnal range in temperature and warm humid climate in Nigeria. This results to mould growth, grain caking, seed germination, rapid development of insects and development of hot spots.

There is usually high deterioration of grains as well as short-term grains product storage as a result of this.

The Federal government of Nigeria in 1990 (Laban, 1990) in her efforts toward ensuring availability of grain all the year round embarked on 250,000 Tons strategic grain reserve using metallic silo in all the state of the country. Under the Nigerian climatic condition these metal silos have been found to have defects like grain dampness and hence mould growth and are associated with high importation cost, caking of grains, technical and management problem, development of hot spots.

1.2 Justification

The low thermal expansion and poor heat transfer characteristic of wooden silo places a mark of advantage in the use of wooden silo for grain storage over the metallic silo. However, silos constructed of other materials like steel, Aluminum, concrete and laterite can be of good use for the purpose of storage of grains.

1.3 Aims And Objective

1. To Investigate the nutritional quality of maize grains stored in wooden grain silo.
2. To determinate of the percentage whole sample, whole (colored), whole (mature), broken and percentage infested of grins (maize).

CHAPTER TWO

LITERATURE REVIEW

Storage is an important phase of the post harvest system. Storage of farm involves keeping the produce in structures in which there is adequate control of the environment in order to maintain the quality of the product. The control of the environment is important because agricultural materials are hygroscopic (can adsorb or desorp moisture) and are always in dynamic equilibrium with their environments. Thus a basket of maize placed in a moist atmosphere will soon absorb a lot of moisture and when this happens, moulds grow, respiration accelerates, both resulting in destruction of the dry matter of maize (nutrients).methods of storage include traditional and imported.

Methods of storage

Traditional methods

(1) Open air drying

(2) Storage in heaps

(3) Storage in baskets

(4) Underground storage

(5) Use of barn

Improved methods

(1) Open in silo and Bins (with aeration)

(2) Storage in corn cribs

(3) Forced heated air drying

(4) Sealed storage

(5) Cooling or chilling in chambers

2.1 Factors Or Conditions That Affect Safe Storage.

2.1.1 Moisture Content

High moisture grain deteriorates fast due to high equilibrium relative humidity (70%) of the inter seed air inside the grain. this condition encourages the growth of microflora.

The respiration of the microflora and the grain itself produces heat and more moisture to further complicate the problem. Such self-heating of high moisture grains often result in uncontrolled temperature tibe to the point of ignition and spontaneous combustion. Recommended levels of moisture have been presented in the table below for safe storage

Table 2.1: Recommended moisture content levels for safe storage

Crop	M.C. ar harvest (wb)	Required M.C for safe storage for 1 year
(Maize)	24-30	13
Wheat	17	13-14
Oats	18	13
Rice	20-24	14
Soybeans	20	11
Hay (grass)	70-80	20-25

Chukwu, 2001

2.1.2 Temperature

For safe long-term storage of grain, temperatures in the range of $5^0 - 10^0$c are considered most desirable. At these temperatures, the respiration rate is low, insect activity is also reduced since most insect species are unable to reproduce at temperatures below 10^0c. however the problem of achieving and maintaining such low temperatures in storages is economic and as well as technical.

Furthermore, low temperatures are known to induce storage disorders known as "chilling injury": in certain materials for example, it is known that at or below 12^0C, yam tissue suffers excessive decay when the tissue or tuber is exposed to ambient conditions. The following table gives valves of respiration heat for some fruits and vegetables.

Table 2:2 Heat of respiration J/(h-kg-°C) for fruits and vegetables

	Heat of respiration J		
Fruit	**At °C**	**4^0C**	**16^0C**
Apples	72	125.3	443
Grapes	52.55	102.1	304.4
Peaches	96.89	151.5	723.2
Pears	67.22		960.2
Vegetables			
Beans	203.4	375.4	1,920
Cabbage	104.6	145.8	356.2
Carrots	185.9	302.9	705.3
Corn	514.2	714.9	
Onions	76.28	163.2	-
Potatoes	37.61	124.8	-
Tomato	89.04	110	492.3

Chukwu, 2001

2.1.3 Oxygen Supply:

A substantial proposition of the deterioration of high moisture grain stored at ambient temperatures is caused by respiration process which requires oxygen. If oxygen is excluded from a grain storage, the oxidative respiration of the grain and associated microflora will cease. This can be accomplished by placing the grain in gas light containers (metal drum with locking rings)

However certain chemical changes and an aerobic fermentation proceed in the absence of oxygen e.g. in the process of ensilage of high moisture grain and forage crops. Consequently they possess a characteristic fermented or dour and is used to feed livestock.

2.1.4 Grain Condition

The condition of the grain as a result of its previous history is an important factor in the storability. Biological materials in general posses some natural resistance to detoriation changes due to the bed coat in several grains and the perineum in root and tubes crops such as cassava and yam. However, mechanical damage, mould invasion etc. tend to decrease this resistance and make the product more susceptible to deterioration influences. Mechanical damage in agricultural products are either to external forces under static or dynamic conditions (dead load or machine injury), or impact damage or internal forces (due to temperature gradient in material chemical or biological changes).

2.2 Silo

This is a tall tower or underground place used in a farm in which grass of other green crops are stored to be used as food for animals. It is a tower of underground place where missiles are kept ready for firing. They are storage structures in which grains are stored loosely in bulk without putting them in bags. They are storage structures for storing of silage. The silos are generally considered to be the most effective containers for ensuring a tightly packed mass in which the circulation of air and the moisture content can be strictly controlled or deep bins. Silos are of various shapes and the materials used in the construction include metals, aluminum, rubber, concrete and wood e.t.c horizontal silos are called bunkers or bins.

Two less efficient types are the trench silo, which is simply a concrete-lined excavation in the silo, and the bunker silo, a brick or wooden chamber built above the ground.

Silos can be horizontal or vertical. Horizontal silos are essentially a trench in the ground. If underground, the wall has to be designed as retaining walls. Horizontal silos are used for the storage of silage

Grain silos are of the vertical type and may be made of adobe brick, cement block, clay bricks of concrete, wood, staves, plywood e.t.c if the silo walls are made of mud, brick or cement, they are liable to develop cracks and absorb moisture from the ambient air. In areas of high relative humidity, (RH), it is necessary to introduce a moisture barriers to the silo walls and is achieved by any of the following methods;

(1) Plastering the outside of wall with morter and it is advisable to use cement-lime-sand or prevent moisture migration

(2) Painting with plastic paint or coaltar.

(3) Incorporating a lining of plastic sheeting in the middle of the wall, floor and roof in such a way as to make the silo airtight. This is now an airtight silo and is referred to as push bin.

The use of metal silo for grain stage in Nigeria has been militated against due to condensation and moisture migration problem.

Large losses of grains has not been put into account when grains are put into the silo, the use of suitable fumigant to the silo, the use of suitable fumigant to control insect has been achieved. Usually with non air tight conventional silos, the fumigant effectiveness is reduced and insect control is poor resulting in heavy insect damage and losses. Only dry grains of about 13% moisture content can safely be in silos, this make it imperative that artificial drying facility can be available when large grain of moisture content more than 13% storage is to be done. This will completely solve the problem of condensation, insect damage and moisture migration. (Chukwu, 2001)

2.3 Types Of Silos

2.3.1 Alternative solid wall bins

2.3.1(a) The "Burkino" Silo

2.3.1(b) The "USAID" Silo

2.3.1(c) The Ferrocement Bin (" Ferrumbu")

2.3.1(d) The "Dicher" Stave Silo

2.3.1(e) The "Pusa" Bin

2.3.1(f) The Metal Silos

Apart from the above listed silo, the most majority common one are the horizontal silo and ordinary silo.

Horizontal silo is parallel either cut into the ground (trenched silo) or built above the ground while ordinary silo which are only water tight are of wood, concrete, mansory staves or block steel.

2.31 (a) THE "BURKNO" SILO

Based on a traditional done shaped type of bin this silo is constructed with established earth bricks various models and capacities are available. Thebase is made of stabilized earth resting on the ground or on concrete pillars. The dome shaped roof is also made of stabiles earth bricks, using special wooden formers. The techniques, of making a doom-shaped roof is not easy to master, and usually has to be done by skilled masons. A variant has been developed with the roof resting upon a wooden frame, which can be erected by unskilled formers.

2.3.1 (b) THE "USAID" SILO

Examples of this silo have been erected in Nigeria, the silo is based on the "Burkino" silo holding one tone of maize grain, the silo rests on concrete pillars supporting a reinforced concrete slab 1.5 meters in diameter or on stone. The walls are made of stabilized earth bricks and are plastered inside and out with cement reinforced with chicken wire mesh. The top is dome shaped with a central round opening, and covered with a cone-shaped earthen cap. This is plastered with cement, and rests on bamboos or on a metallic drum base. An outlet door, consisting of a 15 x 30 cm plate 1.5mm thick which is smeared with grease for easy sliding, is let into the base concrete slab.

2.31 (c) THE FREEOCEMENT BIN ("FERRUMBU")

Development in Cameroon (Qstergaard, 1977), and tested in a number of African countries, this bin is similar to the "Burkino", bin in shape but consists mainly of chicken wire plastered inside and out with cement mortar.

The wall varies in thickness from 3.5cm for a bin of 0.9m3 capacity, to 6cm for one of 14.4m3 capacity.

2.3.1 (d) THE "DICHTER STAVE" SILO

This cylindrical silo was constructed with trapezoidal section concrete blocks (staves) supported externally by tightened steel wire. Both internal and external surfaces are rendered smooth with cement, and the outside may be treated with coaltar to ensure water-proofness. The floor and cover stab consist of reinforced concrete cast in situ, and the whole structure is raised off the ground on four concrete block pillars. A manhole is located in one side of the cover slab, and an 'anti-theft' outlet is built into the bottom of the wall.

2.3.1 (e) THE "PUSA"BIN.

Developed by the Indian Agricultural Research Institute (I.A.R.I). These silos are made of sun-dried bricks or earth; they have a capacity of 1to3 tonnes and are rectangular in shape. A typical "Pusa" bin has compacted earth, or stabilized earth, foundation of bricks. A polyethylene sheet is laid on this, followed by a concrete slab floor 10cm thick. An internal wall of the desired height (usually 1.5 to 2meters) is constructed to brick or compacted earth, with a sheet of polyethylene wrapped around it. This sheet is heat sealed to the basal sheet and the external wall is then erected. During the construction of the wall an outlet pipe is built into its base.

The concrete slab roof is supported by a wooden frame and, like the floor, is constructed of two layers separated by a polyethylene sheet. During its construction, a man-hole measuring 60 x 60cm is built into one corner.

2.3.1 (f) METAL SILOS

Economically valid for storing large quantities (over 25 tonnes), metal silos are often regarded as too costly for small scale storage. Nevertheless, certain projects have been successful in introducing small metal silos of 0.4 to 10 tonne capacity, at farm/village level in developing countries like, Swaziland (Walker, 1975).

Such silos are made of smooth or corrugated metal, and are cylindrical in shape with a flat metal top and, usually but not always, a flat metal bottom. A man-hole with a cover, which may be hinged but is nevertheless lockable, is located, usually to one side, in the top panel; and an outlet pipe provided with a padlock is fitted at the base of the wall.

2.3.1(g) SYNTHETIC SILOS

Various attempts have been made to develop small scale storage bins, using synthetic materials such as buty 1 rubber (o' Dowd, 1971) and high density polyethylene. However, such bins proved to be either too expensive or prone to damage by pests. Also the management level required by such storage facilities is probably too high for most rural situations.

2.3.2 Ventilated Bins

Where long-term grain storage is needed, and the grain can normally be harvested in a fairly dry condition, drying and storage in ventilated bins or silos may be the most economic system. A ventilated bulk storage system consists essentially of a fan and heater unit to provide a supply of slightly warmed air, ducting to convey the air to the grain, and some method of distributing the air to the grain, and some method of distributing the air so that it passes through the grain in the store. These essentials can often be quite cheaply provided, but where large quantities of grain are to be dealt with it becomes desirable to add such, auxiliaries as a damp grains receiving hopper, grain cleaning equipment and conveying equipment to enable easy movement of the grain into and out of the store, or from one part of the system to another. Blowing grain with air of varying degress of relative humility. It may be seen that for the production of grain of a moisture content of 14 percent – the figure necessary for prolonged storage in bulk without further ventilation-the relative humidity of the drying air needs to be about 60-65 percent. The mean relative humidity of the atmosphere of the drier parts of Britain over 24 hours during harvest time varies from 75 to 85 percent, and continuous ventilation with such atmospheric air will in practice produce grain having a moisture condent of around 17-18 percent. It is necessary to warm the air a little to produce grain of lower moisture content, and the amount of warming needed varies with weather conditions. In cold, wet weather, the average temperature increase needed over the 24hours to reduce grain to 14 percent M. C is about 6-10^{0}F (3-5.5^{0}c), where as 0-6^{0}F (6-3^{0}c) temperature rise is adequate to give 6-10^{0}F (3-5.5^{0}c) temperature (Culpin 1981)

2.3.3 Airtight Silos

A. common method of construction is by the use of bolted metal plates protected from corrosion by vitreous enamel or by galvanizing. Provision of pressure relief valves is essential to allow for the expansion and contraction of the silo atmosphere owing to ambient temperature changes. The amount of gaseous exchange is highest with empty or nearly empty silos, and this is one of the reasons why deterioration of grain can become serious if a little grain is left in a silo in spring or summer. To minimize gaseous exchanges, one manufacturer provides a plastic breather bag. So arranged that on cooling, atmospheric air first enters and inflates the breather bag, and only passes through the relief valve into the main silo air space after the breather bag is full, and the vacuum outside the walls of the bag exceeds the relief value setting. Such devices are useful if grain is to be fed from the silo for an appreciable period during spring and summer. In winter ambient temperature differences are smaller, and the cooler air has les tendency to stimulate microbial activity. (Culpin 1981).

2.3.4 Unsealed Silos

The main use of unsealed tower silos is for large stock keeping installations where the moist grain is used up at a rate of at least 3 in (75mm) of silo height per days and the whole silo is emptied before the onset of warm weather in spring. In these circumstances the simplicity of the unsealed tower is attractive, and the main problem is the provide on effective top seal for the period between harvest and the beginning of emptying.

One satisfactory method is to cover the top with at least 6 in (150mm) of any convenient material to absorb condensation moisture, e.g. chopped straw, and to cover this absorbent layer with a heavy guage polythene sheet, well tricked down at the edges. (Culpin 1981).

2.3.5 Flexible Sealed Silos

Silos many be constructed of butyl rubber or similar flexible materials, but good handling systems for filling and emptying them are not easily arranged. The silos themselves are relatively cheap, and the elasticity of the container walls makes it possible to accommodate expansion and contraction of the silo atmosphere without the use of relief valves. It should, however, be reckoned that the trouble free useful life is like by to be much shorter than that of rigid- walled silos. (Culpin 1981).

2.3.6 The Wooden Silo

Wood can be considered as a good material for silo construction because of its low thermal conductivity and low thermal expansion. As far back as 1984 wood has been used for silo construction in Washington United states which has favorably compared with silos made of concrete as well as Aluminium (Warner 1956).

In Nigeria, wood has been primarily used for cribs construction but it is being used for silo onstruciton (Mijinyawa, 1989, Alabadan, 2002).

ADVANTAGES OF WOODEN SILO

(i) It presents a good appearance when properly placed and finished.

(ii) It has low thermal expansion on coefficient and low thermal conductivity.

(iii) The raw materials locally available and inexhaustible if properly planned by tree planting.

(iv) The labour requirement to work the wooden material and erect the silo can be met locally.

(v) It has good ease of workability

(vi) The problem of durability and stability in service are surmountable if correct species are chosen and correctly treated.

DISADVANTAGES OF WOODEN SILO

(i) Panel joints are difficult to be made water proof.

(ii) Several wood species can not and may lead to mould growth that will deterioration of the stored grains

(iii) Difficultly in making the surface of man wood species smoothes, cracks and splits may develop which can leads to insects attack.

2.3.7 The Underground Silos

Storage of grain in underground silos is an ancient techniques practiced in many countries. In Morocco, many farmers prefer underground storage for conservations of their produce. It is estimated that storage capacity with this method totals about a million tones. This technique, used as well in Tunisia, in Egypt and in Sudan, is adapted to the rural context and to small holdings where soil conditions permits. The atmosphere, poor in oxygen, created inside the underground store, permits a reduction in insect attack.

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2.4 AIRTIGHT STORAGE OF HIGH MOISTURE GRAIN

Grain intended for stock feed can be effectively stored in containers which can be maintained substantially airtight. Grain of over 30 percent moisture content can be stored in this way, though in practice storage at such high moisture contents in advisable owing to the greater difficult of handling, and rapid deterioration of the grain after removal from storage. The essential factor in 'airtight' storage is exclusion of oxygen. This prevents the development of moulds and micro organisms which cause moist grain to heat in the presence of air. Some chemical changes take place in moist stored grain, owing to the activity of yeasts. The grain takes on a small comparable with that of brewers' grains and becomes unsuitable for purposes over than stock feeding. The feeding value of the grain is not, however, impaired, provided that the stored remains substantially air-tight.

The main kinds of stored are metal silos which can be sealed apart from provision of relief values; flexible silos made of butyl rubber which can be sealed; and unsealed silos from which air can be effectively excluded by means of an impermeable sheet until rapid and regular use of the grain began. For use of handling, grain kept in sealed silos should be clean and not over about 25 per cent moisture content. With unsealed towers which use a sweet arm top unloaded, somewhat moisture contents need cause no difficulty.(Culpin 1981).

2.5 LOADING AND UNLOADING EQUIPMENT FOR MOIST GRAIN

Most moist grain silos are easily filled with mobile grain handling equipment, especially angers. The main problem is the difficulty of reaching the tops of high towers, especially those 40ft (12m)high or more for these, the most convenient method is usually by means of a forage blower of the normal impeller type. These can effectively fill towers 60ft (18m) high if properly installed and driven at the right speed. Filling rate tends to fall off with increasing height, and there is some grain damage, but this is not usually important except in so far as it may cause emptying difficulties.

For intermediate heights, trolley-mounted augers and chain-and-flight-mobile elevators may be used. The latter can be particularly effective for heights up to about 25ft (7.6m). if grain which is contaminated with chaff or weeds is to be unloaded subsequently by simple augers, it is advisable to preclean it before ensiling. It is essential to seal the silo during breaks in the harvest, in order to avoid any unnecessary healing. Grain temperature should not normally rise above about 80-90°f (26-32°c).

For unloading, one of the most effective methods is use a sweep-arm auger. Which runs in the bottom of the silo, and delivers the grain to a sealed auger running in a trough from the centered to the outside of the silo base.

This transfer auger is used alone until grain no longer flows by gravity to the center of the silo. The sweep arm is then put in gear and gradually works its way round thė silo base. This transfer auger is used alone until grain no longer flows by,gravity the center of the silo. The sweep arm is then put in gear and gradually works its way round silo, leaving only a tin, uniform layer o grain to be swept to the central collecting bowl. Much simpler methods are widely used, but require more shoveling. One of the most common methods is use of a simple sealed auger which can be pushed into any one of the three upended tubes arranged fan-shaped on the flat silo base-where a clean grain of not soled, a conical21 percent M.C is ensiled, a conical base can be almost completely emptied by anger.

One of the disadvantages of imperfect unloading system is that there is a risk that one will enter the silo without taking the precautions necessary to ensure that there is sufficient oxygen in the silo. The danger of suffocation cannot be over-emphasized. (Culpin 1981).

2.6 USE OF PROPIONIC ACID FOR MOIST GRAIN PRESERVATION

Chemical can be used to sterilize grain and so prevent the development of moulds and bacteria. Experience shows that about 0.8 percent of propionic acid applied to grain at 18-20 percent M.C can effectively prevent deterioration for a very long period. One of the chief advantages of using propionic acid for moist grain preservation is that silos do not need to be airtight.

An additional advantage is that there is less danger of the grain going mouldy if used slowly during the following spring, and that chemically preserved grain has a longer "shelf-life", both before and after crushing or other preparation treatment for best results it is necessary to use application equipment that ensures good mixing of the additive with the grain, and avoids headling dangers. (Culpin 1981).

2.7 METEOROLOGY AND GRAIN STORAGE

The losses of food grains by damages during storage are often sufficient to wipe out the grins which are made by improves varieties and difficult cultural methods.

Meteorology is an important role that must be obeyed in grain storage so that one can understand the extents of damage in order to know the best protective method that can be apply in controlling it. Much of the damages in grains stored due to environment factors on the stored grains. The environmental factors include the temperature, the moisture content of the grains, the relative humidity of the surrounding, the effect of insects, mites and micro-organism and the rodents.

Temperature: Low temperature is preferable in order to reduce biological and biochemical deterioration. The temperature of stored grains may rise considerably due to the combined respiratory activities of products, insects, mites and micro-organism.

Moisture content: micro-organism need a certain level of moisture for good growth. Below this level they will grow very slowly or not even growing at all. Grain produce normally should not be stored with a moisture content higher than that which would be equilibrium with relative humidity of 70% otherwise, micro-organism will develop and this is referred to as maximum permissible moisture content for safe storage and safe storage for maize is 13.5% (Muckle and Sterling, 1971).

Insects and mites: there are about 30 important storage pests. Development takes place at the temperature 17^0C and 35^0C at almost any moisture content. Mites develop on produce with a high moisture content while pests develop completely inside the cereals. Some pests could also be found to develop outside the produce.

Micro-organism: Development of most species takes place between 5^0C and 30^0C. Some however have their optimum growth at 50^0C-60^0C while other still develop below 5^0C.

Rodents: In general rodents cause greater damage to the standing crop than to the crop in storage. Losses are cause by direct consumption by rodents.

2.8 GRAINS QUALITY CHARACTERISTICS

The grains quality characteristics include, the intrinsic qualities and the induced qualities.

2.8.1 THE INTRINSIC QANLITIES

2.8.1.1 COMPOSITION

Grains are known to be made up of organic and dry matter. The grains organic matter is made up of carbohydrates, lipids, proteins and vitamins while the dry matter of grain consists of mineral matter (ash) and organic matter. The function of carbohydrate is to provide energy for use by the body. Fats and lipids also provide energy, but they are being oxidized into fatty acids when the conditions of storage are bad. They develop a rancid odour and flavour in the grain as a result of this. Vitamins found in minute quantities in cereal grains are essential for body functions. These vitamins can be destroyed by excessive heat or insect activities during storage certain changes to lipids in grains and carbohydrate are on the other hand desirable. For instance it has been noted that changed in carbohydrates, lipids and protein fractions result in firming of texture in rise on cooking, and increased gas-retention capability in wheat flour it can be seen from the foregoing that grain quality can be influenced significantly by composition.

Other components of grain such as husk in maize are not inedible and according to FAO (1994) quantitatively influence product yield and gross nutrient available to the consumer.

2.8.1.2 GRAIN COLOUR

Cereal grains ranges from very light tan or almost white, to block and are pigment. Highly-pigmented varieties may give low yields of glour (FAO, 1994) where extractive milling is required. For example maize comes either as yellow maize or white maize and the white type yields better white flour (codex Alimentarius commission).

2.8.1.3 AROMA/ODOUR

Fresh grains are normally known to have national aroma or odour that are distinctive, grains is considered bad hen the odour of the grain differs from the accepted characteristic one grains odour or aroma indicates grain quality.

2.8.1.4 BULK DENSITY

Bulk density is known as 'test weight, specific weight or bushel weight and the value is expressed as kilogram per hectoliter (kg/hl). Investigations have shown that insect infestation, excessive foreign matter and high percentage moisture content are factors which affect bulk density. Consequently a product's bulk density is sometime used for an overall evaluation of the grain moisture content, cleanliness and maturity.

2.8.2 INDUCED QUALITIES OF GRAINS

2.8.2.1 FOREIGN MATTER

Grain may be considered unfit for human consumption as a result of the present of foreign matter in the grain mass and can increase cleaning cost and results in losses. Foreign matter may include things like ground, sand day, mud, hair, and straw e.t.c.

2.8.2.2 CONTAMINANTS

The tree left on the grains by chemicals for insect control constitutes the contaminants. These residues often taint the grain or in some rare çases ad toxic residues to the maize grains. Tainted grain is obviously of low quality.

2.8.2.3 BROKEN GRAIN

Inferior quality grains are these grains that are broken when compared to whole unbroken grain. Breakage of grain may be as a result of stress-cracks developed as a result of mechanical impacts on the grain during threshing as well as from fissures that result from excessive drying / weather conditions in the field. There are several of reasons why the amount of broken kernels in a grain mass influences the grain overall quality among these reasons, one is that broken grains reduce acceptability of the grain. Other reasons are that broken kernels increase the rate of deterioration as at the period of storage.

2.8.2.4 IMMATURE GRAIN

Lack of starchy endosperm are found in some grains at harvest. This is a result insect attack, field infections e.t.c content of immature grain is influenced by harvest time, a high content being the result of too early harvest. FAO, (1994)gave the cause for grain chalkiness as incomplete filling of the starchy endosperm. This condition, it was observed, lower the mechanical strength of the grain and causes it to break easily during handling. The broken grain portion is of course, more easily invaded by certain storage pests.

2.8.2.5 INFECTED AND INFESTED GRAIN

Grain damaged by micro-organisms are regarded as inferior quality grains. Insect damage to grain gas been grouped into four categories (Gray, 1966) Viz; (i) bored hole and the disappearance of a large portion of the inside of the kernels; (ii) injury to the germs; (iii) heating and consequent condensation and moulding of the grain mass; and (iv) contamination with excrements and webbing. The first category of damage results in loss of weight and food yield. Injury to the germs reduces the grains ability to germinate. Contamination has a direct implication of food hygiene.

The presence of micro-organisms on the other hand may result to spoilage.

2.8.2.6 GERMINABILITY.

Germination is a measure of grain kernel capability to produce a normal seedling. It is a quality requirement for those involved in marketing and utilization of grain for seed. Among the factors that affect germination are drying temperatures infestation and mould attack, age and condition of storage.

CHAPTER THREE

MATERIALS AND METHOD

3.1 MATERIALS

3.1.1 MAIZE GRAINS

The maize grain used for this experiment was bought from central market, Minna, Niger State Nigeria.

3.1.2 APPARATUS

Crucible with tightly fitting lids, dessicator, mortar and pestle, air oven (Hot oven, size 2; Gallenkamp), balance (mettle Pe 160), Muffle furnaces (icro-Kjeldahl digestion apparatus, Markham semi-micro-nitrogen still, soxhlet extractor and steam plate (GallenKamp) Reflux condenser, Burette and pipette of various sizes.

3.2 METHODS

3.2.1 STORAGE OF MAIZE GRAINS

The inside of the wooden silo was taken care of to ensure that it were insect free by application of baygon within the silo and was left for sometime so as to let the baygon effect be minimize before loading it with maize grains. Phostoxin was inserted into the maize grain in the silo during storage as well as cupex (dust chemical) against termite attack

3.2.2 LOCATION OF THE SILO

The silo was located in Minna, Niger State between June to September 2003.Nigeria has a warm humid climate. It is made up of two season ranges between April to October while the dry season lasts from November to March. Minna is located in longitude 6°25′ to 6°40′East and latitude 9°30′ and 9°45′ North. The average rainfall and relative humidity are 1334mm and 40% respectively.

3.2.3 COLLECTION OF MAIZE GRAINS

Grain sample were collected from the top and bottom of the grain in the silo using scraper once a month for three months. This was done from June to August 2003.

3.2.4 SAMPLE PREPARATION

Grinding of maize samples was done to facilitate easy extraction of the oil and other parameters and consequently to increase the yield. The grinding was done using mortar and pestle to produce the fine particles which was then used for various determination.

3.2.5 DETERMINATION OF PERCENTAGE MAIZE NUTRITIONAL COMPOSITION

3.2.5.1 DETERMINATION OF TOTAL ASH

The method used is based on that outline by TDRI (1984). The crucibles and the Lids were dried in the oven at 105^0C for about 6hours, cooled in the desiccators and weighed. The drying was continued until constant weight were attained (w_1). 5g of ground sample was then put into each crucible and reweighed (w_2). The samples in the crucible were then heated on the busen flam in a fum chamber untile smoking ceased. They were then transferred into the muffle furnaces and heated at 550^0C for about 18 hours, at the end of which the ashes were white. The crucibles were then cooled in the desiccators and reweighed (w_3).

CALCULATIONS: percentage total ash is given by the formula.

$$\% \text{ ASH} = \frac{W_3 - W_1 \times 100}{W_2 - W_1}$$

3.2.5.2 DETERMINATION OF PERCENTAGE PROTEIN

The protein content was determined by the micro-Kjeldahl method, 0.25g of dry powered sample was weighed into clean, dry 100ml Kjedahl flask, 6ml of concentrated sulphuric acid was added to the sample followed by some glass beads (anti-bumping granules). It was then carefully digested over electric heater (digesting block) in the hood (fume chamber) initially with low flame. Till the frothing subsided and then at higher temperature it becomes clear with pale straw colour Heating was then continued for more 60minutes. The heater was put off and the flasks were allowed to cool and 15ml of distilled water was added to each of the flasks. The contents were transferred quantitatively to 50ml volumetric flask. The Kjeledahl flash were rinsed off using distilled water but the glass beads were life in the digestion flask. The contents of the volumetric flask containing the digested sample was then made up to marked volume with distilled water and mixed thoroughly.

10ml of the digest was then pipetted into Markham distiller and 40% sodium hydroxide solution was added to the digest. The steam-distilled ammonium liberated was collected into 5ml boric acid solution containing 4 drops of mixed indicator (Bromo cresol green, methyl blue) in the conical flask. After the indicator turned green, the distillation was continued for the next 2minutes. The distillate was removed and titrated with standard hydrochloric acid the end point been reached when the indicator changed from green through gray to definite pink. The amount of acid used (titre) was recorded (V, ml).

A blank containing 6ml concentrated H_2so_4, one tablet of kjeldahl catalysts without any sample was prepared and the above procedure was carried out on it. The burette reading was recorded (V_2 ml).

CALCULATIONS:

The percentage (%) Nitrogen content is given by the formular.

$$\%\text{Nitrogen } (N_2) \quad \frac{(V1 - V_2)\,x5x14x100}{1000 \text{ x } 70 \text{ x sample wt(g)}} = \frac{\text{corrected titre (ml)}}{10 \text{ x Wt of sample}}$$

The percentage protein was calculated by multiplying % N_2 by a factor of 6.25.

3.2.5.3 DETERMINATION OF PERCENTAGE (%) LIPID CONTENT (Soxhlet EXTRACTION)

(a) Soxhlet extraction was carried out to determine the % lipid content. Two methods were followed in order to calculate the % Lipid extracted.

The first one is the TDRI (1984) method and the second one is the (1S0186 1986) method. 5g of powered sample was weight into a what man filter paper that has been folded and stapled at one end, that has been previously dried to a constant weight and weighed (W_1). After the sample was folded and stapled at the other end and the weight was taken (W_2). This was placed into the extractor. N – Hexane was then powered into the round bottom flask to $^2/_3$ of the round bottom flask placed on a heating mantle set at 50°C until the N – hexane is boiled the extract was continued for 12 hours after which the heating was stop and the apparatus was dismantled. The sample was removed dried to a constant weight in the over at 50°C cooled in dessicator and reweighed (w_3).

CALCULATION

Percentage lipid content was calculated using the formula

$$\% \text{ Lipid} = \frac{W_2 - W_3 \times 1000}{W_2 - W_1}$$

(b) Standard organization method of 1986 the SON method considers the difference in weight of the empty round – bottom flask and that of the same flask with the extracted lipid after the N – hexane has been dried off.

In this method, the clean round – bottom flock was dried to a constant weight in the oven at 105°C and its empty weight was taken (W_x). with the same procedure as above the fat was extracted into the round – bottom flask. The solvent in the flask was recovered using rotary evaporator and the flask containing the extracted lipid was further dried in the oven at 80°C. After drying the flasks were allowed cool in the dessicator and its weight (W_y) was taken.

CALCULATION

% Lipid content is calculated using

$$\% \text{ Lipid content} = \frac{W_y - W_x}{\text{weight of the sample}} \times 100$$

3.2.5.4 DETERMINATION OF PERCENTAGE FIBRE

About 2g of the dried fat – free sample was weighed into a 600ml beaker.200ml of hot sulpuric acid was added and the beaker was placed under the condenser and was brought to boiling withing I minute. It was boiled gently for 30 minute and distilled water was used to maintain volume and to wash down particle adhering to the sides. Filtration was carried out through what man No. 541 paper in a duchner funnel with the use of suction and washing was well don with boiling water. The residue was transferred back to be aker and 200ml hot sodium hydroxide solution was added. It was replaced under the condenser and was brought again to boil within I minute. It was then filtered through porous crucible and washed with boiling water 1% hydrochloric acid after boiling for exactly 30 minutes, and then again with both water after boiling for exactly 30minutes. Washing ,was done twice with alcohol, draying was done overnight at 100^0C it was cooled and weighed. It was ashed at 500^0C for 3 hours, cooled and weighed the weight of fibre was then calculated by difference.

CALCULATION

Crude fibre (% of fat free Dm)

$$\frac{\text{(weight crucible + dired residue)} - \text{(wt crucible + A shed residue)}}{\text{(weight of sample)}}$$

3.2.5.5 TOTAL CARBOHYDRATE DETERMINATION

Due to the complexity of the procedure involved in total carbohydrate determination using clegy – anthrone method, coupled with lack of some reagents, the total carbohydrate was determined by using estimation by difference which has proved reliable (Fleck, 1976; Oyeleke, 1984).

When the total protein, lipid and ash contents are subtracted from 100, the reminder accounts for total carbohydrate.

3.3 DETERMINATION OF PERCENTAGE GRAIN QUALITY

Maize sample was collected from the silo, weighed on an electronic weighing balance to determine the total weight of the maize sample collected. The same sample, after weighing was separated into whole, whole (immature), whole (coloured) broken and infested samples. The different sample were separated and weighed. The weights of the divided by the weight of the total sample and was then multiplied by hundred percent to give the percentage sample. This was done for the first, second and third months for both top and bottom samples of the grain from the wooden silo.

CALCULATION

$$\% \text{ Samples} = \frac{\text{weight of sample}}{\text{Total weight of grain}} \times 100$$

3.4 DESCRIPTION OF SILO USED

The materials used in the construction of the wooden silo is plywood which is made up of 4 piles. Plywood is a processed lumber and as overcome many advantages of the ordinary wood with respect to strength characteristics and gives the possibility pre-fabricating in large section.

The silo constructed had a capacity of 1.87m^3 an equivalent of 1 ton for shelled corn. The wooden silo is hexagonal in shape with an inner diamater of 16.2m and each side measured 0.81m while the height is 1.10m. there are six columns of 1400mm long whish serve as a foundation. This helps to transmit the dead and live load into the foundation. The column holds the parels in place. The plywood used had the following Advantage over ordinary wood.

It had a greater dimensional stability than natural wood.

Plywood had a minimum waraping

Plywood cannot be split by nails

Then veneer can be bent

Large width can be made from plywood.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS OFNUTRIENT COMPOSITION AND PROXIMATE ANALYSIS

The results of the analysis are as shown in table 3-7, all the parameters determined were for top and bottom for each month, taken for three months.

Table 3 summarizes the percentage compositions of the nutrients of the maize. Table 4-7 shows the result of various parameters determined. Table 4.6 shows the result of the proximate analysis of maize (top and bottom) in three experiment months.

TABLE 4.1: NUTRIENT CONSTITUENTS OF MAIZE GRAIN DETERMINATION

Storage period in (months)	Sample	Ash	Lipid	Protein	Fibre	Carbohydrate
0 month	Top and Bottom	1.80	4.80	10.50	2.64	82.90
First month	Top	1.60	4.60	10.00	2.60	83.80
	Bottom	1.58	4.60	10.00	2.60	83.82
Second month	Top	1.40	4.50	9.63	2.58	84.47
	Bottom	1.40	4.50	9.50	2.56	84.60

Table 4.2: ASH CONTENT DETERMINATION

Sample	Wt of empty crucible w_1 (g)	Wt of crucible +sample before ashing w_2(g)	Wt of crucible + sample after ashing w_3 (g)	% Ash
0 month	10.310	15.310	10.400	1.80
1st month top	9.926	14.926	10.006	1.60
1st month Bottom	11.312	16.312	11.391	1.58
2nd month top	10.288	15.288	10.358	140
2nd month Bottom	10.262	15,262	10.332	140

$$\frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Table 4.3: LIPIDS CONTENT DETERMINATION

Sample	Wt of empty crucible w_1 (g)	Wt of thimble + sample before extraction w_2(g)	Wt of thimble + sample after extraction w_3 (g)	% Lipids
0 month	3.160	8.160	7.920	4.80
1st month top	2.618	7.618	7.848	4.60
1st month Bottom	3.261	8.261	8.491	4.60
2nd month top	2.920	7.920	7.695	4.50
2nd month Bottom	2.864	7.864	7.639	4.50

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100$$

TABLE 4.4: PROTEIN CONTENT DETERMINATION

Sample	1ST titre value m/s	2nd titre value m/s	Wt of sample (g)	% Protein
0 month	Sample 4.30 Blank 0.10	4.30 0.10	0.25 -	10.50
1st month top	4.10	4.10	0.25	10.00
1st month Bottom	4.10	4.10	0.25	10.00
Blank	0.10	0.10	-	- -
2nd month top	3.90	4.00	0.25	9.63
2nd month Bottom	3.90	3.90	0.25	9.50
Blank	0.10	0.10	-	-

$$\frac{\text{Corrected titre ml}}{10 \times \text{sample wt}} \times 6.25$$

TABLE 4.5: FIBRE CONTENT DETERMINATION

Sample	Wt of crucible + dried residue (g)	Wt of crucible + ashed residue (g)	Wt of sample (g)	% fibre
0 month	15.210	15.078	5	2.64
1st month top	13.126	12.996	5	2.60
1st month button	15.110	14.980	5	2.60
2nd month top	16.321	16.192	5	2.58
2nd month button	14.072	13.944	5	2.56
Blank				

$$\frac{\text{Wt of crucible + dried residue} - \text{wt of crucible + ashed residue} \times 100}{\text{Sample wt}}$$

TABLE 4.6: PROXIMATE ANALYSIS OFMAIZE (TOP AND BOTTOM) IN THREE MONTHS EXPERIMENT

(%) Parameter	T_1	T_2	T_3	T_4	T_5
Ash	1.80 ± 0.07^a	1.60 ± 0.07^b	1.58 ± 0.01^b	1.40 ± 0.07^c	1.40 ± 0.07^c
Lipid	4.50 ± 0.07	4.60 ± 0.07	4.60 ± 0.07	4.50 ± 0.07	4.50 ± 0.07
Protein	10.5 ± 0.07	10.00 ± 0.71	10.00 ± 0.71	9.63 ± 0.04	9.5 ± 0.07
Fibre	2.64 ± 0.06	2.60 ± 0.07	2.60 ± 0.07	2.58 ± 0.14	2.56 ± 0.08
CHO	82.90 ± 1.14	83.80 ± 0.07	83.82 ± 0.03	84.47 ± 1.41	84.60 ± 0.07

abc Mean in the same column horizontally carrying different superscript are significantly ($P < 0.05$) different.

T_1 = Zero month, T_2 = 1st month (top), T_3 = 1st month bottom,

T_4 = 2nd month top, T_5 = 2nd month bottom

CARBOHYDRATE DETERMINATION

% carbohydrate is determined here by difference i.e total protein +lipid + Ash are taken away from 100, the remainder account for carbohydrates.

i.e 100 - Protein + Lipid +Ash

4.2 DISCUSSION OF RESULT

From table 4.6, it was observed that at the zero month of storage, the value of Ash remains constant for both top and bottom sample i.e. there was no change in the nutritional value of maize for both top and bottom sample at the zero month of storage, for example, the values of Ash at the zero month of storage for both top and bottom samples carrying the same superscript (a) as seen from the table4.6, indicates that there was no difference in Ash value of maize.

From table 4.6, it can be seen that there was no significant difference between top and bottom Ash content of maize sample at the first month of storage, the value of Ash as seen from table 4.6, caring the same superscript (b) indicates no significant difference.

It can be see from table 4.6, that the value of Ash decreases significantly with months i.e. abc means in the same column horizontally carrying different superscript are significantly ($P < 0.05$) different.

There was no difference in lipid content of the stored maize for both top and bottom sample at each month of storage as seen from table 4.6.

The value of protein remains the same for both top and bottom samples of maize at the zero month of storage as well as at the first month of storage and there was no significant difference for both top and bottom sample value at the second month of storage as seen from table 4.6. Fibre value remains the same for both top and bottom samples of stored maize at the zero month of storage as well as at the first month of storage and was not significantly different at the second month of storage as seen from table 4.6.

From table 4.6, the carbohydrate value remains the same for both top and bottom samples of stored maize at the zero month of storage. At the first month of storage, there was no significant difference as well as at the second month of storage.

There is no significant difference in the values of lipid, protein, fibre and carbohydrate with months as seen from table 4.6.

From table 4.6, it can be seen that the value of Lipid, protein, fibre decreased slightly with months and the value of Ash decreased significantly with months.

Also from table 4.6, it is observed that unlike the value of other nutrients which decreased with months, the value of carbohydrate increased slightly with months.

The reduction in crude protein, crude fibre, crude fat (Lipid) and ash contents of the stored maize grain could be due to the combined effect of biological factors such as termite attack and accelerated by physical factors such as temperature of the grains. From visual observation, there was no indication of insect infestation at the onset of the experiment but the possibility of some of the grains harbouring the eggs of the insect before storage could not ruled out otherwise there should not have been any insect infestation during storage during storage. Considering temperature effect, the reason for the constant or no change in crude Ash, crude Lipid, crude protein, crude fibre and carbohydrate between top and bottom maize samples at the zero month of storage was be causes temperature was assumed uniform at the point of storage when the grain samples was collected from the top to represent both top and bottom samples for the experiment.

From the temperature profile diagram, during the period of experimentation, see fig 4.1 and 4.2. The dry bulb temperature was higher than the top temperature and the bottom temperature at the month of June. At the month of July, the dry bulb temperature is higher than the bottom temperature while the top temperature is higher than the dry bulb temperature at the early month of July but time, the dry bulb temperature became higher than the top temperature. At the month of August, bottom and top temperature were higher than the dry bulb temperature.

The embrayo is a highly nutritious part of the seed containing proteins, fats and vitamins. When attacked by the biological and physical factors such as insects and temperature as well as hat damage of the gem portion of the grain (embrayo), the grain seed becomes unviable for planting. Once killed, the seed looses part of its ability to resist deterioration to moulds and other causes. From fig 4.1 and 4.2, it is observed that heat changes within the wooden silo is slow at the months of June, July and August except at the early month of July and at the end of August.

The slight reduction in Lipid, protein, and fibre content with months could as could be a result of the fact that wood is of poor thermal conductivity.

The reason for the increase in total carbohydrate relative to other nutrient content of stored grain is that in most cases, only the embrayo portion of the kernel was attacked heavily by the termite while the endosperm containing carbohydrate was not eaten up much.

Comparing fig4.3 and 4.4, it can be seen that the infestation was higher at the bottom than at the top at the month of June. At the month of July, infestation was also higher at the top than at the bottom of the stored maize. The same applies to the month of August.

In the case of broken grains, as seen by comparing fig 4.3 and 4.4 the percentage broken maize were higher at the bottom than at the top of the stored maize at the month of June. At the month of July, the percentage broken maize were still higher at the button than at the top of the stored maize as well at the month of August.

The percentage whole (coloured maize) were higher at the top than at the bottom at the month of June, July but were less at the top compared to the bottom at the month of August as seen from fig 4.3 and 4.4.

For whole (immatured maize), the percentage whole (immatured maize) were higher at the top compared to the bottom at the month of June. At the month of July, the percentage were higher at the bottom compared to the top. At the month of August, the percentages were higher at the top compared to the bottom of the stored maize.

The percentage whole maize were higher at the top compared to the bottom at the month of June. At the month of July, it was still higher at the top compared to the bottom of the stored maize but at the month of August, it was the same as seen from fig 4.3 and 4.4.

Considering fig 4.3 alone, there was no much difference in percentage whole, coloured, broken, immatured, infested maize at the month of June, July, August.

Considering fig 4.4 alone, there were no much difference in percentage, whole, broke, coloured, immatured maize at the month of June, July, August except with infested maize, but the much difference can only be seen between the month of June and July between July and August, there were no much difference in percentage infestation.

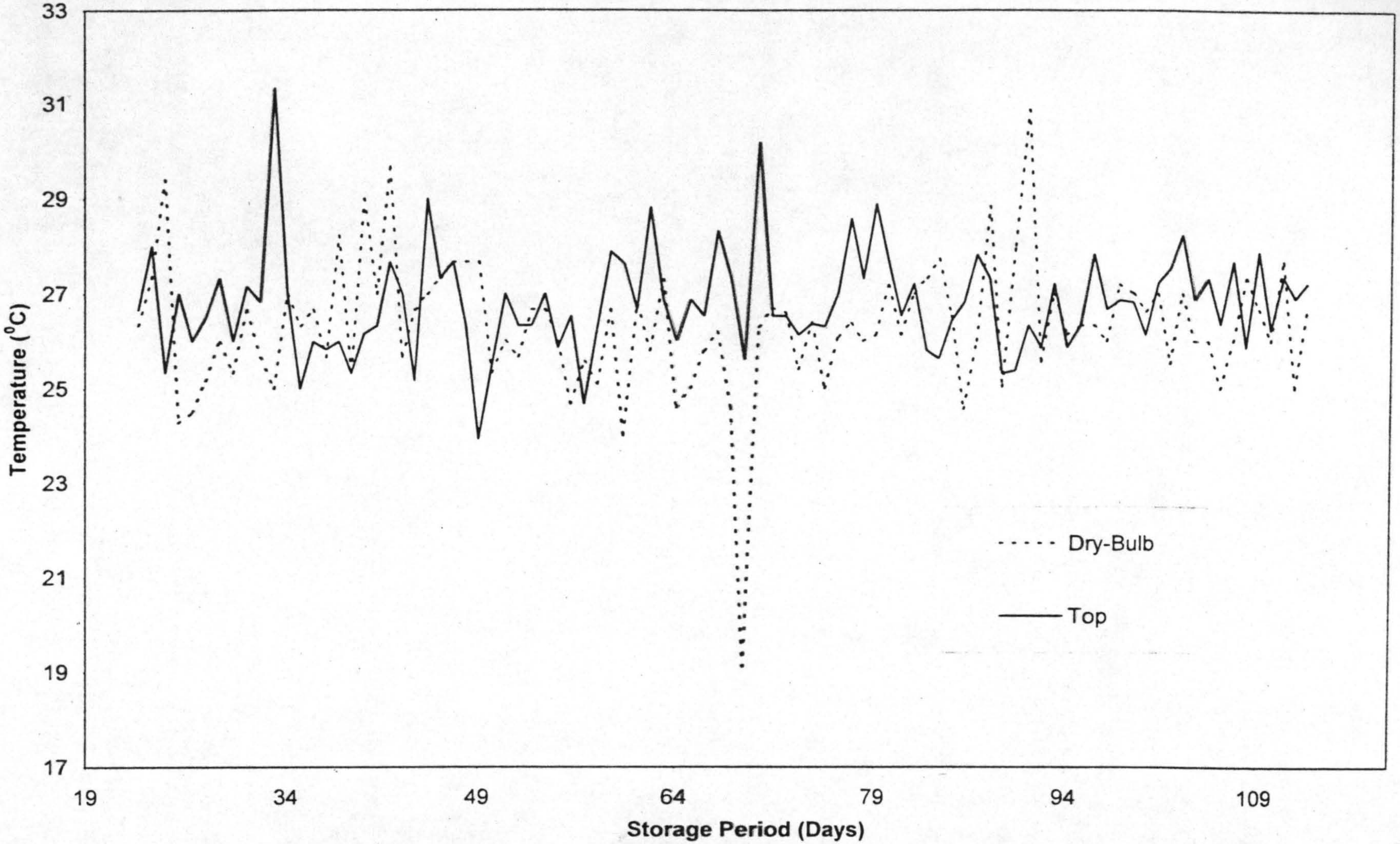


Fig. 4.1: Measured Ambient (Dry Bulb) and Silo Top Temperatures of the Wooden Silo

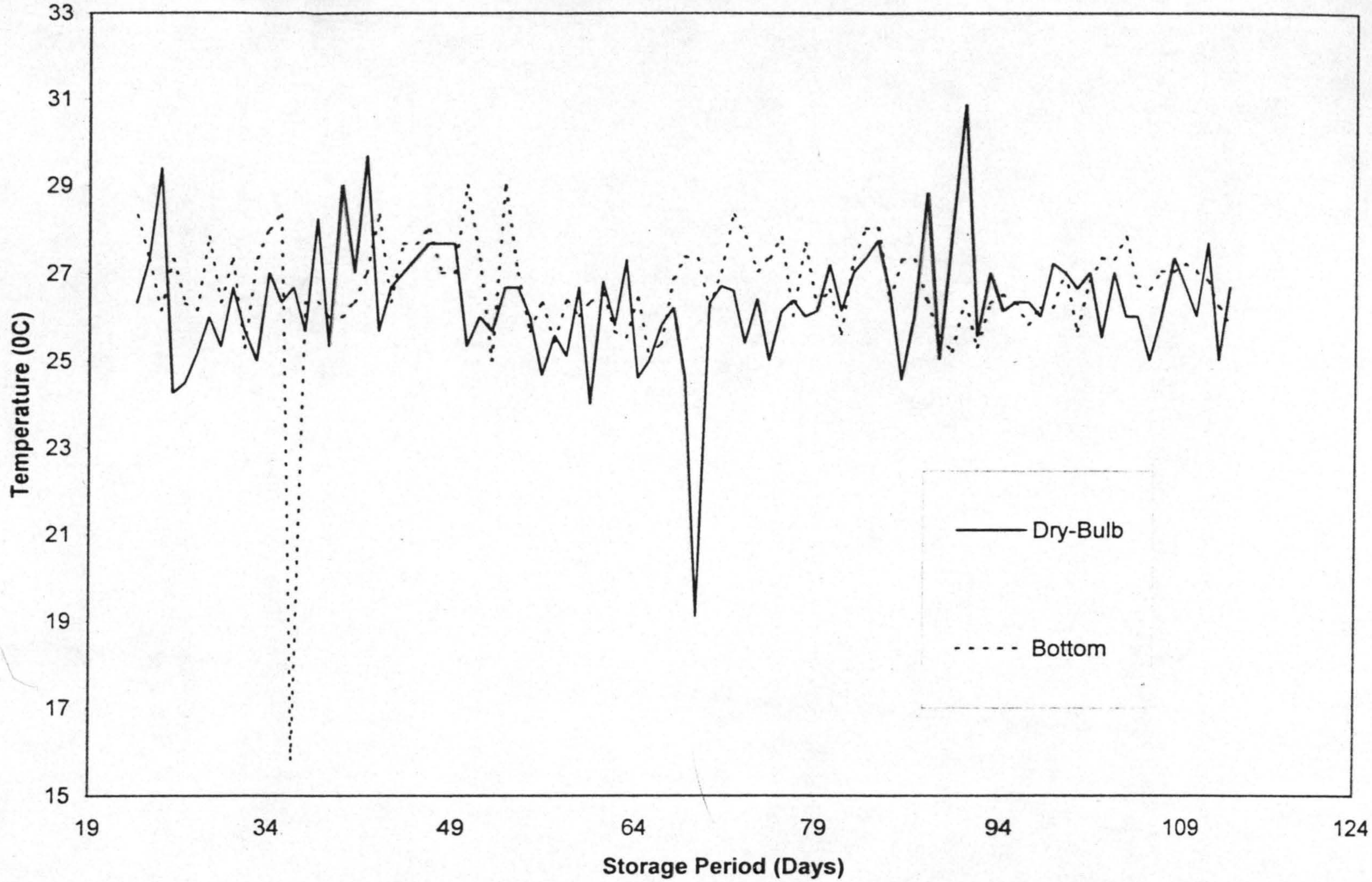
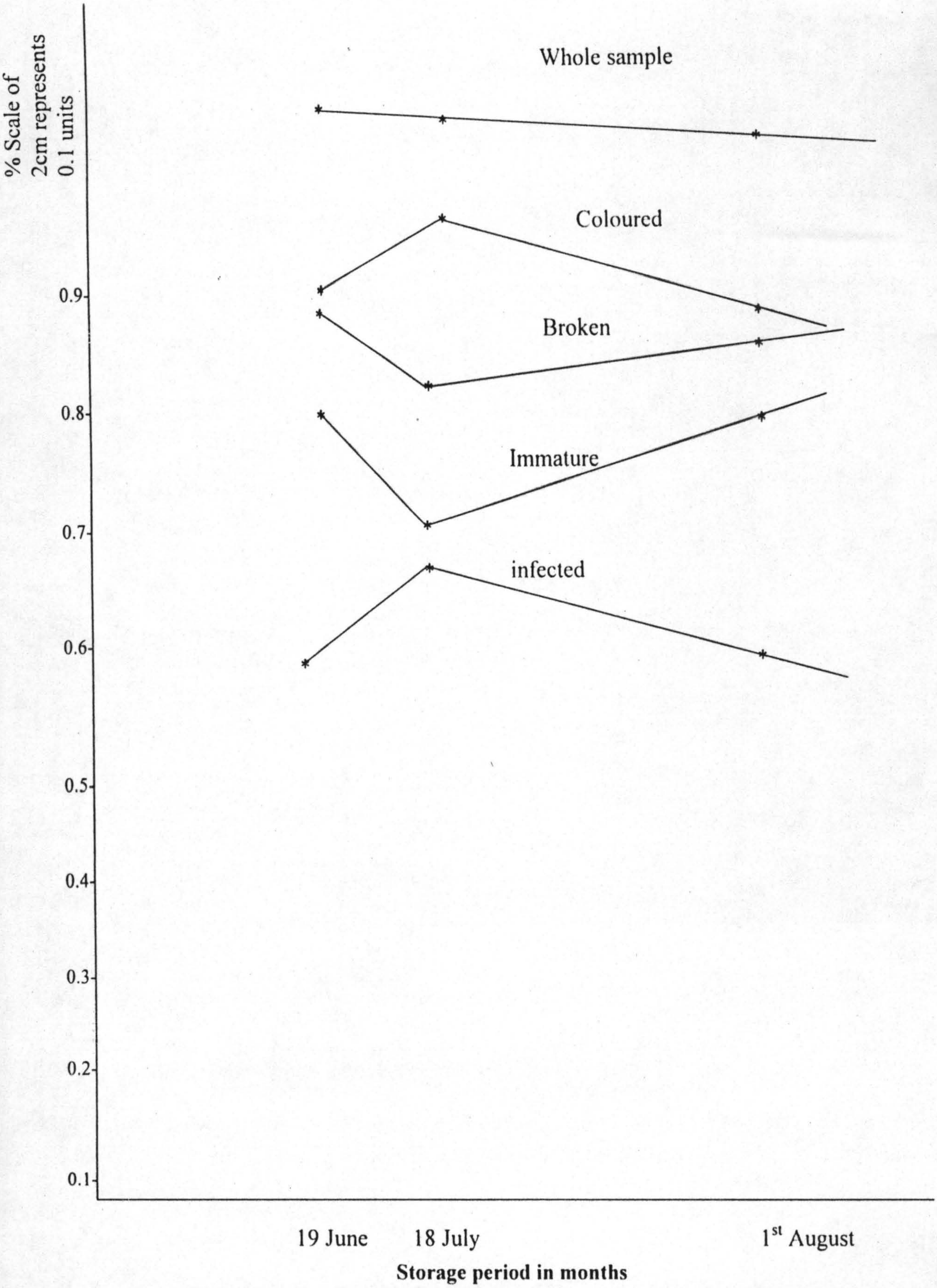


Fig. 4.2: Measured Ambient (Dry Bulb) and Bottom Temperatures of the Wooden Silo



Storage period in months

Fig. 4.3: percentage Quality of maize top sample against storage period

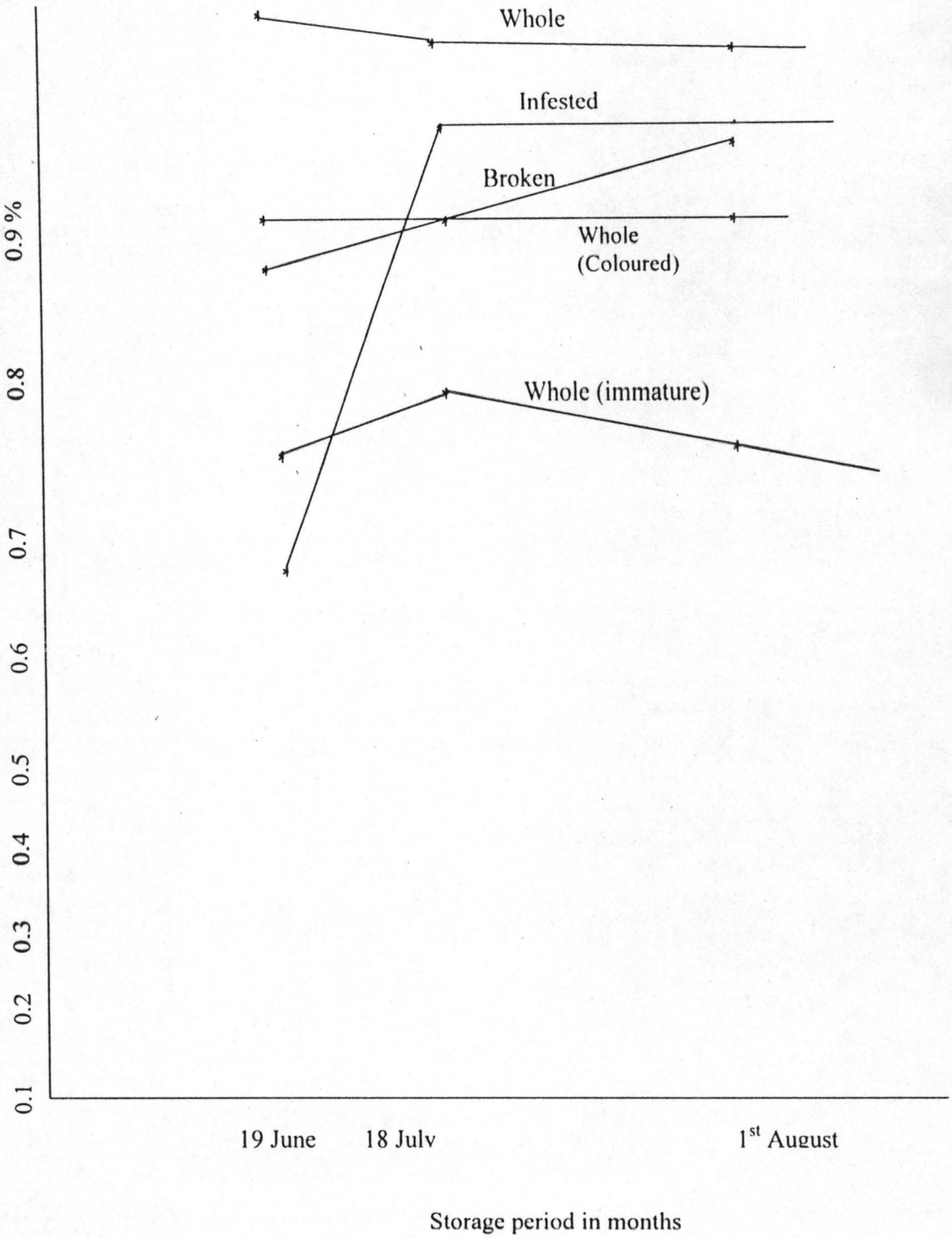


Fig. 4.4 Percentage quality of maize Bottom sample against storage period

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

51. CONCLUSIONS

This work show that there are no significant reductions in the nutrient contents of stored grain except for Ash, which decreased significantly but will month change. This slight reduction can be attributed to the temperature and heat developed by the grains over the storage period, which affected the germ portion of the grain. The germ portion contains the nutrients in the grain.

5.2 RECOMENDATION

The use of wooden silo in this project can be suggested good in the storage of maize grain because of its low thermal conductivity which could reduce the tendency of grain embrayo damage. Because of its low –cost of construction, compared to metal silo, wooden silo can be more easily adoptable by the small farmer who produces only a few tons of maize during the two different semi-annual harvests.

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APPENIX A

way

Descriptives

00001

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
00	2	1.8000	7.071E-02	5.000E-02	1.1647	2.4353
00	2	1.6000	7.071E-02	5.000E-02	.9647	2.2353
00	2	1.5800	1.414E-02	1.000E-02	1.4529	1.7071
00	2	1.4000	7.071E-02	5.000E-02	.7647	2.0353
00	2	1.4000	7.071E-02	5.000E-02	.7647	2.0353
otal	10	1.5560	.1639	5.182E-02	1.4388	1.6732

Descriptives

R00001

	Minimum	Maximum
.00	1.75	1.85
.00	1.55	1.65
.00	1.57	1.59
.00	1.35	1.45
.00	1.35	1.45
Total	1.35	1.85

ANOVA

AR00001

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.221	4	5.536E-02	13.703	.007
Within Groups	2.020E-02	5	4.040E-03		
Total	.242	9			

ost Hoc Tests

omogeneous Subsets

VAR00001

Duncan[a]

VAR00006	N	Subset for alpha = .05		
		1	2	3
4.00	2	1.4000		
5.00	2	1.4000		
3.00	2		1.5800	
2.00	2		1.6000	
1.00	2			1.8000
Sig.		1.000	.766	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

eway

Descriptives

APPENDIX B

R00002

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
.00	2	4.5000	7.071E-02	5.000E-02	3.8647	5.1353
2.00	2	4.6000	7.071E-02	5.000E-02	3.9647	5.2353
3.00	2	4.6000	7.071E-02	5.000E-02	3.9647	5.2353
4.00	2	4.5000	7.071E-02	5.000E-02	3.8647	5.1353
5.00	2	4.5000	7.071E-02	5.000E-02	3.8647	5.1353
Total	10	4.5400	7.379E-02	2.333E-02	4.4872	4.5928

Descriptives

/AR00002

	Minimum	Maximum
1.00	4.45	4.55
2.00	4.55	4.65
3.00	4.55	4.65
4.00	4.45	4.55
5.00	4.45	4.55
Total	4.45	4.65

ANOVA

VAR00002

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.400E-02	4	6.000E-03	1.200	.414
Within Groups	2.500E-02	5	5.000E-03		
Total	4.900E-02	9			

Post Hoc Tests

Homogeneous Subsets

VAR00002

ncan[a]

/AR00006	N	Subset for alpha = .05 1
.00	2	4.5000
.00	2	4.5000
5.00	2	4.5000
2.00	2	4.6000
3.00	2	4.6000
Sig.		.229

eans for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 2.000.

Pa

way

Descriptivos

APPENDIX C

00003

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
00	2	10.5000	7.071E-02	5.000E-02	9.8647	11.1353
00	2	10.0000	.7071	.5000	3.6469	16.3531
00	2	10.0000	.7071	.5000	3.6469	16.3531
00	2	9.6300	4.243E-02	3.000E-02	9.2488	10.0112
00	2	9.5000	7.071E-02	5.000E-02	8.8647	10.1353
otal	10	9.9260	.4979	.1574	9.5698	10.2822

Descriptives

AR00003

	Minimum	Maximum
1.00	10.45	10.55
2.00	9.50	10.50
3.00	9.50	10.50
4.00	9.60	9.66
5.00	9.45	9.55
Total	9.45	10.55

ANOVA

AR00003

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.219	4	.305	1.506	.328
Within Groups	1.012	5	.202		
Total	2.231	9			

ost Hoc Tests

lomogeneous Subsets

VAR00003

n[a]

		Subset for alpha = .05
00006	N	1
	2	9.5000
	2	9.6300
)	2	10.0000
)	2	10.0000
)	2	10.5000
		.086

ıs for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 2.000.

APPENDIX D

...way

Descriptives

...0004

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
...0	2	2.6400	5.657E-02	4.000E-02	2.1318	3.1482
...0	2	2.6000	7.071E-02	5.000E-02	1.9647	3.2353
...0	2	2.6000	7.071E-02	5.000E-02	1.9647	3.2353
...0	2	2.5800	.1414	.1000	1.3094	3.8506
...0	2	2.5600	8.485E-02	6.000E-02	1.7976	3.3224
...tal	10	2.5960	7.260E-02	2.296E-02	2.5441	2.6479

Descriptives

...R00004

	Minimum	Maximum
...00	2.60	2.68
...00	2.55	2.65
...00	2.55	2.65
...00	2.48	2.68
...00	2.50	2.62
...otal	2.48	2.68

ANOVA

...R00004

	Sum of Squares	df	Mean Square	F	Sig.
...etween Groups	7.040E-03	4	1.760E-03	.218	.918
...Vithin Groups	4.040E-02	5	8.080E-03		
...otal	4.744E-02	9			

...st Hoc Tests

...omogeneous Subsets

VAR00004

an[a]

R00006	N	Subset for alpha = .05 1
0	2	2.5600
0	2	2.5800
)0	2	2.6000
)0	2	2.6000
)0	2	2.6400
j.		.423

ns for groups in homogeneous subsets are displayed.

. Uses Harmonic Mean Sample Size = 2.000.

vay

Descriptives

APPENDIX E

)005

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
)	2	82.9000	1.4142	1.0000	70.1938	95.6062
)	2	83.8000	7.071E-02	5.000E-02	83.1647	84.4353
)	2	83.8200	2.828E-02	2.000E-02	83.5659	84.0741
)	2	84.4700	1.4142	1.0000	71.7638	97.1762
)	2	84.6000	7.071E-02	5.000E-02	83.9647	85.2353
al	10	83.9180	.9232	.2919	83.2576	84.5784

Descriptives

00005

	Minimum	Maximum
)0	81.90	83.90
)0	83.75	83.85
)0	83.80	83.84
)0	83.47	85.47
)0	84.55	84.65
otal	81.90	85.47

ANOVA

R00005

	Sum of Squares	df	Mean Square	F	Sig.
etween Groups	3.659	4	.915	1.140	.434
Vithin Groups	4.011	5	.802		
otal	7.670	9			

st Hoc Tests

mogeneous Subsets

VAR00005

an[a]

R00006	N	Subset for alpha = .05 1
0	2	82.9000
)0	2	83.8000
)0	2	83.8200
)0	2	84.4700
)0	2	84.6000
g.		.127

ns for groups in homogeneous subsets are displayed.

. Uses Harmonic Mean Sample Size = 2.000.

DETERMINATION OF % WHOLE, WHOLE (COLOURED), WHOLE (IMMATURE) INFESTED AND BROKEN GRAIN.

APPENDIX F

Grain Quality At Silo Bottom (First Month)

Weight (g)	Whole sample (g)	Whole (coloured)(g)	Whole (immatured) (g)	Infested (g)	Broken (g)
	38g	0.38g	0.33g	0.29g	0.39g
Total weight (g)	43.44g	43.44g	43.44g	43.44g	43.44g
%	87%	0.87%	0.76%	0.67%	0.90%

Wt of sample + foreign matter + cup = 44. 44g

Wt of cup = 1.00g

Wt of sample + foreign matter = 44.44g – 1.00g = 43.44g

APPENDIX G

Grain Quality At Silo Top (First Month)

Weight (g)	Whole sample (g)	Whole (coloured)(g)	Whole (immatured) (g)	Infested (g)	Broken (g)
	35.10g	0.36g	0.32g	0.24g	0.35g
Total weight (g)	39.87g	39.87g	39.87g	39.87g	39.87g
%	88%	0.90%	0.80%	0.60%	0.88%

Wt of sample + foreign on matter + cup = 40 87g

Wt of cup = 1.00g

Wt of sample + foreign matter = 40.87g – 1.00g=39.87g

APPENDIX H

Grain Quality At Silo Bottom (Second Month)

Weight (g)	Whole sample (g)	Whole (coloured)(g)	Whole (immatured) (g)	Infested (g)	Broken (g)
	36.62g	0.40g	0.33g	0.41g	0.38g
Total weight (g)	42.34g	42.34g	42.34g	42.34g	42.34g
%	86%	0.90%	0.78%	0.97%	0.90%

Wt of sample + foreign on matter + cup = 43. 34g

Wt of cup = 1.00g

Wt of sample + foreign matter = 43.34g – 1.00g = 42.34g

APPENDIX I

Grain Quality At Silo Top (Second Month)

Weight (g)	Whole sample (g)	Whole (coloured)(g)	Whole (immatured) (g)	Infested (g)	Broken (g)
	41.08g	0.44g	0.25g	0.31g	0.38g
Total weight (g)	47.22g	47.22g	47.22g	47.22g	47.22g
%	87%	0.93%	0.74%	0.66%	0.80%

Wt of sample + foreign on matter + cup = 48. 22g

Wt of cup = 1.00g

Wt of sample + foreign matter = 48.22g – 1.00g=47.22g

APPENDIX J

Grain Quality At Silo Bottom (Third Month)

Weight (g)	Whole sample (g)	Whole (coloured)(g)	Whole (immatured) (g)	Infested (g)	Broken (g)
	35.33g	0.37g	0.30g	0.41g	0.40g
Total weight (g)	41.56g	41.56g	41.56g	41.56g	41.56g
%	85%	0.89%	0.72%	0.99%	0.96%

Wt of sample + foreign on matter + cup = 42. 56g

Wt of cup = 1.00g

Wt of sample + foreign matter = 42.56g – 1.00g = 41.56g

APPENDIX K

Grain Quality At Silo Top (Third Month)

Weight (g)	Whole sample (g)	Whole (coloured)(g)	Whole (immatured) (g)	Infested (g)	Broken (g)
	38.35g	0.39g	0.36g	0.27g	0.38g
Total weight (g)	45.12g	45.12g	45.12g	45.12g	45.12g
%	85%	0.87%	0.80%	0.60%	0.84%

Wt of cup = 1.00g

Wt of sample + foreign matter = 46.12g – 1.00g = 45.12g

APPENDIX L

COSTING OF THE MATERIAL

S/No	Item	Quantity	Unit Price (₦)	Total Price (₦)
1	½ plywood	6 sheet	1,800.00	10,800.00
	¼ plywood	1	1,100.00	1,100.00
2.	2-3 Timber	6	100.00	660:00
	2-2 Timber	12	150:00	1,800:00
3.	Paint Emulsion	2	350:00	700:00
4	Bags of Maize	6	1,200:00	7,200:00
5	Nails	3	60:00	180:00
6.	Chemicals:	3	70:00	210:00
	i. Phostoxin	1	2,200:00	2,200:00
	ii. Curpex (dust chemical)	1	1,500.00	1,500.00
7.	Body filler	¼ tin	1,000:00	1,000:00
8.	Padlock	3	70:00	210:00
9.	Workmanship			6,500:00
10.	Copper constatan	12	375.00	4,500.00
	Total	:	=	**38,560:00**

Plate 1:

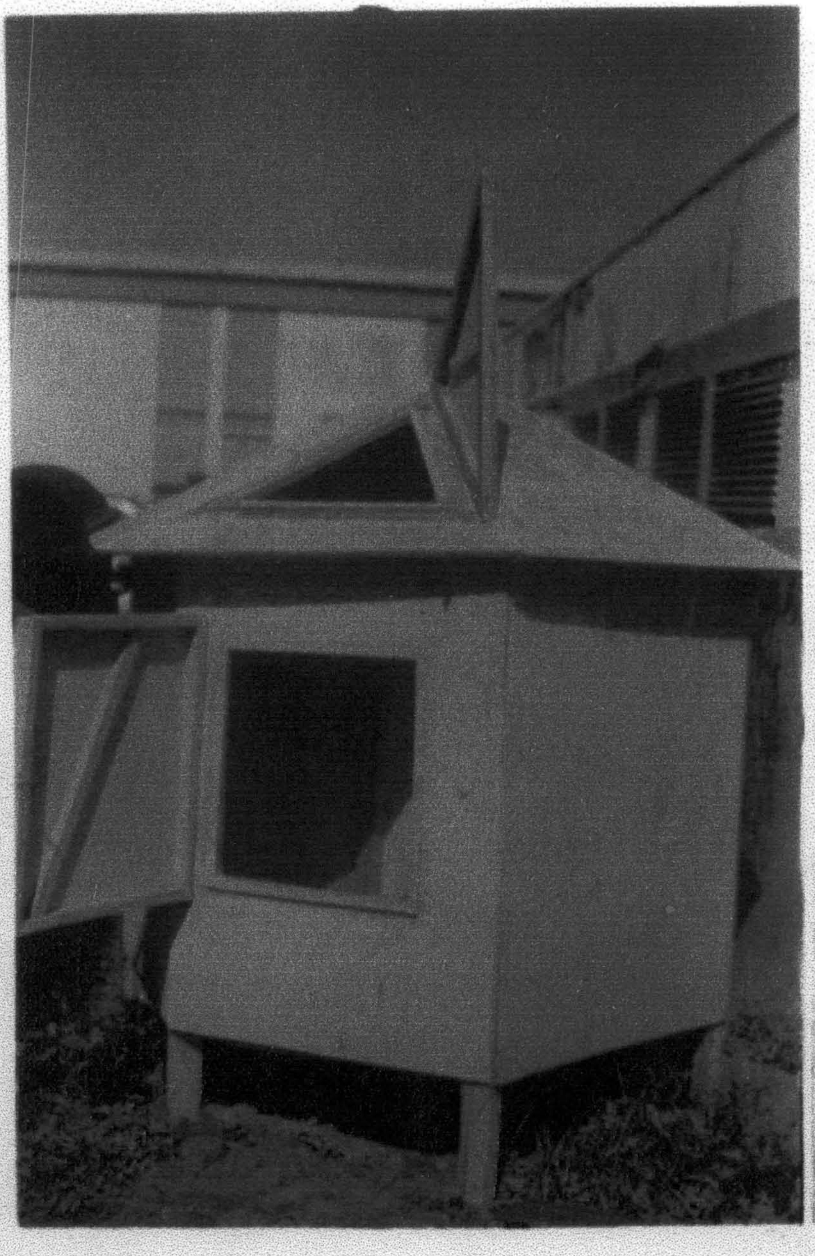

PLATE 1: DIAGRAM OF CONSTRUCTED WOODEN SILO

Plate 2:

PLATE 2: INTERNAL VIEW OF THE WOODEN SILO USED