INSECT INFESTATION OF STORED GRAIN IN A CYLINDRICAL STEEL SILO AND PHYSICAL QUALITY OF SEEDS AFTER STORAGE

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DECEMBER, 2010.

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE IN AGRICULTURAL & BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

DECEMBER, 2010

DECLARATION

I hereby declare that this project work is a record of a research that was undertaken and written by me. It has not been presented for any degree or diploma or certificate at any university or institution. Information derived from personal communications, published and unpublished work were duly referenced in the text.

16 - 12 - 2010

ABDULGANIYU, ISMAIL DEYEMO

Date

CERTIFICATION

This is to certify that the project titled: Insect Infestation of Stored Grain in a Cylindrical Steel Silo and Physical Quality of Seeds after Storage, by Abdulganiyu, Ismail Deyemo meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG) of the Federal University of Technology, Minna, and it is approved for its contributions to scientific knowledge and literary presentation.

Engr. Dr. B.A Alabadan
Supervisor

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Date

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Head of Department

13/12/2010
Date

External Examiner

9/12/2020
Date

DEDICATION

This work is dedicated to the glory of the Almighty God, the Master of the Universe, the one with the sole knowledge of the mysteries that surround the worlds.

ACKNOWLEDGEMENT

My profound gratitude to the Almighty Allah for His unquantifiable blessings at all times.

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At this juncture, I would like to turn the wheels around to give him a standing ovation for a job well done; my father, my mentor, my best friend Alhaji J. A. Abdulganiyu. Daddy you are great! Also not forgetting our mother Mrs S. A. Abdulganiyu and my siblings Taofeeq, Hammed, Simbiat, Tajudeen, Tawakalitu, Ruqayat, Rilwan, Aisat, and Lateef Abdulganiyu, I love you all.

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ABSTRACT

A cylindrical steel silo was used as structure materials to carried out this project, on the first day of storage the grain (maize) was stored with the application of phostoxine and coopex chemicals which serves as cure or preventive measures for the stored grain throughout their storage periods. The silo was kept under a room temperature to avoid climatic factors such as rain, sun that may affect the temperature of the stored grain (maize).The temperature and relative humidity reading were taken 3 times in a day .i.e. in the morning, afternoon and evening. Moisture contents reading were also taken 3 times in a day on weekly basis, the initial moisture content of the grain is 12.6%.The severe attack of insects, pests during grain storage is responsible for substantial losses in the grain storage sector all over the world. Prevention of insects, pests has been achieved mainly by a chemical strategy but the intensive use of chemical compounds has resulted in the evolution of resistant populations and presence of chemical residues both in foods and in the environment.Phostoxin and coopex chemicals are effective fumigant for disfection of storage maize which was applied at the first day of the storage. With these applications, there was no any pest, rodents or insects attack on the stored grain (maize).On like other structure materials such as wooden silo, insect like snout beetle which also known as weevil or termites could easily attack the grains through the wooden material which is not easy to attack grains in a metallic silo. It was observed that there would be a change in colour and peeling off the paint on the wooden structure, which was as a result of the effects of the sun and rain on the wooden structure which was not applicable to a metallic silo . This research shows that the structure materials made of metal are most preferable than that of wooden materials, and the process maintains the qualities of the stored grain physically for future use.

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CHAPTER ONE

1.0 INTRODUCTION

Grain silo is a storage tower or structure used or designed to store Agricultural grains or produces such as guinea corn, threshed rice, shelled maize and so on. This is done so that there will be assurance of food supply at all season of the year. Some of these 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 not only must crop yield be increased, but regular returns must be ensured. [Lasisi, 1975].

In Nigeria, a wide variety of Agricultural products are being produced ranging from cereal grains (such as rice, sorghum, maize) to roots and tubers (such as cassava and yam) to vegetables and fruits and a host of dairy products (Ashafu, 1986). In the northern part of the country, maize is the principal food crop for the people that is been grown and the demand for it is all year round, but it can only be produced within a certain period during the year therefore is need to store some of the grains so that there will be continuous supply for the people all through the year regardless of the season.

In the tropics, there are serious losses of farm produce particularly grains before, during and after harvest as well as dung storage. Lack of adequate storage facilities is one of the major reasons for the shortage of food grains in the tropical countries and also through insect infestation, attacks by rats, birds and some other micro-organism. Owing to these, farmers are forced to keep a small portion of their grains and dump the rest in the market at a reduced loss of stored Agricultural produce and enhance marketing efficiency and to meet demand, which is evenly spread throughout the year (Igbeka, 1983).

More so, large scale producers require large storage facilities for their products. Therefore, there is the need to design a farm grain structure that will be suitable for storing grains produced in large quantity. The choice of materials also depends on the environment and the technology needed to install the structure. Hence the need for the design and construction of the metal silo which will be more advantageous than the wooden silo came up using metallic material such as aluminium or steel to meet the need of the local farmers.

1.1 Statement of Problem

One of the most acceptable methods for storing grains on a large scale is the use of the silo, made from different materials like Aluminium, Steel, Wood or Concrete. Due to the humid climate in Nigeria, the wide diurnal (daily) range in temperature results in excessive heating on the metallic silo roofs and walls and its distribution with the bulk grain as well as moisture condensation. This results to grain caking, development of hot spots, mould growth, seed germination and rapid developments of insects. This usually results in the short–term grains product storage as well as high deterioration of grains.

In a way to put a check on this or fight this problem, the federal government of Nigeria in 1990 (Laban, 1990) embarked on a 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 such as grains dampness, caking of grains, development of hot spots, this leads to mould growth and are associated with high importation cost, technical and management problem.

1.2 Justification

There are silo constructed of other materials like woods, concrete, laterite, rubber and other synthetic materials which can be of good use for the purpose of storage of grains. The use of the metallic silo in the storage of grains has been constructed due to its advantage over the wooden type of silo for its resistance to rodent attack and the facility to control insects by fumigation. More so, the silo cannot be attacked by an insect like termite when compared to the use of wooden silo. When kept under shade at room temperature the effect of direct sunlight on the silo will be reduced, thereby avoiding excessive heating on the metallic silo and all other consequences that might follow.

1.3 Aims And Objectives

This project's objective is to evaluate the 1 metric tonne capacity metallic silo over a storage period of three months. And it is aimed at:

1. Evaluating the physical quality of the maize stored inside a metallic silo.
2. Determining the extent of insect infestation on the stored maize and the silo.

1.4 Scope of Study

The scope of this project is limited to the infestation of the stored grain in a metallic silo, a case study of the permanent site of Federal University of Technology, Minna.

This will look at standardizing of insect infestation of stored grains in minna for a safe storage.

1.5 Significant of the Study

The purpose of this study is to develop a means of determining infested grains stored in a cylindrical steel silo.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Purpose of Storage

Storage has to do with the collection and the keeping of the Agricultural produce that are not presently in use for future use in structures in which the adequate control of the environment in order to maintain the quality of the product. Storage is also an interim in the complex logistics of transporting agricultural produce durable and semi-perishable from producer to processor and its products from processor to consumer.

Products of agriculture need to be stored from one harvest to the next even to the time of their need. Storage is important because naturally agricultural materials are hygroscopic (that is can absorb or give out moisture) and are always in dynamic equilibrium with their environments.

The economics of storage create the need for way to accumulate goods for subsequent distribution to the market place on basis of fluctuation demand. If all products were manufactured as they were ordered rather than held in large quantities for possible future sales. There would be little need for storage.

2.2 Conditions That Affects Safe Storage

2.2.1 Grain condition

Biological materials in general possess some natural resistance to deterioration changes due to the bed coat in several grains and the perineum in root and tubes crops such as cassava and yam. For the storability of any grain, its condition as a result of previous history is an important factor.

However, the product becomes more susceptible to deterioration due to the influence of the principal enemies of the harvest: insects, moulds, rodents. These are discussed below;

Insect

Although peasant farmers find it difficult to estimate losses caused by insects, on the other hand they can the infestation period. The FAO project in Benin studied interest in how villagers perceive precisely identify and estimate losses due to insects according to several criteria: quality of conservation between varieties of cereals and period of infestation. Generally, it can be affirmed that insects cause the greatest losses (Boxall, 1994). Two major insect that attack maize grain in tropics are Weevils, Prostephanus truncates (Larger Grain Borer), Trogoderma granarium (Khapra beetle).

Khapra beetle

Khapra beetle (Trogoderma granarium) is a general storage pest .It occurs mainly on cereals and cereals products, and compound animal feeding stuffs. It is principally serious under hot dry conditions, complete destruction of grains and pulses may take place in a short time .In humid climates, It is not competitive with other storage pests with faster rates of increase. It present in a stored grain, the stage most commonly seen during inspection is the larva and the most usual evidence for infestation is cast larval skins. From daily observation, there was no attack on the grains and the silo since the silo was kept under a room temperature.

Larger grain borer

These insects infest both stored grain and maturing maize ears in the field. In a very short time, the adults produce large quantities of floury dust as they bore into and feed on the grains. Damage grains can be readily identified since they are usually covered by a film of this dust.

The adult beetles are 3 to 5mm long, cylindrical in shape and reddish brown to dark brown. They can fly around. Daily observation showed that, there was no action of larger grain borer on the grain in the silo.

Moulds

The development of moulds is linked with specific atmospheric conditions (temperature and humidity) as in the northern zones of Nigeria where humidity is very high. In the rest of the sub-region the climate does not favour the growth of moulds, except where water infiltrates through a defective roof.

Where the storage of maize cobs, millet or sorghum is on the ground in the new warehouses, moulds appear in the lower layers of the stock. The major influence mould has on grain is the case of mycotoxins.

Mycotoxins

Mycotoxins are highly toxic metabolites produced by various moulds. The toxicity of mycotoxins causes chronic illnesses affecting the nervous system, the cardio-vascular system and the digestive and pulmonary systems. Certain mycotoxins are carcinogenic and others are immunodepressives (lowering resistance to disease), (Cooker, 1994).

The principal mycotoxins are produced by certain species of Aspergillus, Fusarium and Penicillium. The worst are aflatoxins including the Aflatoxin M1 in milk (produced by A. flavus and A. parasiticus), Ochratoxin A (A. ochraceus and P. verrucosum), Zearalenone and Deoxynivalenol (F. graminearum) and Fumonisins (F. monoliforme).

Stored maize is a man-made ecosystem in which quality and nutritive changes occur because of the interactions among physical, chemical and biological factors.

Fungal spoilage and mycotoxins contamination are of major concern. Fungal infection can result in mycotoxins contamination during growing, harvesting, storage, transport and processing. The main fungal species and mycotoxins associated with maize are Aspergillus flavus and aflatoxins, fusarium verticillioides and F. proliferatum and fumonisins, F. graminearum and trichothecenes and zearalenone. A. flavus can infect maize pre-and post-harvest and an increase in aflatoxin content can occur if the phases of drying and storages are poorly managed. Although, Fusarium species are predominantly considered as field fungi, it has been reported that fumonisin production can occur post-harvest when storage condition are inadequate (marin et al. 2004). In order to reduce the impact of mycotoxin in the food stored, it is necessary to control insect pests and fungal contamination, according to the maize stored in a metallic silo.

Rodents

For most villagers, the presence of mice in local storage structures is almost permanent. Present in straw granaries, they equally find their way into clay granaries through the roof or by making holes in the base and can thus cause the granary to collapse.

They cause serious wastage of the stored produce (as much as 20% loss per year) both by their consumption and faecal contamination.

2.2.2 Temperature

Temperature in the range of 5^0-10^0C are considered most desirable for safe long term storage of grain. At these temperatures, the respiration rate is low, insect activity is reduced since most insect species are unable to reproduce at temperatures below 10^0C. Achieving and maintaining such low temperatures in storage brings about technical and economic problem.

"Chilling injury" being brought about by low temperature induces storage disorders in certain materials. For example, yam tissue is said to suffer excessive decay at or a temperature below 12^0C when the tissue or tuber is exposed to ambient conditions.

2.2.3 Oxygen supply

Respiration process which requires oxygen brings about the substantial proportion of the deterioration of high moisture grain stored at ambient temperatures. When stored grains are placed in gas light containers (metal drum with locking rings), this puts a stop to the oxidative respiration of the grain and associated micro flora, which literally means that oxygen is excluded from the grain storage.

Nevertheless, some certain chemical changes and an aerobic fermentation proceed in the absence of oxygen. For example in the process of ensilage of high moisture grain and forage crops. This brings about a characteristic fermented odour and is used to feed livestock.

2.2.4 Relative humidity

Absolute humidity is the mass of water vapour divided by the mass of dry air in a volume of air at a given temperature. The hotter the air is, the more water it can contain.

Relative humidity is the ratio of the current absolute humidity to the highest possible absolute humidity (which depends on the current air temperature).

2.2.5 Moisture content

Moisture content is the quantity of water that is contained in material. Before taking any measure, there are certain percentages of moisture content required for each crop. For example, high moisture grain determines fast due to high equilibrium relative humidity (70%) of the inter seed air inside the grain. This condition encourages the growth of micro flora.

Heat and more moisture are further produced by the respiration of the micro flora and the grain itself which leads to further complication. High moisture grain that is selfheating often results in uncontrolled temperature to the point of ignition and spontaneous combustion.

Recommended moisture content levels for safe storage are tabulated below:

Table 2.5: Recommended moisture content levels for safe storage.

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

Chukwu, 2001.

2.3 Evaluation of Grain Storage Structure and Methods

2.3.1 Low-level grain storage

Village level storage is another name used for low level grain storage and there are several types of traditional storage structure used by farmers for storing their grains each adapting to the climate of the country and these are usually made out of locally available materials.

Cribs of various types are used by maize farmers and these cribs are of poor facilities for continuous drying of maize and insect control. An improved maize crib has therefore been designed for use by farmers for effective storage in maize at level. This is mainly done by mixing small quantities of cement with the earth or careful finishing or smoothing of the silo walls.

2.3.2 Middle level grain storage

At the middle level grain storage, the use of sacks and rhombus are found.

1. **Sacks:** This form of storage is very common with retailers and markets and to is mostly used for storing shelled produced in bags which are shocked and are usually on raved planks in stores, barn or houses.
2. **Rhombus:** This is another example of middle level grain storage. Many physical structures can be identified with the rhombus. The rhombus could be either roughly cylindrical in shape or flask shaped tapering at one end. Damages by rain torrents and rodents accessibility are both reduced and avoided by slightly raising the floor of the rhombus.

2.3.3 High level grain storage

High level grain storages are complex storage structures intended for the commercial storage of large quantities (several thousand of tonnes) of produce.

The silo is the commonest type of high level grain storage and specialized builder offer various types of silos, two, in particular.

i. Vertical silos
ii. Horizontal silos

The vertical silos are mainly made up to several sheet metal or reinforced concrete storage bins stacked vertically.

The horizontal silos are made of sheet metal or concrete and are composed of juxtaposed square or rectangular bins laid horizontal.

High level grain storage as these should be equipped with ventilation system backed up by temperature controls; all these are to avoid the disadvantages of potential rise in temperature, and to guarantee good storage.

In term of storage, these ventilation systems can have the following effects:

1. To lower the temperature of the grain in order to slow down biochemical degradation process (cooling ventilation)

2. To keep the grain at a constant temperature, by systematically evacuating the heart produced by the grain mass itself (maintenance ventilation)
3. To dry the grain slowly

2.3.4 Commercial level grain storage

Grain storage in this level is carried out by large scale grades, exporters, agro-based and allied companies, government agencies and some of the few existing large scale farmers.

The structure of these storage methods is long lasting and permanent and they are mainly silos or warehouse.

2.4 Silo

Silos are storage structure in which grains can be stored loosely in bulk without putting them in bags or sacks. Before the grains are finally stored in the silos they are stored in sacks by the production and precautions have to be taken to ensure the safety of the grain and maintain its quality.

The problem of condensation and moisture migration has being a serious one in Nigeria which has militated against the use of metal conventional silo for grain storage. Nevertheless, heavy losses have not been recorded when grains are put in the silos, insect control is achieved by the use of suitable fumigants. Only dry grains of about 13% moisture content can be safely stored in silos. Any one above this is liable to the problem of condensation moisture migration and even insect damage.

Improvement that have been introduced to silo storage including making them air tight, shading them on top with palm tree leaves or grass and also using Nitrogen atmosphere to protect the grains stored this will completely solve the problem of condensation moisture migration and insert damage.

2.4.1 History, development and underlying problem of silo in Nigeria

In Nigeria, the use of silos as grain storage structure start back tots the mid-1950s. The first silo in Nigeria was a twenty-tonne aluminium type enacted at Ilaro in Ogun State. (Williams, 1971).

The extension service division of the military of agriculture and natural resources of the Western state coordinated the grain storage programme of the Western Nigeria and they were responsible to helping the farmers store their grains during the period of low crisis and release them to the market when the prices were not favourable. Silos were made free of change for farmers use through the United State Agricultural Department in conjunction with the grain storage programme of Western Nigeria. Since the use of the large volume imported silos did not meet the requirement of the small-scale farmers in Nigeria due the cost of acquisition and maintenance.

2.4.2 Type of silo

2.4.2.1 Alternative solid wall bins

a. The "BURKINO" silo

b. The "PUSA" bin

c. The USAID" silo

d. The Ferrocement bin

e. The Synthetic silos (plastic and rubber silo)

The "burkino" silo

This silo is constructed with stabilized earth bricks based on a traditional dome shaped type of bin, in which various models and capacities are available. The shaped root is made of stabilized earth bricks, using special wooden formers. The base is also made of stabilized earth resting on the ground or on concrete pillars.

Skilled masons are the ones that usually make a doom-shaped roof because its technique is not easy to master. A variant has been developed with the roof resting upon a wooden frame, which can be erected by unskilled farmers.

The "pusa" bin

These silos are made of earth or sun dried bricks; that are rectangular in shape and have capacity of 1 to 3 tonnes. This is developed by the Agricultural Research Institute (I.A.R.I)

A typical "Pusa" bin has a foundation of bricks, stabilized earth or compacted earth. 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 2 meters) 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. An outlet pipe is built into its base during the measuring 60 × 60cm is built into one corner.

As the Pusa bin has been widely adopted in India, it has also been demonstrated in some African countries. When loaded with well dried grain it has been given good result.

The "USAID" silo

The "USAID" silo is based on the "Burkino" silo and example of this silo have been erected in Nigeria, holding one tonne of maize grain. A concrete reinforcement slab was made which is 1.5 meters in diameter on which the silo rest. The walls are made of stabilized earth brick 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 rest on bamboos or on a metallic drum base. An outlet door, consisting of a 15×30cm plate 1.5mm thick which is smeared with grease for easy sliding, is let into the base concrete slab.

The ferrocement bin ("ferrumbu")

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

The wall varies thickness from 3.5cm for a bin of $0.9m^3$ capacity, to 6cm for one of $14.4m^3$ capacity.

The synthetic silo

Various attempts have been made to develop small scale storage bins, using synthetic materials such as butyl 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.

2.4.2.2 The controlled storage bins:

The following are classified as controlled storage bins:

a. Metal silo
b. Wooden silo
c. Concrete or Cement silo
d. Ventilated silo
e. Air-tight silo
f. Unsealed silo
g. Flexible sealed silo
h. Plastic/Rubber silo
i. Shallow and Deep silo
j. Underground silo

The metal silo

Metallic silos are economically valid for storing large quantities (over 25 tonnes), metal silos are often regarded as too costly for small scale country. 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).

Metal 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 provide with a padlock is fitted at the base of the wall. In the design of metallic silos, avoiding silo failures is paramount, therefore if the following is not avoided, it can result in silo failure. These include;

a. Concentration of high loads on comparatively small areas.
b. Poor stability of such high and slender structures endangered by wind action and one sided loading
c. Still dubious knowledge of pressures in storage bins.
d. Lack of experience of many engineers in the planning and analysis of such structures.

The wooden silo

Wood is a good material for silo construction because of its low thermal conductivity and low thermal expansion. Wooden products have not been considered for grain silo construction in Nigeria because of the numerous problems which are believed to be associated with timber. Although wood has been successfully used in silo construction in Washington, United State as far back as 1948, which has been favourable compare 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 construction (Mijinyawa, 1989, Alabadan, 2002).

Advantage of wooden silo

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

ii. It has good ease of workability.

iii. It has low thermal expansion on coefficient and low thermal conductivity

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

v. The labour requirement are locally available and inexhaustible if properly planned by tree planting

vi. The raw materials are locally available and inexhaustible of properly planned by tree planting.

Disadvantage of wooden silo

i. Several wood species can rot and many lead to mould growth that will lad to deterioration of the stored grains

ii. Panel joints at different to be made water proof

iii. Difficulty in making the surface of many wood species smooth, cracks and splits may develop, which can lead to insect attract.

Concrete/cement silo

Concrete silos are cementing rich, and often include other materials which normally have to be imported into developing countries. Concrete has been used widely in the construction. Concrete in itself is a durable and economical material for construction. It includes masonry silo, brick silos, hollow tile cement stave and monolithic concrete silo. The use of clay blocks for silo was developed by the Iowa experimental station (Iowu silo).

Advantages on concrete silo

i. Large handling is possible
ii. Concrete is fire proof, rodent proof and it can be constructed into any desire shape
iii. The raw materials for concrete silo are locally available and the labour required for the construction is considerably cheap
iv. The concrete silo is a bad conductor of heat and grain store are protected against moisture condensation.

Disadvantage of concrete silo

i. Concrete is heavy and handling is difficult
ii. Concrete is very poor in tension so the walls must be reinforced to resist the lateral pressure of the grain stored
iii. The difficulty in handling can lead to cracking and breakage of the pre-cast concrete in transit.
iv. Concrete structure are permanent., it can not be easily remolded
v. If surface finishes is not smooth, there will be insects attack on the stored grains and this leading to the deterioration of the quality of the grain.

Ventilated bins/silos

The ventilated bins or silo may be the most economic system for long-term grain storage especially when the grain can normally be harvested in a fairly dry condition. A ventilated bulk storage system consists essentially of a fan and heater unit to provide a supply of slightly warmer air, ducting to convey the air to the grain and some method of distributing the air so that it passes through the grain in the store. These essential 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 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 60-65percent. The mean relative humidity of the atmosphere of the drier parts of Britain over 24hours during harvest time varies from 75 to 85 percent, and continuous ventilation with such atmospheric air will in practice produce grain having moisture 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 either conditions. In cold, wet weather, the average temperature increase needed over the 24 hours to reduce grain to 14 percent M.C is about 6-10^{0}F (3-5.5^{0}C), whereas 0-6^{0}F (0-3^{0}C) temperature rise is adequate to give 6-10^{0}F (3-5.5^{0}C) temperature (Culpin, 1981).

Air-tight silos

A common method of construction is by 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 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 bags, 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 fewer tendencies to stimulate microbial activity. (Culpin, 1981).

Unsealed silos

The unsealed (tower) silos are mainly used for large stock keeping installation where the moist grain is used up at a rate of at least 3 inch (75mm) of silo height per day and the silo is emptied before the onset of warm weather on spring. In cases like these, the simplicity of the unsealed (tower) is silo so attractive, between harvest and the beginning of employing.

A method that brings about satisfaction is this; to cover the top with at least 6 inch (150mm) of any convenient material to absorb condensation moisture, for example, chopped straw, and to cover this absorbent layer with a heavy gauge polythene sheet, well tricked down at the edges. (Culpin, 1981).

Flexible sealed silos

This type of silos may be constructed of buty: rubber or similar flexible material, but good handling systems for filling and employing them are not easily arranged. The silos themselves are relative cheap, and the electricity of the container walls makes it possible to accommodate expansion of the silo atmosphere without the use of relief values. It should, however be reckoned that the trouble free useful life is likely to be much shorter than that of rigid-walled silos (Cuplin, 1981).

Plastic/rubber silo

Silos made of plastic/rubber of various types have been tested but found not suitable. Rigid plastics and fibre glass have not been competitive with wood or steel.

Plastic/rubber silo can result into the problem of moisture condensation as a result of high tendency of the material to absorb heat and its high degree of susceptibility rodent attack.

Weathering under the intense heat of this country leaves a lot of cracks graduating into cuts and holes on the silo rubber after a period of use. Losses as much as 60% or more were common in the rubber silo (Agboola, 1985).

Shallow and deep silo

Based on various classification methods, silo can either be shallow or deep one of this method is based on the plane or rupture which is determined by repose angle of the stored grain.

A silo is said to be deep when the plane of rupture intersect the silo wall within the grain mass. While a silo is said to be shallow when the plane of rupture do not intersect the silo wall within the grain mass

A silo can also be shallow and deep due to the ratio of height to least lateral dimension. Deep silo is the silo in which the depth is greater than the least lateral dimension while a shallow silo is the silo in which the depth is less than the least lateral dimension.

Underground silo

Storage of grain in underground silos is an ancient techniques practiced in many countries. In Morocco, many farmers prefer underground storage for conservation of their produce. It is estimated that storage capacity with this method totals about a million tonnes. 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. Experiment has shown that insect infestation, fungal growth and taste acceptability are well controlled in underground storage silo system.

2.5 Meteorology and Grain Storage

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

And so, meteorology is an important role that must be obeyed in grain storage so that one can understand the extent of damage in order to know the best protective method that can be apply in controlling it.

Much of the damages on grains stored are due to environmental 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: In order to reduce biological and biochemical deterioration low temperature is preferable. 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 needs a certain level of moisture for good growth. Below this level they will grow very slowly or not even grow at all. Grain produce normally should not be stored with moisture content higher than that which would be equilibrium with relatively 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 between 17^0C and 35^0C at almost any moisture content. Mites develop on produce with high moisture content while pests develop completely inside the cereals. Some pests could also be found to develop outside the produce.

Micro-organisms: Development of most species takes place between 5^0C and 30^0C some however has 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 the crop in storage. Losses are caused by direct consumption by the rodents

2.6 Quality Characteristics of Grain

The certain criteria of grain qualities established in any grading standard are those that are of most importance for the end-use. Generally, these criteria, according FAO (1994), are the intrinsic varietal qualities and those that are environment or process-induced.

The intrinsic qualities assigned to grains include composition, colour, bulk density, odour and aroma as well as size and shape; induced qualities are age, broken grain, chalky or immature grain, foreign matter, infested and infected grains and moisture content.

On the other hand, Henderson and Perry (1980) classified the quality criteria, which they termed as grade factors, under three broad headings of fication, physical characteristics include moisture content until size and weight, texture, colour, foreign matter and shape; chemical characteristics include such factors as viability, type and amount of insect damage, and amount of mould damage.

All of these characteristics and how they influence grain quality are described in the following sections.

2.6.1 The intrinsic qualities

2.6.1.1 Composition

Grains are known to be made up of organic and dry mater. The grains organic matter is made up of carbohydrates, lipid, protein and vitamins while the dry matter of grains 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 mixture quantities in cereal grains are essential for body functions. These vitamins found in mixture 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

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.

2.6.1.2 Grain colour

Cereal grains are pigmented and range through the colour spectrum from very light tan or almost white, to black. Where extractive milling is required, highly pigmented varieties may give low yields better white flour (Codex Alimentaries Commission).

2.6.1.3 Aroma/Odour

Fresh grains are normally known to have national aroma or odours that are distinctive. A grain is considered bad when the odour of the grain differs from the accepted characteristics one grains odour or aroma indicates grain quality.

2.6.2 Induced qualities of grains

2.6.2.1 Contaminants

The traces of chemical left on the grains for insect control constitutes the contaminants. These residues often taint the grain or in some rare cases add toxic residues to the maize grains. Tainted grain is obviously of low quality.

2.6.2.2 Chalky or immature grains

Immature grains come about as a result of lack of starchy endosperm found in them at harvest. This condition is as a result of sterility, filed infections, insect attack and so on. Immature grain content is influenced by time of harvest, a high content of this being the result of too early harvest. FAO (1994) give the cause for grain chalkiness as incomplete filling of the starchy endosperm. From observation, to is be revealed that immaturity of grain 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.

2.6.2.3 Infected and infested grain

Infested grains or grains that are damaged by micro-organism are said to be inferior quality. Insect damage to grain has been grouped into categories (Grey, 1966) Viz;

(i) Bored holes and the disappearance of a large portion of the inside of the kernels;

(ii) Injury to the germs;

Heating and consequent condensation and moulding of the grain mass and Contamination with excrements and webbing.

The first category of damage results in loss of weight and food yield. Injury to the germs reduces the grain ability to germinate. Contamination has a direct implication on food hygiene.

On the other hand, the preserve of micro organisms may result in spoilage and in certain instance when toxins produced are ingested health problems do occur.

2.6.3 Grain Quality Standards

A standard is a precise and authoritative statement of the criteria/specification necessary to ensure that a material, product of procedure is fit for the purpose for which it is intended. It therefore helps to define products and lay down quality assurance producers for ensuring that the quality is in harmony with the generally established standards (SON, 1989). Standards are established for a very wide variety of materials, products and services. Quality standards are established for grains in order to provide an unambiguous description of their quality, to protect consumer's rights and to provide a clear indication of quality requirement to both producer and end-user.

Quality standards for grains are also known as grading standards because grading itself means sorting the grain into its various quality fractions under a standard classification on the basis of commercial value or usage. The establishment of these grading standards will therefore set the guidelines and rules for sale and purchase of grains. However in Nigeria, these standards are rarely employed in grain marketing. One of the reasons for this is that grain trade involves direct choice and price negotiation by the buyer, in front of the commodity. In such a situation the quantity of the grain will be assessed visually and it will be influced by the end use. The price will also be determined by local factors. Another reason for non-compliance with standards is that most buying and selling of grain back place in rural areas and standard. Grain standards are nevertheless established and implemented in flour mill and government storage depots.

Grain quality standards are of three types Viz; standard specification, standard test method and grading standards. Standard specifications basically define and specify the grain. They provide criteria for characterizing the nature of the grain, usually on a pass or fail basis. A sample of grain is judged against the standard and may be accepted if it passes all the criteria listed.

Standard test method sets down the producers for testing the specifications of grain samples. All samples must be tested in accordance with the standard methods before the results can be accepted as truly representing the quality of grain being considered. Grading standard is used to group (grade) grain into one of several classes based on inherent quality and projected market value.

CHAPTER THREE

3.0 METHODOLOGY

3.1 LOCATION OF THE SILO

The project is being carried out in Agricultural and Bio-Resources Engineering Laboratory at the Federal University of Technology Minna, Niger State, between August to October 2010.

It is necessary to consider the temperature, relative humidity where the silo is being kept; these factors affect the quality of the stored grains and the materials (metallic silo) used as the main silo of the project.

3.1.1 Temperature

The temperatures of the, grains (maize) were determined with temperature and relative humidity meter. The temperature was determined by switching the meter to a temperature point. This was done daily, i.e. in the morning, afternoon and evening, together with the ambient temperature of the silo.

3.1.2 Relative Humidity

The relative humidity of the grains was determined with temperature and relative humidity meter by switching it to the relative humidity point which was carried out in the same procedure alongside with the temperature i.e. in the morning, afternoon and evening. The readings were recorded.

3.1.3 Initial Condition of the Grains

3.1.3.1 Moisture Content

The moisture content of the grain was determined with moisture content probe meter. The probe was inserted into the grains (Maize) which now indicate the moisture content of the grain on the system given its initial moisture content to be

12.6%. The moisture content of the grains was also determined three times a day on a weekly basis.

13.1.3.2 Colour

There is need to determine the initial colour of the grain before storage, this is done visually in order to determine if there is any change in colour of the grains (Maize) during storage period. The initial colour was noted (Milky Colour).

3.1.3.3 Infestation

The source of infestation for the stored grains (Maize) may be from the field crop, the detection for this infestation is a must for safe storage. Before storage, the grains were properly checked to make sure that they were not infested from the market.

The effects of biological activities in the grains (Maize), snout beetle also known as *Weevil* is the type of insect that commonly attack the grains. The application of phostoxine chemical and coopex (Dust Chemical) was applied on the first day of storage. This will serve as both a cure and a preventive measure for further attacks by insects.

3.1.4 Initial Condition of the Silo

3.1.4.1 Size

The silo was designed cylindrically, with a design capacity of 1 metric tonne.

3.1.4.2 Shape

The metallic silo is cylindrical in shape with diameter of 0.96m while the height is 1.95m

3.1.4.3 Materials

The material used for the construction of the silo is steel.

3.2. Silo Evaluation

3.2.1 Effect of weather on silo

3.2.1.1 Peeling

A daily observation of the Silo revealed that no certain changes had started to occur on the body of the Silo (metallic silo)

3.2.1.2 Colour

A daily observation of Silo also showed that there is no change in the colour of the Silo, the same to its initial colour before storage.

3.2.1.3 Expansion

A daily observation of Silo also showed that there is no any expansion of the Silo.

3.2.1.4 Dimensional Changes

Dimensional change is as a result of mechanical stress on the material as well as moisture fluctuations within the metallic material. These changes caused by shrinkage and swelling which may result in shape, checking out to determine whether there was any changes for the material but there is no any dimensional changes on the material what so ever.

3.3 Grains Evaluation

3.3.1 Shape and Size

Shape and Size are inseparable in a physical object. The chartered standards method is used in determining the shape of the grains; this is done by visual comparison of the shape of the object with chartered standards. From the visual view, the grain is truncate in shape.

3.3.2. Colour

Daily observation of the colour of the grains compared to the initial colour of the grain before storage showed that there was no change in colour.

3.3.3 Insect Infestation

A sample of the grain was obtained from the top, middle and bottom of the silo. Hundred seeds were selected at random from each sample into replicates of five making it twenty seeds per replicate. Each replicate was spread out in a flat tray and ten seeds was randomly selected and carefully examined for any physical damaged that might have been caused by insect. The result was recorded.

This procedure was repeated for samples obtained from the middle and bottom of the silo.

The extent of insect infestation was calculated in percentage using;

$$\text{percentage infestation} = \frac{\text{No of damaged grain}}{\text{Total No of Sample}} \times 100$$

3.3.4. Mycotoxins contamination

Stored maize is a man-made ecosystem in which quality and nutritive changes occur because of the interactions among physical, chemical and biological factors.

Daily observation showed that there was no mould growth on the grain. Since there was no mould development on the grain, the case of Mycotoxin infection is also not available on the stored grain.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1. Results

Table 4.1(a) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples at the top.

Table 4.1(a) Results obtained from the samples at the top

Replicates	No. of Seed Defected
1	0
2	0
3	0
4	0
5	1
Total in Sample	1

The percentage infestation on the grain at the top is

$$= \frac{1}{100} \times 100\%$$

$$= 1\%$$

Table 4.1(b) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples obtained from the middle.

Table 4.1(b) Results obtained from the samples at the middle

Replicates	No. of Seed Defected
1	1
2	0
3	0
4	0
5	0
Total Sample	1

The percentage infestation on the grain at the middle is

$$= \frac{1}{100} \times 100\%$$

$$= 1\%$$

Table 4.1(c) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples obtained from the bottom.

Table 4.1(c) Results obtained from the samples at the bottom

Replicates	No. of Seed Defected
1	0
2	0
3	0
4	0
5	0
Total Sample	0

The percentage infestation on the grain at the bottom is

$$= \frac{0}{100} \times 100\%$$

$$= 0\%$$

Table 4.2(a) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples obtained from the top in the second month.

Table 4.2(a) Results obtained at the top in the second month

Replicates	No. of Seed Defected
1	1
2	0
3	0
4	0
5	0
Total Sample	1

The percentage infestation on the grain at the top is

$$= \frac{1}{100} \times 100\%$$

$$= 1\%$$

Table 4.2(b) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples obtained from the middle.

Table 4.2(b) Results obtained at the middle in the second month

Replicates	No. of Seed Defected
1	0
2	0
3	0
4	0
5	0
Total Sample	0

The percentage infestation on the grain at the middle is

$$= \frac{0}{100} \times 100\%$$

$$= 0\%$$

Table 4.2(c) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples obtained from the bottom.

Table 4.2(c) Results obtained at the bottom in the second month

Replicates	No. of Seed Defected
1	1
2	0
3	0
4	0
5	0
Total Sample	1

The percentage infestation on the grain at the bottom is

$$= \frac{1}{100} \times 100\%$$

$$= 1\%$$

Table4.3 a) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples obtained from the top in the third month.

Table 4.3(a) **Results obtained at the top in the third month**

Replicates	No. of Seed Defected
1	1
2	0
3	0
4	2
5	0
Total	3

The percentage infestation on the grain at the top is

$$= \frac{3}{100} \times 100\%$$

$$= 3\%$$

Table 4.3 (b) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples obtained from the middle in the third month.

Table 4.3(b) **Results obtained at the middle in the third month**

Replicates	No. of Seed Defected
1	1
2	0
3	0
4	0
5	1
Total Sample	1

The percentage infestation on the grain at the middle is

$$= \frac{2}{100} \times 100\%$$

$$= 2\%$$

Table 4.3 (c) below shows the values obtained during the physical test on grain damaged by insects after the storage period for samples obtained from the bottom in the third month.

Table 4.3(c) Results obtained at the bottom in the third month

Replicates	No. of Seed Defected
1	0
2	0
3	0
4	1
5	0
Total Sample	1

The percentage infestation on the grain at the bottom is

$$= \frac{1}{100} \times 100\%$$

$$= 1\%$$

Discussion of Result

From table 4.1(a), it can be observed that only one seed damaged during the physical test, from table 4.1(b), Only one seed was discovered damaged during test while table 4.1(c) shows that no damaged seed was recorded. And it was observed that all the damaged seeds were not due to insect attack but rather from broken effects.

Table 4.2(a), shows that only one seed damaged from the top during the second month, Table 4.2(b), shows that no damaged seed was recorded at the middle during this month in question while only one damaged seed was recorded at Table 4.2(c).

Table 4.3(a) shows the highest number of damaged seeds of three (3) at the top, Table 4.3 (b) was closely followed with two (2) damaged seeds while only one was recorded at table 4.3(c).

The above results shows that, the seeds damage in a metallic silo from top, middle, and bottom from first month to third month are very minimal which shows that with a metalic silo, a safe storage with minimal loss is guarateed.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the test carried out during the storage period, it was observed that the effects of biological activities in the silo only applicable to a wooden structure for storage, it not experienced using storage structures made of metal. This automatically made it possible for the grains to be well stored during the period of test performed.

From the study, it can be concluded that, the extent of insect infestation on the stored maize in the metallic silo were very minimal, thus showing no insect infection while the physical qualities such as shape, size and colours which remains milky from the first day of storage to the storage period of three (3) months.

5.2 Recommendation.

The issue of storing grains within short period of 3 months cannot give an accurate result of storage process of any grains. It is necessary that the storage structures made of metals should be practiced for a much longer duration; this is to enable the test to cover all the seasons in the year for better results of storing the grains.

The tests, which will cover a longer durations will cost much and so the department of agricultural and bio-resources engineering in Federal University of Technology Minna, should take interest and make funds available for further work on this project.

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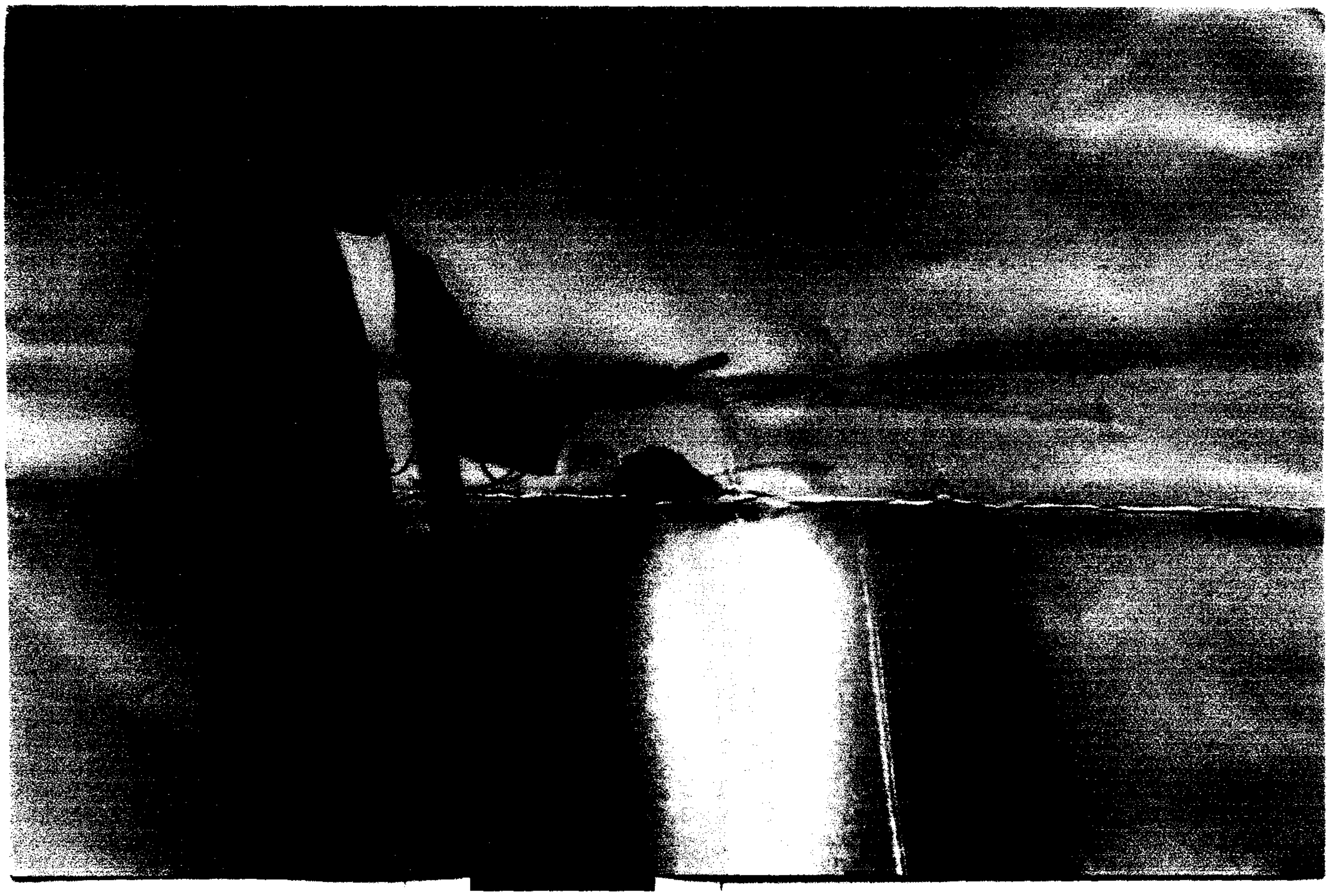
APPPENDIX 1



APPENDIX 2