ANALYSIS OF FACTORS INFLUENCING THE ADOPTION OF IMPROVED GROUNDNUT STORAGE TECHNOLOGY IN GHANA

By

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DECLARATION

I, Festus Selorm Kofi Attah, do hereby declare that this submission is my own work towards the MPhil (Agricultural Economics) and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

This study employs the Logit model to analyze factors influencing farmers' choice of groundnut storage technologies, cost incurred and awareness of storage conditions on aflatoxin growth. Adoption was specified as a function of personal and institutional factors. Whilst awareness of storage conditions on aflatoxins and cost incurred and knowledge of aflatoxins and cost incurred were specified as a function of personal, institutional and aflatoxin management practices. Cross sectional data was collected for 2011 crop year from a sample of 200 maize farmers from the Tamale Metropolis, Savelugu Nanton and Tolon Kumbungu Districts in the Northern Region of Ghana.

Empirical result showed that adoption of improved storage technology was positively influenced by AEA contact and household size. The study revealed that an average cost of GH¢35.648 is incurred for a six month period of groundnut storage. Again, farmers who belong to farm groups, drying groundnuts in shell, store in well aerated locations, store in rooms free from seepages or leakages of water and store groundnuts away from other products are more likely to incur a cost of GH¢11 or more during groundnut storage . The study recommends that MoFA and all other relevant institutions concerned with groundnuts should increase their contact with farmers. This was proven by the study to influence the adoption of improved groundnut storage technology. Again, extension contact should emphasize sorting of groundnuts, membership of farm groups, sorting of groundnut before storage, storage in well aerated room, and storage in room free from seepages and leakages as way of curbing aflatoxins during storage.

DEDICATION

I dedicate this write-up to the ALMIGHTY GOD for his guidance and protection throughout my nine years in KNUST. It is again dedicated to my Mum (Alornu Suzy) and Dad (Kwame Attah) for giving me the roots to grow; and my siblings Michael, Rolland, and Elizabeth who supported me with wings to fly. I cannot do without mentioning Madam Hope who gave me some moral support when the going was getting tough.

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LIST OF ACRONYMS

ADP	Agricultural Development Project
AEA	Agricultural Extension Agents
AFB2	Aflatoxin B2
AFBI	Aflatoxin B1
AFGI	Aflatoxin G1
AFM1	Aflatoxin M1
AW	Water Activity
CIMMYT	International Maize and Wheat Improvement Center
DRG	Dry Roasted Groundnut
EC	European Community
FAO	Food and Agriculture Organization
FBO	Farmer Based Organization
FAOSTAT	Food and Agriculture Organization Statistics
GDP	Gross Domestic Product
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
JHS	Junior High School
KMC	Kernel Moisture Content
LD_{50}	Lethal Dose 50%
MoFA	Ministry of Food and Agriculture
SARI	Savanna Agricultural Research Institute
SAS	Statistical Analysis System
SHS	Senior High School
SPSS	Statistical Package for the Social Sciences
UNEP	United Nation Environmental Programme
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background

Groundnut (*Arachis hypogea L.*) is an annual legume, which is also known as peanut, earthnut, monkey nut and goobers. According to FAOSTAT (2011), groundnut is the 13th most important food crop of the world. It is the world's 4th most important source of edible oil and 3rd most important source of vegetable protein. Cultivated groundnut originates from South America (Weiss, 2000). It is one of the most popular and universal crops grown in more than 100 nations in six continents (Nwokolo, 1996). Groundnut is grown on 25.2 million hectares of land with a total production of 35.9 million metric tons (FA0, 2006). Especially in the developing countries, groundnut has an important role both as oil and food crop. As a food crop, groundnut plays a key role in the diet of rural and urban communities in Ghana, chiefly because of its high contents of protein (21-30%), fat (41- 52%), and carbohydrate (11-27%). It is also rich in calcium, potassium, phosphorus, magnesium and vitamin E. Groundnut haulms are nutritious and widely used for feeding livestock (Waliyar, 2006).

In Ghana, it is the most widely cultivated legume and features prominently in the cropping system of the Savanna and Forest Savanna transitional agro-ecological zones (Asafo-Adjei et al., 1998). Groundnut production in Ghana in 2010 was estimated at 530887 tonnes from 353376 hectares (FAOSTAT, 2012). Groundnut cultivation is concentrated in the northern part of the country. This Tsigbey et al. (2001) attributed to the fact that, more than 90% of farmers cultivate groundnut in a typical northern farming community.

The groundnut has the ability to fix high amount of atmospheric nitrogen and thus enhancing the sustainability of farming systems in Ghana. Groundnut can be consumed in roasted/boiled form, processed into oil for cooking or paste for soups or as spreads. National per capita groundnut consumption was is estimated at 0.61 kg/week (Awuah, 2000), while Jolly et al. (2008) estimate that 80 percent of Ghanaians consume groundnuts or groundnut products at least once a week and 32 percent at least three times a week. According to Marfo et al. (1999), its haulm is used as fodder and the cake in formulating animal feed (Asafo-Adjei et al., 1998). Groundnut cake is often deep-fried or dried to make a snack locally called "kuli-kuli". Groundnut flour is used as an ingredient in soups, sweet, confectionaries and puddings. Groundnut especially those produced in developing countries has been used traditionally since the origin of humanity (Ibrahim et al., 2010). It also has a wide application in the confectionery industry.

Stored agricultural produce is affected by many factors that determine their quality. Sinha (1973) identified product condition, storage container or structure, length of storage and type of handling as the factors determining the quality of stored agricultural produce. Invariably, groundnut quality in storage is affected by the afforestated factors. Bediako et al. (2009) indicated that produce storage increases the selling opportunity for all actors in the value chain. It is also critical for farmers to harness the benefits of agricultural commodity marketing. Bediako et al. (2009) reckoned was because; produce storage reduces post-harvest losses and enhance farmers' participation in marketing. Furthermore, storage regulates farm produce flows to the market and helps to stabilize price over time and space. In addition, produce storage ensures food security among most households since it can contribute to a large extent in reducing or forestalling high prices often encountered during the lean season.

In Ghana, storage of groundnut leaves much to be desired. According to Bediako et al., (2009) smallholder farmers store groundnuts in-shell in earthen pots, mud bins, bamboo baskets, or in wicker receptacles which are often than not plastered with mud or cow dung with little or no use of pesticides. For long-term storage, the containers used in storing groundnut are sealed with mud after the addition of ashes, ground pepper, dried neem leaves or other local herbs to control storage pest (FAO, undated).

Groundnut just like any other crop lends itself to fungal infection during storage. The fungi *Aspergillus flavus* and *Aspergillus parasiticus* are two such fungi, which attack groundnuts both before and after harvest (pre and post-harvest). Aflatoxins are the toxic substances produced by strains of fungi belonging to *Aspergillus flavus* and *A. parasiticus.* Aflatoxin, a mycotoxin from these fungi has the potential to harm both humans and animals (Munimbazi and Bullerman, 1996; Njapau et al., 1998).

Since, early 1960's aflatoxin contamination has led to human and cattle health concerns, significantly influencing groundnut trade worldwide. It is considered to be one of the leading causes of hepato-cellular carcinoma, one of the most common cancers in developing tropical countries. Groundnut can be contaminated with aflatoxin at various stages before harvest, during harvesting, field drying, curing and in storage (Waliyar, 2002; Babu et al., 1994). This toxin remains associated with the crop from harvest through storage and consumption (Cotty 1990). Groundnut invasion by aflatoxin and subsequent aflatoxin occurs at farm level before harvest (during pod development phase), during post-harvest drying and storage (Awuah and Kpodo 1996; Holbrook et al., 2000) and transportation to markets.

Aflatoxins are the major toxins affecting the quality of groundnut meant for human consumption. As the future of groundnut lies in its use as a food crop by itself and in a variety of food products that are widely consumed, it is a clear indication of widening health risk of aflatoxin contamination (Waliyar, 2006).

1.2 PROBLEM STATEMENT

The inelastic nature of most agricultural produce demand in the short-run including groundnuts makes storage a very attractive practice. This implies that, there is a direct relationship between the price and the total revenue realized by producers; the higher the price the higher the revenue and vice versa. For this higher revenue to become a reality, farmers will have to store to obtain better prices during the lean season. This is especially so because, agricultural produce including groundnuts are not grown throughout the year.

The farmer, however, stands the risk of insect, pest and fungi infestation during the period of storage; the latter being of outmost importance in this study. One such fungus is the *Aspergillus flavus* responsible for aflatoxins in groundnuts.

Aspergillus flavus, a ubiquitous fungus responsible for aflatoxins in groundnut, invades in the field and during storage thus making groundnuts unwholesome for consumption. This mycotoxin proliferates under certain environmental conditions, moisture or relative humidity, which may be in the form of kernel moisture content (KMC) is the most important environmental factor with temperature following closely (Keenan and Savage, 1994)

Mycotoxins (including aflatoxins) according to the FAO (in: Schmale and Munkvold undated) affect 25% of the world's crops each year with an annual loss of around 1 billion metric tons of food and food products. In the US, it was reported that income losses due to Aflatoxin contamination cost an average of more than US$100 million per year to US producers (Coulibaly et al., 2008).

Furthermore, economic loses according to Schmale III and Munkvoid (undated) occur because of yield loss due to disease induced by toxigenic fungi; this was corroborated by Amoako-Atta et al., (2007) that mouldiness of groundnut kernel is constraining production in Ghana. Atuahene-Amankwa et al, (1990) attributed this to unsatisfactory post-harvest pod handling that characterizes some production areas; reduced crop value resulting from mycotoxin contamination; Babu et al. (1994) reported significant export losses in Malawi's groundnut export due to aflatoxin contamination.

In addition, losses in animal productivity from mycotoxin-health related problems have been reported. Diary are reported to have significant reduction in milk yields which coincide with the excretion of AFMI in their milk (Coker, 1979). Lastly, Ray et al.

(1986) cited in Keenan and Savage (1994) reported abortion and symptoms suggestive of acute of aflatoxicosis after pregnant cows ingested aflatoxin-contaminated groundnuts; and human health cost.

Even though the latter is difficult to quantify, it draws its importance from the fact that, the ever increasing cost of animal protein has made groundnuts an even more important source of protein and thus exposing more people to the aflatoxin menace. In this regard, several reports have been made to that effect. Notably, the aflatoxicosis outbreak in Kenya in 2004 with 317 cases, and 126 deaths (Claudia et al., 2007) shows the severity of the aflatoxin problem.

These economic impacts are felt all along the food and feed supply chains: crop producers, animal producers, grain handlers and distributors, processors, consumers, and society as a whole (due to health care impacts and productivity losses). For example in Uganda, aflatoxin is considered one of the most important quality problems (Kaaya et al., 2006). However, that level of awareness is not in Ghana. Awuah et al. (2009) revealed that up to 90 percent of surveyed farmers, processors, and consumers are unaware of aflatoxin, while 92 percent of farmers in the Ejura Sekyeredumase district of Ashanti Region had never heard of aflatoxin (Jolly et al. 2006). Jolly et al. (2009) reckoned that contrary to suggestions that, for example, the more that professionals in decision-making positions are aware of contamination, the more they will be willing to implement measures to reduce the presence of contaminated groundnuts from the food supply, their actual behavior does not complement the assertion.

Storage has been found to play a pivotal role in curbing aflatoxin proliferation in groundnuts. Studies conducted by Keen and Martin (1971) in Swaziland comparing stored groundnut samples from agricultural stations and those from rural areas revealed a vast difference in aflatoxin contamination. They attributed the difference to differences in storage. This observation is in agreement with what William (2004); Aziz-Baumgartner (2005); Soler (2007) observed, that storage techniques and proper ventilation are also issues that contribute to build up of aflatoxins. Kpodo (1995) in his report the "Present status of research on the aflatoxin problem in groundnut in Ghana" revealed high levels of aflatoxin contamination in damaged groundnut kernels in earlier surveys. (5.7 - 22168, $ugkg^{-1}$). These levels reported in Kpodo (1995) exceed the accepted levels in the E.U and U.S, which are $4ngg^{-1}$ ($2ngg^{-1}$) and $20nng^{-1}$ for humans and $20nng^{-1}$ and $20nng^{-1}$ for livestock respectively (Freeman et al., 1999, ICR1SAT).

Ghana, therefore stands the risk of export revenue loses as result of aflatoxin contamination since aflatoxin contamination is a serious problem in the international peanut market and has seriously hampered the export business of the developing countries (Nautiyal, 2002). As a result aflatoxins have negatively impacted on the realization of the full economic benefit from groundnuts (Kaaya et al., 2006). Ghana just like any other exporter country is expected to meet certain quality parameters fixed by importer countries for international trade in groundnut kernels and cake. For example, the general guidelines for the quality of groundnut pods and kernels formulated by the Natural Resources Institute of the United Kingdom Ministry for Overseas Development relate to pod colour and type, size, pod texture, cleanliness, freedom from damage and absence of blind nuts; for in-shells and, grading for size or count, shape, ease of blanching, skin colour and conditions; resistance to splitting, moisture content, cleanliness, oil content and flavour; for kernels. Quality guidelines also specify that, the groundnut lots must be free from aflatoxin contamination.

While groundnut hulls may be contaminated by *Aspergillus flavus* during growth in the soil, there is also the chance for contamination to occur at various stages after harvest. Contamination can occur during field curing and drying, storage (Freeman et al., 1999) and transport (Keeman and Savage, 1994).

Considering the current knowledge and opportunities available to farmers in Ghana, field curing like lime and gypsum application will be a difficult and expensive management practice and may not be economically feasible for farmers to undertake and for that matter aflatoxin management must be at the post-harvest level (Florkowski and Kolavalli, 2013). Drying to required moisture level could easily be achieved by farmers in the tropics provided rainfall does not interfere with this drying process. However, more often than not groundnut is stored and this can negatively or positively influence quality depending on the storage structure.

However, groundnut storage in Ghana leaves much to be desired. According to Bediako et al., (2009), smallholder farmers store groundnuts in-shell in earthen pots, mud bins, bamboo baskets, or in wicker receptacles which are often than not plastered with mud or cow dung with little or no use of pesticides. These also include annual storage structures built purposely for groundnut storage made of paddy straws, split bamboos, reeds, ropes. With these kinds of storage technology being employed by our small-holder farmers, who form the majority of groundnut producers; groundnut from these storage technologies will not meet the quality and quantity level. This will be as a result of loss through insect and pest attack and aflatoxin infestation. However, improvements have been made in this regard through the introduction of improved storage structures built with traditional materials with the purpose improving the longevity and quality of stored groundnuts.

Diop et al. (2004) in a World Bank Policy Research Working paper also alludes to the fact that, technical processes exist to reduce aflatoxin contamination (e.g., through ammoniac as used in Senegal for groundnut meal) but the best method is to improve farm practices through use of the best quality and resistant seeds, proper management of farms, and appropriate storage to avoid exposure to high temperature and humidity. The latter is the focus of this study because according to Florkowski and Kolavalli (2013) awareness of aflatoxin is low among producers and traders and they are unaware of the fact that improper groundnut storage can aggravate contamination. In addition, storage technologies according to Florkowski and Kolavalli (2013) could control the spread of aflatoxin contamination by directly affecting the growth of toxic *Aspergillus* strains and indirectly by control of insects feeding on groundnuts.

It is against this background of information that the following research questions arise:

1. What personal and institutional factors influence the adoption of groundnut storage technologies?
2. What is the relationship between cost incurred in storing present groundnuts and the knowledge of good practices in groundnut storage?

1.3 OBJECTIVES OF STUDY

The key objective of the study is to analyze factors influencing farmers' choice of groundnut storage technologies and cost incurred in groundnut storage.

The specific objectives of the study are to:

1. Determine the personal and institutional factors that influence the adoption of improved groundnut storage technology to reduce aflatoxin contamination;
2. Estimate the relationship between cost incurred in storing present groundnuts and the knowledge of good practices in groundnuts storage.

1.4 JUSTIFICATION

Groundnut production practices in Ghana make the crop susceptible to infection. Groundnuts are often intercropped with maize, cassava, millet and sorghum, all highly susceptible to aflatoxin contamination.

An integrated management strategy for pre-harvest control of aflatoxin in groundnuts was proposed by Waliyar et al. (2008). However, it requires the application of soil amendments such as gypsum and compost. The treatment may not be economically feasible for farmers who lack the resources needed to even purchase seed (none of which is certified), fertilizer, or herbicides. Therefore, until the market guarantees premium prices or increased yields can help them recover the additional production costs, the focus on managing aflatoxin must remain on postharvest handling (Florkowski and Kolavalli, 2013).

A key point of postharvest contamination identified by Freeman et al. (1999) is storage. Poor storage practices contribute to infestation because farmers do not control key factors that stimulate *Aspergillus* growth (Florkowski and Kolavalli, 2013).

In Ghana, mature groundnuts kernels, after harvesting and drying are stored in jute and kept in barns built of thatch or mud (Nautiyal, 2002). These sacks are sometimes re-used or employed in storing other products such as maize, rice, sorghum and cocoa thus increasing chances of contact with *Aspergillus* spores (Awuah and Kpodo 1996; Hell et al., 2000). Awareness of aflatoxin is low among producers and traders (Awuah et al., 2009) and more importantly, few are aware that improper groundnut storage can aggravate contamination (Florkowski and Kolavalli, 2013).

Past research has revealed and developed groundnut varieties that are tolerant to *Aspergillus flavus* invasion and subsequent contamination (Waliyar et al., 1994). However, there is little written on how adoption of good storage technology could reduce aflatoxin contamination and factors that will influence the adoption. The results from this study should elicit some information on these factors.

CHAPTER TWO

LITERATURE REVIEW

This chapter examines relevant literature on technology adoption: groundnut production in Ghana, storage technologies, economics of storage, and aflatoxins. It also reviews existing literature on the process of adoption, measurement of adoption, and factors affecting adoption

2.1 Groundnut Production in Ghana

Groundnut production in Ghana in 2010 was estimated at 530887tonnes from 353376 hectares (FAOSTAT, 2012). The national production statistics based on the area cropped (ha) and the corresponding quantity produced (tonnes) from 2000 to 2009 is shown in Table 2.1. However, groundnut cultivation is concentrated in the northern part of the country. This Tsigbey et al. (2001) attributed to the fact that, more than 90% of farmers cultivate groundnut in a typical northern farming community. In Senegal, for instance, groundnut account for 70 percent of the rural labor force and 60 percent of households' agricultural income. Groundnut production and processing represent about 2 percent of GDP and 9 percent of exports in that country (Diop et al., 2004).

Table 2.1: The national groundnut (in shell) production statistics from 2000 to 2009.

Production			Gross Production Value		Export	
Year	Area Cropped(ha)	Quantity (tonnes)	Current million US$	Constant million US$ (2004-2006)	Quantity (tonnes)	Value (1000US$)
2000	218000	209000	92	146	968	870
2001	254000	258000	134	180	149	69
2002	384000	520000	206	363	879	368
2003	464700	439000	211	307	2067	861
2004	431667	389649	200	272	1924	1203
2005	450000	42000	313	294	1111	383
2006	480000	52000	436	363	318	226
2007	341640	301770	245	211	746	316
2008	350660	470100	392	329	608	418
2009	336500	485100	341	339	608	418

Source: (FAOSTAT (C) FAO Statistics Division 2012/03/March, 2012)

Ghana between the year 2000 and 2009 exported a total of 9378 tonnes of groundnut with an export value of a total of 5.732 million US dollars which averages to about 0.3% of the total groundnut production in the same period (Table 1.1) and figure 1.1 also presents the trend.

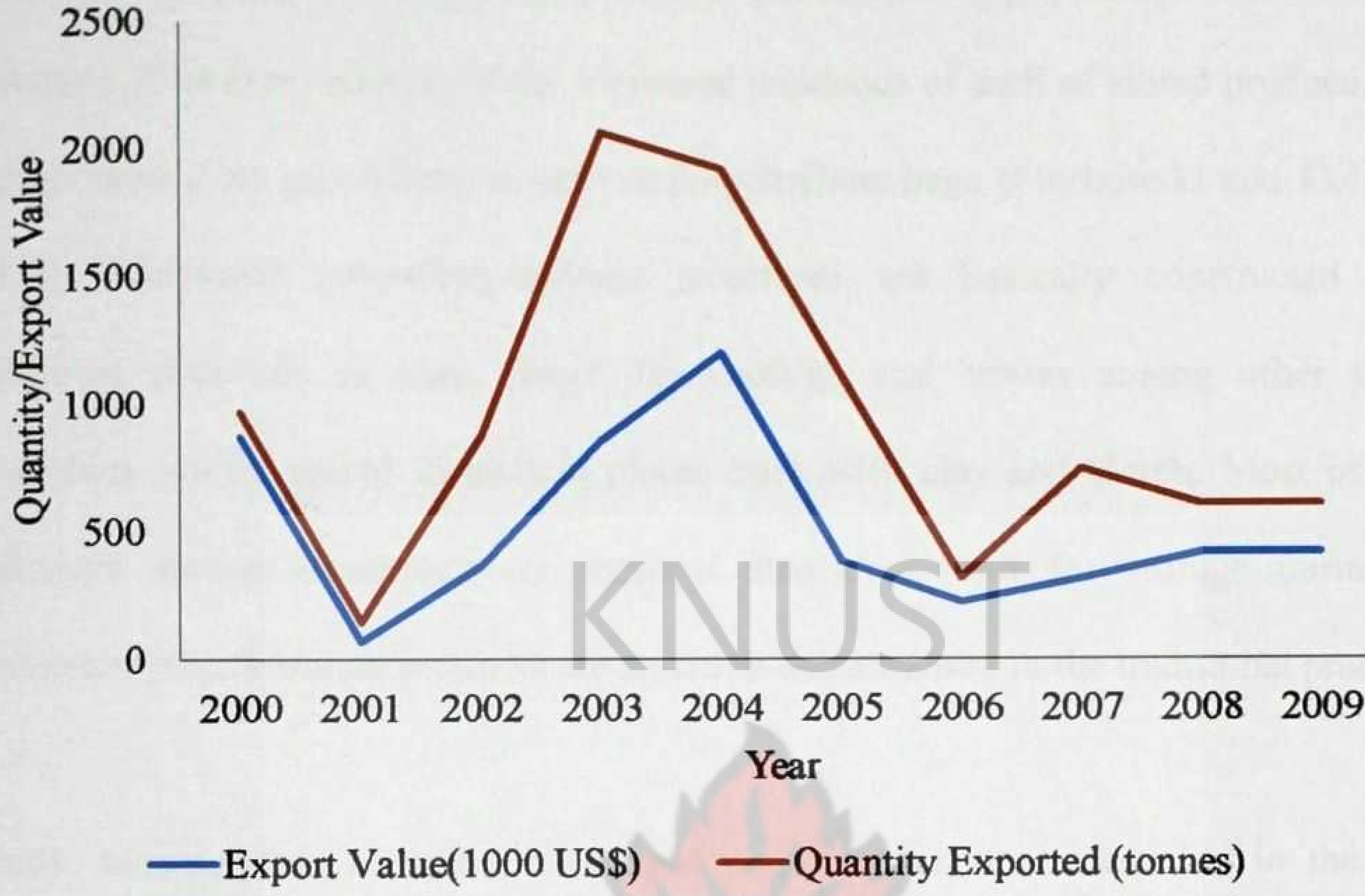


Figure 2.1 Quantity and Export Value of Groundnut (in shell) from 200-2009.

2.2 Groundnut storage in Ghana

Groundnut storage in Ghana takes several forms and employs varying traditional materials. According to Nautiyal (2002) groundnut kernesl, after harvesting and drying are stored in jute bags and kept in barns built with thatch or mud. For the purposes of analysis groundnut storage technologies in Ghana are classified under traditional and improved and treated under this section. However, in Ghana, irrespective of the storage technology employed, polythene sacks, jute sacks, baskets and sometimes the bare floor are employed during storage. Racks are also employed to serve as platforms for the sacks, thus preventing direct contact with the bare floor. This section therefore gives a brief description of both the traditional and improved groundnut storage technologies

2.2.1 Traditional storage technology

Farmers traditionally stored in shell groundnuts in traditional pupuris, traditional storage structures. However, because of the increased incidence of theft of stored produce, most farmers now store groundnuts in jute or polyethylene bags (Florkowski and Kolavalli, 2013). Traditional groundnut storage structures are basically constructed using traditional materials of clay, thatch for roofing, and straws among other things. Groundnut can be stored in kitchen places built with clay and thatch. Most of these traditional storage structures are seasonal structures built for storage during the production year. Multiple products are stored in one structure in the traditional practice.

Mostly, maize, yams, cowpea, millet and sorghum are stored together in the same storage structure. This leaves room for pest and disease infestation and disease transfer (including aflatoxins) with pest which otherwise did not have affinity for some particular crops beginning to do so. Also, because all the bags used by groundnut farmers are re-used after handling other crops such as maize, rice, sorghum, beans, or cocoa, the probability is high that the insides of the reused bags contain Aspergillus spores (Awuah and Kpodo 1996; Hell et al. 2000).

This is especially so, considering the amount of resources available to most peasant farmers in Ghana and thus cannot afford to own multiple storage places (Appendix B).

2.2.2 Improved Storage Technology

This structure was developed with indigenous knowledge based on advices from Agricultural Extension Agents of MoFA. The norm with most farmers was to store all their produce in one storage structure; hence the need to develop a single structure that could hold multiple products. The improved groundnut storage technology is a three-compartment structure designed to hold three different crops depending on the farmer. This structure is designed to maintain constant temperatures which are normally not favourable for fugal proliferation. This structure practically solves the problem associated with the traditional storage structures where more than one crop is stored in the same structure. Other crops known to be stored in this structure include yams and cassava during the lean season of groundnuts (Appendix B). This diversification makes it possible for owner farmers to obtain maximum benefits from this structure.

2.3 Economics of Storage

In the study of storage of farm products, it is important to know about the significance of storage. Since the cost of storage affects economic returns, therefore, it is of critical importance to study the economics of storage. This section deals with storage profits and storage costs.

2.3.1 Storage Profit

The farmers' revenue from the farm production is governed by the productivity, price of produce and cost of production. Thus, the price is an important factor in deciding the farmers' income through farm production. The prices of farm produce usually remain lowest during harvest and maximum during the lean or off season. To take advantage of prospective increase in prices in off season, farmer stores a part of their marketable surplus in different types of storage structures depending on their storage capacity.

Storage is a physical function in the marketing of commodity. It is essential for regular supply as well as a mechanism of price stabilization. However, profit due to storage of produce is mainly governed by the following factors: price variation; storage cost; storage losses; and periodicity of storage (Saxena, 2003).

Price Variation

Price variation refers to fluctuation in the price over a given period of time. It is closely related with the storage profit. If the prices have a rising trend, the profit gained through storage will also be rising. On the contrary, if the prices are having a dropping tendency, the profit will also be shrinking accordingly (Saxena, 2003).

Storage Cost

Storage cost includes the fixed and variable costs incurred in the storing of farm produce. This cost is inversely related with the storage profit that is; the higher the cost of storage, the lower will be the economics (Saxena, 2003).

Storage Losses

Storage losses cover the physical loss in produce during storage. This loss in storage varies with the methods and practices used in storage. If the losses are increased, the profit from storage decreases simultaneously (Saxena, 2003).

Periodicity of Storage

Periodicity of Storage

Periodicity refers to the difference in time between time of storing and marketing the produce. The price variation in different periods of storage is responsible for the economics of storage to a certain extent (Saxena, 2003)

2.3.2 Storage Cost

Storage like other services cost money and will be performed only if customers want storage badly enough to pay for it (Darrah, 1971). The types of storage cost and components of the cost as a result of storage are discussed in this sub-section.

Types of Storage Cost

There are three types of storage costs involved in the storage of food products. The first of these is represented by commercial storage rates including cost of moving products into and out of storage and the cost of providing space with the proper humidity and temperature. The second is interest on the amount of capital invested in the stored products, although, this is often overlooked. It is an important cost which is incurred by the owner of the product. The third type is somewhat less evident than the other two types, but, nevertheless, significant. It includes decline in value during storage and loss from shrinkage, deterioration, insects and rodents damage (Saxena, 2003).

Components of Cost

It is a difficulty to measure the exact cost of storage of agricultural products due to their certain peculiarities. This is occasioned by the high risk involved in storing such products (Saxena, 2003).

Like any costs, cost of storage may be categorized into: Fixed cost or over head cost and Variable or prime cost (Saxena, 2003).

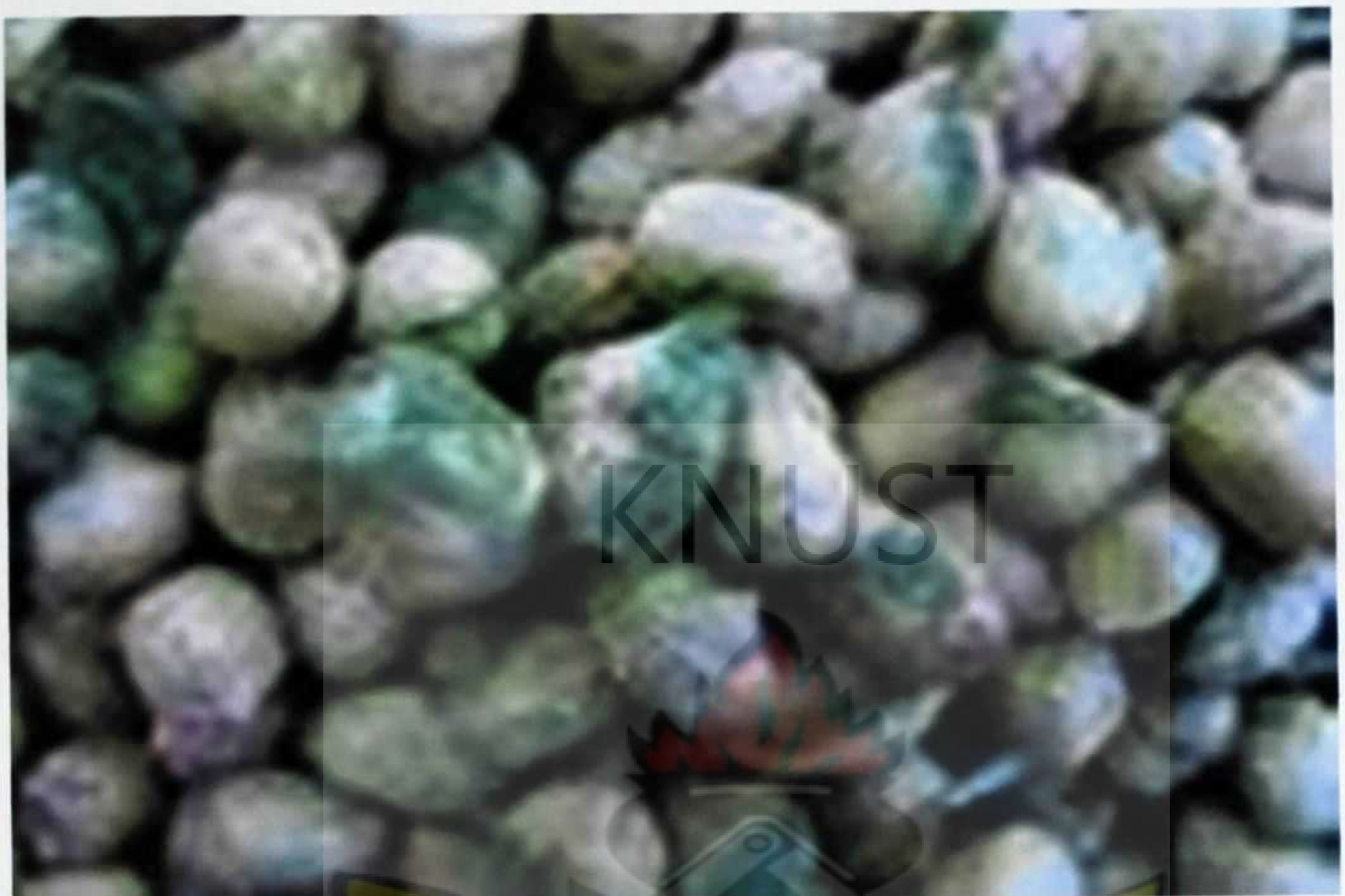
Fixed costs are non-recurring cost which does not vary with change in the quantity stored. It remains constant. Constituents of fixed cost in storage are: Interest on building; repair on building; and depreciation on building.

Variable costs are recurring cost incurred in the storage which varies with the change in quantity stored. The following constitute a variable cost of storage: Cost of bag; handling charges; cost of insecticide or pesticide; interest on value of product; and interest on working capital (Saxena, 2003).

2.4 Aflatoxin Contamination of Groundnuts

This section briefly discusses the two major ways of entry of aflatoxins into groundnuts: Pre-harvest contamination and Post-harvest contamination. The section concludes on aflatoxin presence in foodstuffs and permissible levels in various importing countries.

Plate 2.1 Groundnut sample infested by aflatoxin



Source: www.icrisat.org.aflatoon.effem.asp.

2.4.1 Pre-harvest Contamination

Pre-harvest infestation or contamination is a key economic problem for the groundnut industry (Keenan and Savage, 1994) and this is discussed in this section.

Two major types of pre-harvest contamination were identified by Keenan and Savage (1994). These are: groundnuts mechanically or biologically damaged in the soil and groundnut contamination with no obvious kernel damage.

Pre-harvest contamination primarily occurs under heat and drought stress (Waliyar and Adomous, 2002). Most especially, during, the later growing stage, when growth rate of the plant is in decline (Keenan and Savage, 1994). Hot, dry soil conditions increase the susceptibility to insect damage by termites. Termites are known carriers of *A. flavus* spores (Keenan and Savage, 1994).

Contamination may occur with no obvious kernel damage. The groundnut plant which is unusual in its flowering develops flowers above the ground, and after fertilization fruits develop beneath the soil surface (Keenan and Savage, 1994). This they attributable to low molecular weight compounds with antimicrobial and antifungal properties called phytoalexins (Strange, 1984). However, as the plant approaches maturity this ability slows down as a result of a fall in the production of phytoalexin (Waliyar and Adomou eds., 2002). Another important factor is the water activity (AW). According to Keenan and Savage (1994), AW is a measure of the available water in a food system, derived from the relative humidity of the atmosphere with which the food is in equilibrium. Regardless of temperature or maturity of kernel, AW below 0.95 leads to a cease in phytoalexin production in the plant but not fungal growth (Keenan and Savage, 1994). However, adequate irrigation forestalls pre-harvest aflatoxin contamination, even when soil temperatures are at optimum (Sanders et al, 1985). Nonetheless, groundnuts are never grown under irrigation in Ghana (Tsigbey et al., 2001).

Groundnut cultivars vary in their resistance to aflatoxin contamination. In recent times resistant cultivars have been developed. However, some of these cultivars found to have been resistant under laboratory or controlled conditions have fallen victim to aflatoxin infection under normal farm conditions (Sanders et al, 1985).

2.4.2 Post-Harvest Contamination

While groundnut hulls may be contaminated by *Aspergillus flavus* during growth in the soil, there is also the chance for contamination to occur at various stages after harvest. Contamination can occur during field curing and drying, storage (Freeman et al., 1999) and transport (Keeman and Savage, 1994). Moisture is once again the sole most important parameter, with temperature following closely (Llwellyn et al., 1988). After harvest, uprooted plants are left in an inverted. This is to facilitate fast and efficient kernel drying and was corroborated by Devi and Hall (2000) who reported significant reduction in AF levels as a result of inverted windrow drying of groundnut. In Ghana, Amoako-Atta et al. (2007) reported the adoption of inverted windrow drying of groundnuts. Depending on prevailing environmental conditions it can take 2-3 days for moisture content of the kernels to be reduced from 40-50% to 20-25% (Keenan and Savage, 1994). The more rapidly natural drying is achieved after uprooting, the less aflatoxin invasion is observed. However, care must be taken; that nuts do not dry too rapidly. (Keenan and Savage, 1994). Also, in a study conducted in Mali by Waliyar et al. (2007) pods removed immediately after lifting reduced aflatoxin contamination by 60% and 30% for removing pods two weeks after lifting, whiles over maturity as a result of delay in harvesting could lead to mould infestation and subsequent aflatoxin development. Prior to storage sorting should be done. This is because damaged/mouldy kernels usually have high AF levels (Awuah and Kpodo, 1996; Mehan and Gowda, 1997).

Studies conducted in Swaziland by Keen and Martin (1971) comparing samples of stored groundnuts from rural areas and agricultural stations showed 26% contamination in the former and zero contamination in the latter. This difference was attributed to the differences in storage containers and methods of storage. Form of storage also plays an important role in maintaining groundnut quality. According to Xiao (1989) groundnuts stored in the shell are less susceptible to contamination during storage, due to the presence of the seed testa.

2.4.3 Aflatoxin Presence in Foodstuffs

As a result of the health risk associated with consumption of aflatoxin infested groundnut and products, many countries have established maximum permissible levels.

Table 2.2: Maximum Permissible Levels of Aflatoxins in some select Countries.

		Maximum permissible level (ngg^{-1}), 1995	
Country	Aflatoxin Type	Foodstuffs	Livestock feed
Belgium	B_1	5	20
France	B_1	1	20
Germany	B_1	2	20
Ireland	B_1	5	20
Italy	B_1	5	20
The Netherlands	B_1	0	20
Sweden	$B_1B_2G_1G_2$	5	10
UK	$B_1B_2G_1G_2$	4	20
USA	$B_1B_2G_1G_2$	20	20

Source: Freeman et al., 1999

Early studies by Bearwood (1964) surveyed the groundnut market in Accra and reported that 69 percent of tested samples were highly contaminated with aflatoxins.

In a report by Kpodo (1995) aflatoxin contamination levels of (5.7 to 22168 μgkg^{-1}) were observed in damaged kernels, way above the permissible level in most importing countries. Notable, Ho and Takoradi the aflatoxin levels were between 13144 – 22168 μgkg^{-1}. These contamination levels raise serious health concern since most of these groundnuts are consumed as food. Also, is the tendency of producers to sell their healthy pods leaving the damaged and less attractive pods for home consumption; either as a spice (*dawadawa*) or for feeding poultry. Awuah and Kpodo (1996) confirmed earlier studies on aflatoxin contamination levels in groundnut when samples from 21 selected markets in 10 regions of Ghana yielded high levels of *Aspergillus flavus*.

A study conducted in Nigeria by Bankole and Eseigbe (2004), revealed high aflatoxin content in Dry Roasted Groundnuts (DRG). According to them, continuous consumption of DRG by Nigerians could have serious health implications. This study, invariably, shows that with the current reports on aflatoxin levels reported in Ghana, consumption of DRG by Ghanaians which is a delicacy could as well have health implications. The marketable commodities derived from groundnuts, including edible oil, expeller meal, oil cake, confectionery products and peanut butter each denote a different level in the groundnut trade chain. Aflatoxin contamination at each level is potential sources of a fall in export earnings. Kpodo (1995) reported significant aflatoxin levels in peanut butter (33 - 826μgkg^{-1}) which raises a cause of concern. With the inception of the acceptance level, economic losses have been incurred by most developing countries because of a drop in exports (Otsuki et al., 2001). Babu et al. (1994) in a study conducted in Malawi reported a 0.01% loss in groundnut exports as a percentage of the trade balance in 1988/89 to a loss of 1.77% in 1981/82 because of aflatoxin contamination. A compounding issue is the tendency for developing nations, including their local farmers to sell the best produce and as such forced to consume the less attractive nuts domestically. For example, in Ghana, although rejected kernels are likely eaten by the poor, while the paste is consumed by almost all households, *kulikuli* or *kulikuli sim* is eaten by wealthier consumers able to purchase prepared meat dishes (Florkowski and Kolavalli, 2013).

Most groundnut products are consumed locally, and also used in the formulation of poultry and animal feeds. Notably, are the groundnut paste and groundnut oil used in soup and stew preparation respectively. In a study in Malaysia by Hamid (1997), (In: Mehan and Gowda1997), eight of ten peanut butter sampled were found to be contaminated with aflatoxin in the range 4 – 400 μgkg^{-1}(which is above the acceptable limit in most importer countries in Table 2.1).

2.5 Economic Effects of Aflatoxins

Aflatoxins in groundnuts, and for that matter in all crops, can have direct economic effects resulting in loss of produce or loss of market value as well as indirect economic effects from loss of animals, increased costs of veterinary and human health care services, costs for food-borne disease surveillance and food monitoring (Table 2.2). Presence of high levels of aflatoxins in groundnuts may make it unacceptable for marketing, causing financial loss to the farmer or retailer (Okello et al., 2010). For example in Malawi, export losses as a percentage of trade balance ranged from 0.01% in 1988/89 to1.77% in 1981/82 (Babu et al., 1994). Due to generally high level of self-consumption, international trade in groundnuts is thin: only 5 percent of world production is sold in the international markets. Sub-Saharan Africa (Senegal, Gambia, Nigeria, Malawi, South Africa and Sudan) has lost most ground in the world market of edible groundnuts, and collectively accounts for only 5 percent of the world market. In the groundnut oil market segment, however, Senegal is the largest supplier, but this market has become all the more thinner as other vegetable oils are increasingly used as substitutes of groundnut oil (Diop et al., 2004).

Economic losses may reach 100% depending on the market, when the entire produce/product is rejected by the market if aflatoxin levels are higher than acceptable standards. It is estimated that Africa loses over United States dollars 670 million annually due to requirements for European Union aflatoxin standards for all food exports and world over, billions of dollars are lost by farmers and traders due to aflatoxin contamination (Otsuki et al., 2001; Guo et al., 2009). Disease burden on farmers and the citizenry pose direct economic costs to persons and governments concerned. Kenya in 2004 recorded 317 cases of aflatoxin related health problems and 126 deaths (Claudia et al., 2007) showing the severity of the aflatoxin problem.

Table 2.3: Examples of Economic Losses Associated with Aflatoxin (and other mycotoxins) contamination

Bearer	Economic losses and costs
Primary Produce	1. Outright food and feed loss 2. Less income from contaminated food
Intermediary	1. Less income from products refused, condemned or sold at a discount 2. Potential loss of market 3. Increased costs due to surveillance control
National/Government	1. Lower forex from reduced exports 2. Increased cost due to surveillance and control 3. Increased costs of shipment, sampling and analysis of products for export 4. Increased need for expenditures in human health and livestock care services 5. Increased cost of training, communication and extension programs
Consumer (human or livestock)	1. Impaired health and productive capacity 2. Possible higher medical and veterinary costs
International Level	1. Loss of market value or market 2. Trade distortions

(Adapted from Jemmali, 1987).

2.6 Management of Aflatoxins

Aflatoxin contamination of crops (including groundnuts) has been shown to take its roots from both pre-harvest and post-harvest conditions. This contamination could occur in field, during storage and in transit. For that matter management of aflatoxins should be one of prevention rather than cure or containment. Anamika and Waliyar (2000) identified three methods of aflatoxin management: pre-harvest management, post-harvest management and detoxification and these are treated under this section.

2.6.1 Pre harvest Management

Pre harvest management of aflatoxins, according to Anamika and Waliyar (2000) is the best and most widely explored strategy.

In groundnut, Waliyar and Tabo (2002 eds.) recommended the adjustment of sowing and harvesting dates and gypsum application as effective in preventing aflatoxin contamination. They also recommended application of lime, which reduces seed contamination by *A. flavus* by 47%, manure by 33%, crop residues by 24% and combination of manure and crop residues by 50%. Other cultural control measures are selection of the right cultivar which fits a particular growing season such that, maturity coincides with the end of the rainy season for adequate drying, optimum plant population and irrigation in the last 4-6 weeks of crop growth to forestall pre harvest aflatoxin contamination of groundnuts.

Mehan (1989) identified the three types of resistance: resistance to contamination (pod wall); resistance to seed contamination (seed coat); and resistance to aflatoxin production (cotyledons). However, use of resistant varieties should not be used in isolation but rather in concert with other cultural and crop handling procedures suitable for a particular agro ecological zone.

Cole and Cotty (1990) identified three basic types of biological control strategy for pre-harvest contamination: the use of an agent that annihilates the pest; an agent that secretes poisons that destroy the hosts (atoxigenic agents); and the use of an agent that competes with the pest in its ecological niche.

2.6.2 Post-harvest Management

Satish and Popat (2008) identified the following as harvest and post-harvest aflatoxin management practices: harvesting at right maturity; avoiding damage to pods; proper curing; separation of damage pods; thorough drying; use of polythene lined bags for storage; storage in well-aerated and well-covered space; storage place free from seapage or leakage of water; and fumigation of storage room.

Detoxification takes its importance from the fact that, foodstuffs intended for human and animal consumption could contain levels of aflatoxin that exceeds the minimum acceptable level. This could be achieved by physical sorting. Sorting is based on the knowledge that contaminated kernels are either discoloured or shriveled (Keenan and Savage, 1994). However, the hazard lies where visual examination does not reveal kernels with concealed/hidden damage (Anamika and Waliyar, 2000). Manual sorting can be inadequate. Chemical detoxifications are employed when visual sorting proves inadequate.

2.7 Methodological Issues

This section discusses how to assess adoption, defines, and describes the adoption process and reviews some relevant literature on adoption of storage technologies.

2.7.1 Assessing Adoption of Improved Agricultural Technology

Periodic monitoring of farmers' opinions and experience is a sine qua non to the design and testing of agricultural technologies. It is also important to carry out some sort of assessment after a new technology has been recommended or introduced. CIMMYT (1993) outlined the importance of having a continual interchange between farmers and researchers as technology is being developed and tested. This interaction, according to them, provides the first indication of the acceptability of the technology. Another method of assessing a technology's acceptability is by using follow-ups to check what farmers who hosted experiments do the following year. Once a technology has been released, which also initiates an extension programme, it is possible to study a random sample of farmers to determine and analyze the extent of adoption (CIMMYT, 1993).

An informal survey also plays a key role in providing researchers with preliminary feedback about the acceptability of a technology. Informal survey further provides information about policy – related problems that may militate against the spread of a technology. An informal survey may be adequate for analyzing adoption patterns.

However, formal surveys generate quantitative information that is necessary for decision makers and are better able to explain some of the not easily understood issues of variability in adoption among farmers. This is based on the assumption that such a survey will be conducted as part of a research or extension effort that has been thought out, planned and executed and has included various opportunities for assessing farmers' opinions and practices along the way. The assumption also extends to the design of the questionnaire, which is preceded by a good informal survey that helps researchers pin point key issues to be pursued in the questionnaire. These methods are however not the only ways of studying the spread of adoption of a new technology. Data generated from an agricultural census may provide some insight into the degree to which farmers use a particular technology. If a new technology involves purchased inputs, for example, surveys for ascertaining the spread of the technology (CIMMYT, 1993).

2.7.2 The Adoption Process

Technologies play an important role in economic development. Adoption and diffusion of technology are two interrelated concepts describing the decision to use or not to use and the spread of a given technology among economic units over a period of time. Rogers (1983) defines diffusion as the process by which a technology is communicated through certain channels over time among the members of a social system. Rogers (1983) then defined adoption as use or non-use of a new technology by a farmer at a given period of time.

Ferder et al. (1985) distinguished individual adoption (farm level) from aggregate adoption. Individual adoption was defined as the degree of use of a new technology (innovation) in a long-run equilibrium when the farmer has full information about the new technology and its potential. Aggregate adoption on the other hand was defined as the process of spread of a technology within a region. Similarly, Thirtle and Ruttan (1987) defined aggregate adoption as the spread of a new technique within a population. The adoption decision involves also the choice of how much resource (i.e. land) to be allocated to the new and old technologies if the technology is not divisible (e.g. mechanization, irrigation). However, if the technology is divisible (e.g., improved seed, fertilizer and herbicide), the decision process involves area allocation as well as level of use or rate of application (Ferder et al., 1985). The intensity of adoption of divisible technologies can be measured at the individual level in a given period of time by the share of farm area under the new technology or quantity of input used per hectare in relation to the research recommendations (Feder et al., 1985). This measure can be applied to the aggregate level of adoption in a region. On the other hand, the extent of adoption of non-divisible agricultural technologies such as tractors and combine harvesters at the farm level at a given period of time is dichotomous (use or no use), and the the aggregate measure becomes continuous. Aggregate can therefore be measured in the latter case as the percentage of farmers using the new technology.

The concept of early and late adopters provided the basic surmise for explaining the S-shaped nature of the adoption path (Rogers, 1995). Studies by Mosher (1979), Rogers (1983), Mahajan and Peterson (1985), and Bera and Kelly (1990) provide explanations related to the process of acquiring information and the time lag that creates in terms of the speed of adoption among various members of the community in question to become adopters.

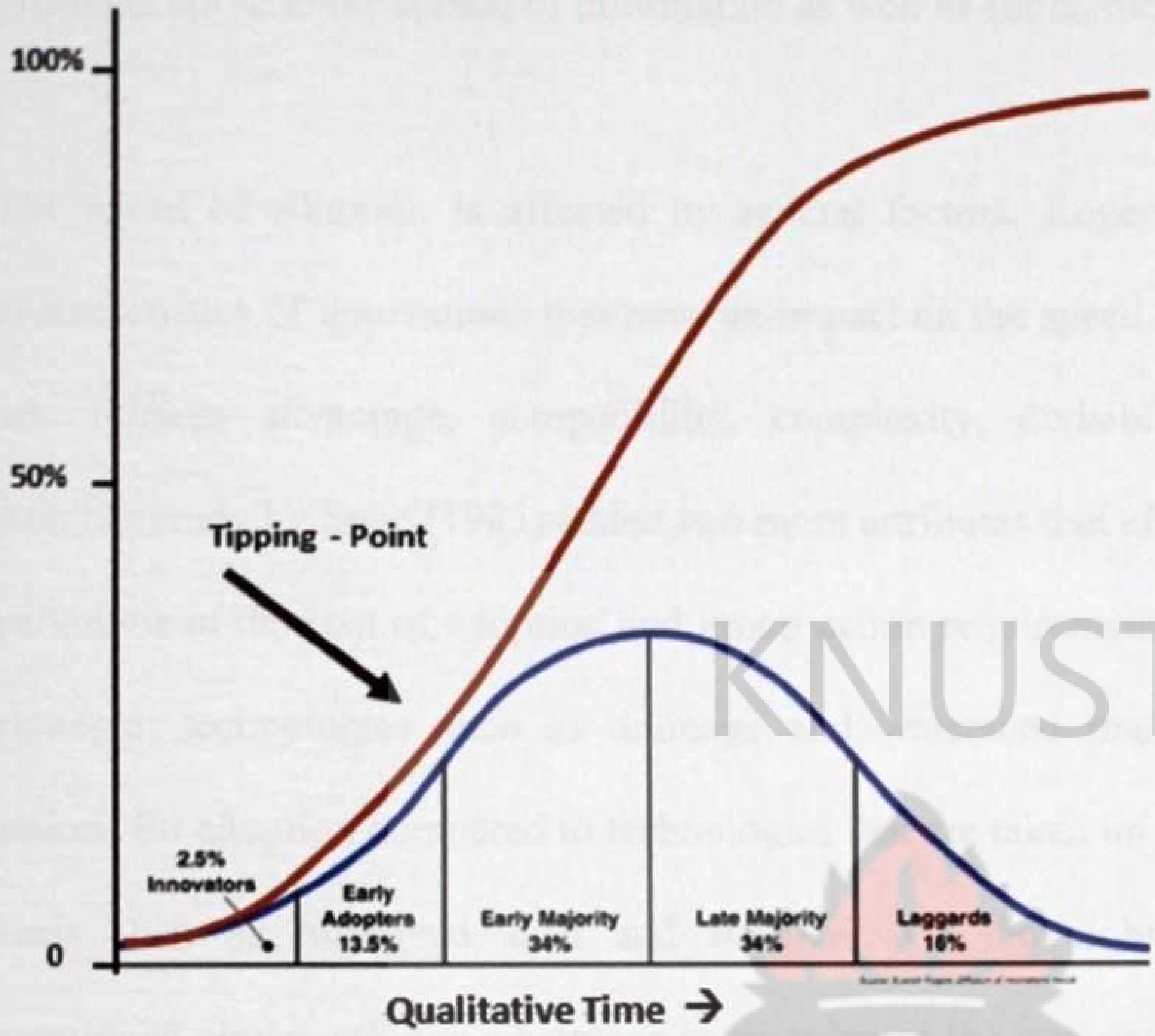


Figure 2.2 Rogers (1995) S-shaped Adoption curve

The S-shaped curve (Figure 2.2) results from the fact that only a few members of the social systems (farmers) adopt a new technology in the early stage of the diffusion process. At the initial stages of introduction of a new technology, only few farmers obtain full information about the potential economic benefits of the new technology and hence the adoption speed is slow. Also is the risk associated with technology and hence the decision not to adopt.

However, in subsequent time periods potential adopters acquire more information about the benefits of the technology and the degree of riskiness associated with it. Then the adoption accelerates till it reaches the point of inflection after which it increases gradually at a decreasing rate and begins to level off, ultimately reaching an upper ceiling. Studies by Grilches (1957) and Mansfield (1961) attributed the S-shaped diffusion curve to the spread of information as well as economic factors.

The speed of adoption is affected by several factors. Rogers (1983) identified five characteristics of innovations that have an impact on the speed of adoption. These traits are: relative advantage, compatibility, complexity, divisibility, and observability. Another study by Supe (1983) added two more attributes that affect the rate of adoption: variations in the cost of adoption and group action requirements of the technology. For example, technologies such as drainage and watershed management require group actions for adoption compared to technologies that are taken up on an entirely individual basis such as improved seed and fertilizer. Of the technological characteristics mentioned above, relative advantage is regarded as the one with the strongest effect on the rate of adoption. The relative advantage can be subdivided into economic and non-economic categories. The economic categories are related to the profitability of the technology while non-economic features are function of variables including saving of time (leisure) and increase in comfort (Ratz, 1995 in Abera, 2008).

Generation of improved technologies is a time-intensive process and technologies also depreciate (Alston et al., 1998). Adoption studies also revealed five categories of adopters in a social system. The categories included innovators, early adopters, early majority, late majority, and laggards (Mosher, 1979; Rogers 1983). The traits of these groups were described in a study by Rogers (1983), who indicated that the majority of early adopters are expected to be younger, more educated, venturesome, and willing to take risk.

In contrary, late adopters are expected to be older, less educated, conservative, and not willing to take risk. However, Rundquist (1984) revealed some drawbacks of this categorization to be evidence indicating a movement from one category to the other, depending on the technology introduced.

It is a common knowledge to extension workers that most individuals do not adopt a new technology immediately after being aware of its existence. Empirical researche by rural sociologists have lent credence to the notion that, there are stages in the adoption process. Rogers (1962) and Odoemenem and Obinne (2010) identified five stages of adoption. They revealed that, the process commences with the stage of awareness, where the individual is exposed to the innovation but is deficient in the information about it. That individual would have to be enlightened on what he/she expects in adopting an innovation. He outlined the interest stage as the next stage; where the individual becomes interested in the idea and endeavours to acquire additional information about it. This is basically a personal information seeking process. The third stage according to Rogers is the evaluation stage; where the individual mentally applies the innovation to his present and anticipated future situation and then decides whether or not to give it a try. The trial stage is where the individual uses the innovation on a small scale in order to ascertain its utility in his own situation. Lastly, the adoption stage is where the individual decides to continue full employment of the innovation without any hindrance.

2.7.3 Empirical Studies on Adoption of Storage Technologies

Farid et al. (2010) applied the Logit model in innovation adoption by agro-biotechnology companies in Malaysia. According to the authors, the main determinants of the level of adoption level of knowledge, amount of funds, level of acceptance and receptiveness, level of cooperation, level of transfer of technology and personal characteristics. The paper revealed that, according to the academic researchers, among the variables listed above, level of knowledge, acceptance and transfer of technology influence the level of adoption of biotechnology innovation in Malaysian agro-biotechnology companies. These results are consistent with a number of theoretical and empirical studies revealing that knowledge of an innovation is the first step in the decision-making process (Rogers, 1995). As suggested by Chong et al. (2009), knowledge is an independent variable that determines the level of adoption of an innovation. Some researchers like Harryson et al. (2007), believe that knowledge gained from university research benefits companies and accelerates the level of adoption.

Abiodin et al. (2000) conducted a study into the adoption of homestead grain storage technology in the South-West Agricultural Zone of Nigeria. According to the authors, the major grains and pulses that are stored in the study area at the homestead level are maize, guinea corn, rice, cowpea, soya bean and groundnut. The study considered four (4) recommended improved homestead grain storage technologies namely; storage in air tight containers (Hermatic), use of recommended storage chemicals, use of polythene lined storage sacks and cold-treatment in sealed containers were considered to attain the objectives of the study. The training and visits (T&V) system of the Agricultural Development Project (ADP) was found to be the most prevalent source of information to the respondents, followed by the radio. Also, the paper revealed increase use of interpersonal communication as well as prompt and adequate intervention by government in the provision of credit facilities and subsidy inputs will enhance the rate of adoption.

Ntege-Nanyeenya et al. (1997) used the Logit model to assess the factors affecting the adoption of Maize production technologies in Iganga District, Uganda. The study was aimed at identifying socio-economic and technical factors affecting the adoption of improved maize, 'Longe 1' and related practices, and develop recommendations for research, extension and policy. Results of the logistic regression model showed that the use of hired labour, level of education, membership in farmers' group, and land tenure had statistically significant effect on the probability of adopting Longe 1 technology. Also, Mugisha et al., (2004) investigated the adoption of improved pest management (IPM) groundnut production technologies in eastern Uganda. The objective was to determine factors that influence the adoption of IPM in groundnut production. The results showed that adoption was significantly influenced by education ($p< 0.1$), family size ($p< 0.05$), association membership ($p< 0.01$), extension visit ($p< 0.05$), access to credit ($p< 0.05$), size of cultivable land ($p< 0.01$) and household income ($P< 0.05$).

Atibioke et al., (2012) in a study to identify factors that determine famers' adoption of Nigerian Stored Products Research Institute's (NSPRI) grain storage technologies in selected villages in Ilorin West LGA of Kwara State. The Logistic regression model revealed sex, level of education and occupation significantly influenced the adoption of NSPRI grain storage technologies.

CHAPTER THREE

METHODOLOGY OF THE STUDY

In this chapter, the concept of improved- groundnut storage as an adopted technology, as well as the concepts of percentiles for identifying differences amongst groups are outlined. Hypotheses are formulated about factors influencing improved groundnut storage technology adoption, awareness of storage conditions on aflatoxin growth and relationship between cost incurred in groundnut storage and knowledge of aflatoxin management practices. Finally, the data collection process and the study area and household survey procedure are detailed.

3.1 Conceptual Framework

The conceptual framework on the adoption of improved groundnut storage technology and cost incurred on storing a product are discussed in this section.

3.1.1 Adoption of Improved Groundnut Storage Technology

The Binary Logistic regression model is employed to evaluate farmers' choice of groundnut storage technology. With this model, one can hypothesize a farmers' overall preference or ranking of a choice alternative as a function of the utility that the alternative holds for the individual (Gensch and Recker, 1979). One can also surmise that the farmer's utility for an alternative is separable in two components: (1) a deterministic component, and (2) a random component.

Assuming that farmers' make adoption decision based upon the objective of utility maximization, a farmer will adopt a technology when the utility (net benefit) of a new technology (U_n) exceeds the utility of a traditional technology, (U_t).

The choice of the farmer is designated by dummy variable, Y_n.

$$Y_n = \begin{cases} 1, if\ U_n > U_t\ \ \forall_t \neq n \\ 0 \qquad if\ otherwise \end{cases} \tag{1}$$

The utility derivable from a new technology is postulated to be a function of the vector of the observed farm characteristics (e.g. farm size, distance to market) and farmer characteristics (e.g. gender farmer, age of farmer), perceived technology characteristics (X_{ni}) and disturbance term having zero mean. Hence, the utility that the farmer obtains from choosing an alternative can be decomposed into a part that the researcher observes and those that are unobservable. In a linear form, this decomposition is expressed as:

$$U_{ni} = \beta Z_{ni} + \varepsilon_{ni} \tag{2}$$

Where, Z_{ni} is a vector of observed variables relating to alternative i for person n that depends on attributes of the alternative X_{ni}, interacted with attributes of the person S_n, such that it can be expressed as:

$Z_{ni} = Z(x_{ni}, s_n)$ for some numerical function z. (3)

Farmers are postulated to weigh the consequences of adoption of a new technology against its economic, social, and technical feasibility and choose the technology (T) that promises higher utility than the traditional technology (Adesina and Zinnah, 1993; Rahm and Huffman, 1984). Suppose, an individual farmers' satisfaction or utility of adopting a new technology, for a given vector of economic, social and physical factors (X) is denoted by $U_n(X)$ and the preference of adopting the traditional technology $U_t(X)$; then the preference for adopting the new and old technologies can be expressed as a linear relationship. This can be decomposed as:

$$U_n(X) = X\beta_n + \varepsilon_n \quad (4)$$

$$U_t(X) = X\beta_t + \varepsilon_t \quad (5)$$

Where β_n, β_t and $\varepsilon_n and\ \varepsilon_t$ are response coefficients and random disturbances associated with the adoption of new and traditional technologies, respectively. If the index of adoption is denoted by Y, it will take a value of one if the farmer is willing to adopt the new technology and zero otherwise. The probability that a given farmer will adopt the new technology can be expressed as a function of X as follows:

$$P(Y = 1) = P(U_n > U_t)$$

$$= P(X\beta_n + \varepsilon_n > X\beta_t + \varepsilon_t)$$

$$= P[X(\beta_n - \beta_t) > \varepsilon_t - \varepsilon_n]$$

$$= P(X\beta > \varepsilon)$$

$$= F(X\beta) \quad (6)$$

Where P is the probability function, $\beta = (\beta_n - \beta_t)$ a vector of unknown parameters that can be interpreted as the net influence of the vector of independent variables on adoption of the new technology, $\varepsilon = (\varepsilon_n - \varepsilon_t)$ a random disturbance term and $F(X\beta)$ is a cumulative distribution function F evaluated at $X\beta$ (Rahm and Huffman, 1984).

A Logit model is commonly used to analyze adoption decisions (Salasya et al., 1998). The Logit model was chosen for the analysis of the adoption of improved storage because of the ease of computation and mutually exclusive and exhaustive nature of the responses. The Logit model, which is based upon cumulative logistic function, is computationally easier to use than the other types of model and is also has the advantage to predict the probability of farmers adopting any technology.

The Logit model assumes that the underlying stimulus (I_i) is a random variable which predicts the probability of adoption of the improved groundnut storeage technology:

$$P_i = \frac{e^{I_i}}{1+e^{I_i}} \quad (7)$$

Conceptually, the behavioural model used to examine factors influencing the adoption of improved groundnuts storage technology is given by:

$$Y_i = g(I_i)$$

$$I_i = b_o + b_j X_{ji} \quad (8)$$

Where, Y_i is the observed response of the i^{th} observation (i.e. binary variable, $Y_i = 1$ for an adoption, $Y_i = 0$ for non-adopter). I^* is an underlying stimulus index for the i^{th} observation (generally, there is a critical threshold $\{I^*\}$ for each farmer, if $I_i < I_i^*$, the farmer is observed to be non-adopter and if $I_i . I_i^*$, the farmer is observed to be an adopter), g is the functional relationship between the field observation (Y_i) and the stimulus index (I_i) which determines the probability of the improved groundnut storage technology adoption.

$I = 1,2, \dots m$ are the observation on variables for the adoption model; m is the sample size, X_{ji} is the j^{th} explanatory variables for the i^{th} observation and $j = 1,2,3, \dots n$, b_j is an unknown parameter, $j = 0,1,2,3, \dots, n$, where n is the total number of explanatory variables.

The Logit model assumes that the underlying stimulus index I_i is a random variable which predicts the probability of improved groundnut storage technology adoption:

$$P_i = \frac{e^{I_i}}{1+e^{I_i}} \quad (9)$$

Therefore, for the i^{th} observation (an individual farmer):

$$I_i = \ln\frac{P_i}{1-P_i} = b_0 + \sum b_j X_{ji}, \text{ which is the logit model} \quad (10)$$

The relative effect of each explanatory variable (X_{ji}) on the probability of improved groundnut storage adoption is measured by differentiating with respect to x_{ji}, that is $\frac{\delta P_i}{\delta x_{ji}}$, using the quotient rule:

$$\frac{\delta P_i}{\delta x_{ji}} = \left(\frac{e^{I_i}}{1+e^{I_i}}\right)\left(\frac{I_i}{X_{ji}}\right) \quad (11)$$

The formula can be used in predicting changes in the probability of adopting improved groundnut storage technology (Adeogun et al., 2008).

3.1.2 Empirical Model on Improved Groundnut Storage Technology Adoption

The Logit is modeled on the assumption that the ownership is a function of the latent variable, and ownership is observed only when the latent variable exceeds the individual specific threshold value. The latent variable is assumed to a function of individual, farm, household, and socio-economic characteristics.

An individual farmers' decision to adopt or not to adopt the groundnut storage technology is assumed to be an outcome of a complex set of factors. Some of these factors the researcher observes and others the researcher does not. Working with the deterministic part, the researcher can estimate the probability of adopting a groundnut storage technology.

The empirical model employed is this study is specified as following Gujarati (1998); the model is specified as:

$$Adopt = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \varepsilon \quad (12)$$

Table 3.1 Definition of Variables and A priori expectations for Adoption Model

Variable	Definition	A Priori expectation
$Adopt$	1 if farmer adopts improved groundnut storage technology; 0 if otherwise	
β_0	Constant	N/A
$\beta_1 - \beta_9$	Parameters to be estimated	N/A
X_1	Awareness of storage conditions on aflatoxin growth (dummy variable, 1 if aware of storage conditions on aflatoxin growth 0 if otherwise)	+
X_2	Age of farmer in years	+/-
X_3	Education (dummy, 1 if farmer has received any formal education, 0 if otherwise)	+/-
X_4	Gender (dummy variable, 1 if male, 0 otherwise)	+/-
X_5	Membership of a farm group (dummy variable, 1=yes, 0= no)	+
X_6	Access to credit (dummy variable, 1= yes, 0= no)	+
X_7	Awareness of ill-effects of aflatoxins (dummy variable,1 if farmer is aware of the ill-effects of aflatoxins 0 if otherwise)	+
X_8	Household size	+
X_9	Average income from all sources	+
ε	Error term	N/A

3.1.3 Cost Incurred in Storing an Agricultural Product

In the study of costs in storage of farm products, it is important to know about the significance of storage. Since the cost of storage affect the economy of storage, therefore it is of immense importance to understand the cost of storage. This section briefly presents the components of the storage costs as pertained to the study.

Owing to the peculiarities of agricultural products and the high risk involved in storage, it is difficult to measure the exact cost of storage of agricultural commodities.
Nevertheless, an attempt has been made to measure the cost of storage of groundnut based on what was done on wheat by Saxena (2003) on the economics of storage of wheat. Like any other costs, costs of storage may be categorized into: Fixed cost or Over head cost and Variable cost or prime cost.

For the purpose of this analysis, fixed cost is a non-recurring cost which does not vary with changes in the quantity stored, is ignored. This was due to the difficulty in acquiring such information or its unreliability in instances where they were available. This cost includes interest on building, repair of building; and depreciation of building.
The variable cost is the recurring cost incurred in the storage which varies with the changes in quantity stored. Following Saxena (2003) the constituents of variable cost of storage are: cost of bag or sacks; cost of insecticide or pesticide; interest on value of wheat stored and interest on working capital. Again, for the ease of analysis, losses due to storage were not taken as cost item in the study of the cost structure. Also, interest on

value of wheat stored and interest on working capital were ignored during the data collection.

Variable cost was therefore calculated as the sum of cost of sacks, insecticides, pesticides, fumigation among other cost.

$$VC = X_1 + X_2 + X_3 \dots X_n \qquad (13)$$

Where, VC is the total variable cost associated with groundnut storage and $X_1 - X_n$ the various variable cost incurred.

3.1.4 Empirical Model on Cost Incurred and Knowledge Aflatoxin Management Practices

The Logit model is employed in this analysis by adopting the high-medium-low procedure to create a dichotomous variable. The high-medium-low procedure is based on the percentiles. This name is derived from the percentiles ranges with 75th, 50th and 25th corresponding to the high, medium and low respectively. This procedure is useful is studying the differences amongst a group. So, in this instance the average cost incurred in storing groundnut is subdivided into 75th, 50th and 25th percentile. Three different models are estimated with the same independent variables but different dependent variables to ascertain practices employed by farmers in different cost categories.

First, respondents in the 75th percentile of average cost are coded one (1) and respondents in the 25th percentile are coded (0) to create a dichotomous dependent variable which is regressed against the independent variable- aflatoxin management practices (high model).

Similarly, respondents in the 75th percentile are again coded 1 (1) and those in the 25th – 50th percentile are coded zero (0) creating a dichotomous dependent variable which was regressed against the independent variables- aflatoxin management practices (medium model).

Lastly, respondent farmers in the 25th – 50th percentile of average cost are coded 1 (1) and those in the 25th percentile are coded zero (0) to create a binary variable which was regressed against the same dependent variables as the high and medium model (low model)

The empirical model is broadly specified as:

$$AvCos = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + X_{10} + \varepsilon \quad (14)$$

Table 3.2 Definition of Variables and A priori expectations for Cost Incurred Model

Variable	Definition	A Priori expectation
$AvCos$	**Model I:** 1 if respondent farmer is in the 75th percentile of average cost and 0 if in 25th percentile **Model II:** 1 if respondent farmer is in the 75th percentile of average cost and 0 if in the 25th -50th percentile **Model III:** 1 if respondent farmer is in the 25th- 50th percentile and 0 if in the 25th percentile.	
β_0	Constant	N/A
$\beta_1 - \beta_9$	Parameters to be estimated	N/A
X_1	Membership of farm group (1 if farmer is a member of a farm group, 0 if otherwise)	+/-
X_2	Form in which groundnut is dried (1 if farmer dries unshelled, 0 if otherwise)	+
X_3	Number of months of storage	+
X_4	Sorting (1 if farmer sorts groundnut, 0 if otherwise)	+
X_5	Storage in aerated room (1 if farmer stores in well aerated room 0 if otherwise)	+
X_6	Storage in room free from seepages or leakages of water (1 if farmer stores in room free from seepages of water, 0 if otherwise)	+
X_7	Storage on racks (1 if farmer stores on wooden rack, 0 if otherwise)	+
X_8	Store with other products (1 if farmer stores groundnut with other products, 0 if otherwise)	+/-
X_9	Throw away damaged nuts (1 if farmer throws away damaged nuts 0 if otherwise)	+
X_{10}	Number of years in groundnut farming	+
ε	Error term	N/A

3.2 Hypotheses of the study

1. Adoption is negatively influenced by farmer's age and gender.
2. Education level, extension contact, awareness of aflatoxin, household size, farming experience, credit availability, average income from all sources and membership of farmer association positively influences the adoption of improved groundnut storage technology.
3. Farmers who are knowledgeable in aflatoxin management practices such as drying groundnuts in shell, sorting, storage in well-aerated location, storage in rooms free from leakages or seepages of water, disposing off damaged nuts, storage on racks and storing groundnuts away from other products are more likely to be in the higher average cost percentile.
4. Farmers who belong to cooperative societies are more likely to be in the higher average cost percentile.

3.3 Data collection

In this section, the study area is described followed by the sampling techniques adopted in the data collection.

3.3.1 Study Area

The Study Area

This study was undertaken in three districts in the Northern of Ghana, namely, Tolon - Kumbungu, Tamale Metropolis and Savelugu Nanton Districts. The communities where data were collected were Wovogu, Wovoduma, Gbalali under the Tamale Metropolis, Diare and Gushie under the Savelugu Nanton District and Kpalisogu and Tivigoli of the Tolon Kumbungu District.

Tamale Metropolis

The Tamale Metropolitan Assembly is located at the centre of the Northern Region. It lies between latitude 9.16° and 9.34° North and longitudes 00.36°and 00.57. The Metropolis experiences one rainy season starting from April/May to September/October with a peak season in July/August (ghanadistricts.com 3/5/2012). The end of the rainy season in the study area coincides with the groundnut harvesting period which peaks in September. The Metropolis experiences a mean annual rainfall of 1100mm within 95 days of intense rainfall. Staple crop farming is highly restricted by the short rainfall duration. The dry season is usually from November to March. It is influenced by the dry North-Easterly (Harmattan) winds while the rainy season is influenced by the moist South Westerly winds.

The mean day temperatures range from 33 °C to 39 °C while mean night temperature range from 20°C to 22°C. The mean annual day sunshine is approximately 7.5 hours. However, temperatures above 35°C have been proven to inhibit groundnut development (Nautiyal, 2002). The climactic conditions have to a greater extent influenced the vegetation of the area. The Tamale Metro lies within the Guinea Savanna belt of Northern Ghana. The main soil types include sand, clay and laterite ochrosols. Several crops are grown in the Tamale metropolis. The introduction of subsidies on agricultural inputs raised production of both domestic and industrial crops. Significant among these were rice, maize, sorghum, groundnuts and beans. Currently it is estimated that 60% of the people are engaged in agriculture in the Metropolis. The major crops cultivated include maize, rice, sorghum, millet, cowpea, groundnuts, soya bean, yam and cassava under a total land area of 38,352 hectares (ghanadistricts.com 3/5/2012).

Savelugu Nanton District

The District occupies a total land size of 1760.70 square kilometers. It shares boundaries with West Mamprusi in the North, Karaga to the East, Tolon/Kumbungu in the West and Tamale Metropolitan Assembly to the South. The area receives an annual rainfall averaging 600mm, considered enough for a single farming season. The annual rainfall pattern is erratic at the beginning of the raining season, starting in April, intensifying as the season advances raising the average from 600mm to 1000mm. Temperatures are usually high, averaging 34°C. This average is actually lower than the average temperature needed for groundnut development. The maximum temperature could rise as high as 42°C and the minimum as low as 16°C. The low temperatures are experienced from December to late February, during which the North-East Trade winds (harmattan) greatly influence the District. The generally high temperatures as well as the low humidity brought about by the dry harmattan winds favour high rates of evaporation and transpiration, leading to water deficiencies (ghanadistricts.com 3/5/2012). This condition is conducive for optimum drying of groundnuts after harvest.

Tolon Kumbungu District

The District shares borders with the West Mamprusi District to the north, West Gonja to the west and south and with the Salvelugu-Nanton District and Tamale Municipality to the east. The land area of the District is 2,400km^2 of which 70% is arable and therefore has potential for Agricultural purposes (ghanadistricts.com 3/5/2012). The district is home to key agricultural institutions such as the Savanna Agricultural Research Institute (SARI), University of Development Studies (UDS) and Animal Research Institute (ARI). This is reflective of the various technologies adopted by the farmers in this district and for that matter the study area. Several groundnut varieties are grown in this study including Manipinta ('Aban'), China, 'Bogla', 'Afa-Isa', 'Mista' and 'Chekopaga'.

3.3.2 Sampling Procedure and Method of Data Collection

A farmer level study was conducted in the Northern Region of Ghana. A multi-stage sampling procedure was used in the data collection. First of all, three districts were purposely selected for the study area based on evidence of the dominance of groundnuts amongst the crops grown in those districts. Specifically, Tolon Kumbungu, Tamale Metropolis and Savelugu Nanton Districts were used as case studies in the study. With the assistance of district agricultural extension agents from the Ministry of Food and Agriculture (MoFA), seven communities were randomly selected from the districts. These were Wovogu, Wovoduma, Gbalali under the Tamale Metropolis; Gushie and Diare under the Savelugu Nanton District and Kpalisogu and Tivigoli of the Tolon Kumbungu District.

Primary data were collected by administering structured questionnaires to respondent groundnut farmers in the above mentioned districts. Purposive sampling procedure was employed in order to choose the population within the communities; which was all groundnut farmers in the community. Hereafter, a simple random sampling procedure was used to select the sample size from the list of groundnut farmers in the communities. Adopters were defined as those who used improved groundnut storage technology, whilst non adopters were those who did not use the improved groundnut storage technology. A pretested structured questionnaire was administered to 30 farmers before finalizing the questionnaire and its subsequent administration. Enumerators administered the questionnaires with assistance from the resident extension officers in the respective districts of study. In all 200 questionnaires were administered to farmers. Personal interviews and observations were also conducted. Copies of the questionnaires can be found at the appendix section of this study. Computer software's used in the data analysis process included the SSPSS, Microsoft Excel were employed in data entry and descriptive analysis and SAS in inferential analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents and discusses the results obtained from the various analyses undertaken to address each objective. The results of the demographic characteristics and other selected variables are hereby presented first. This is then followed by empirical results of Logit regressions which analyzed factors influencing the adoption of improved storage technology and estimate the relationship between cost incurred in producing good quality groundnuts and farmers knowledge of good practices in groundnuts storage.

4.1 Individual and Demographic Characteristics

The age distribution of respondents is found in Table 4.1. The mean age of respondents was 36.3. The minimum age was 18 and a maximum of 75. The male to female ratio was skewed towards the male with 75% of the respondents being male and 25% female. Seventy percent of respondents were within the age category of 18-40, with 26.5% being between 41-60 and 7% in the 60-75 age category. This implies that, the young are actively engaged in groundnut farming; age is quite a necessary factor in technology adoption especially where labour is critical for its success. This high level of youth involvement in groundnut farming could be attributed to the fact that, groundnut farming is less capital and labour intensive. Majority of the farmers were illiterate. This is at a great disadvantage to technology adoption. Agwu and Anyawu 1996 (in Agwu et al., 2008) reported an increase in education positively influences the adoption of improved agricultural practices. The majority (77.5%) of respondents had no formal education, 6.5, 6.0, 9.0, 0.5, 0.5 percent of respondents had primary, J.H.S, S.H.S, Technical and Polytechnic education respectively. This is especially so, because the level of education in the three Northern Region with an illiteracy level of 70% (ghanadistricts.com 3/5/2012) is low compared to the other regions of Ghana (Table 4.1). Household size, varied greatly across respondents. Of the 200 respondents interviewed, the range of dependents was between zero and twenty with an average of 8.5 a departure from the regional average of 7.4 (ghanadistricts.com3/5/2012) and national average of 4 (Ghana Statistical Service, 2008)

Table 4.1: Socio-economic Characteristics of Respondent Farmers

Socio-economic Characteristics	**Frequency**	**Percentage**
Age		
18-40 years	11	70
41-60 years	38	26.5
61-75 years	55	7
Minimum age 18		
Maximum age 75		
Gender		
Male	150	75
Female	50	25
Education		
None	155	77.5
Primary	13	6.5
JHS	12	6.0
SHS	18	9.0
Technical	1	0.5
Polytechnic	1	0.5

The 75th, 50th and 25th percentile of average cost incurred in groundnut storage were 30, 20 and 10 respectively. Again, 32, 66 and 52 respondent farmers were in the 75th, 50th and 25th percentile respectively.

The maximum income reported from groundnut sales per 100kg bag was GH¢41.91 and a minimum of GH¢25.36. These differences in price could be attributed to time of sale and according to Florkowski and Kolavalli (2013) relatively high price for the old crop may result from low moisture content and can be expected to drop as newly harvested groundnuts enter the market (Table 4.2).

Table 4.2 Descriptive Statistics of some selected Continuous Variables

Variable	Frequency	Mean Value	Standard Deviation
Age	200	36.3years	11.96
House Hold Size	200	8.5	0.26
Average Income per annum from Groundnut Sales	200	GH¢460.0	30.98
Price of groundnut immediately after Harvest100kg bag	93	GH¢25.36	1.50
Price of groundnut 3 months After Harvest 100kg bag	120	GH¢30.44	0.65
Price of groundnut 6 months After Harvest 100kg bag	152	GH¢41.91	0.89
Average Cost incurred in Storing present Groundnuts 100kg bag	197	GH¢35.65	4.97

Source: Field Survey, 2011

However, the average income from groundnut sale per annum was ¢460. The results further reveals a profitability difference of 16.711%, 39.507% and 27.370% between sale immediately after harvest and 3-months after harvest; sale immediately after harvest and 6-months after harvest; and 3-months after. These disparities could be attributed to gluts immediately after harvest pushing down prices and shortages pushing up prices as months after harvest increases.

Table 4.3: Average Price at Time of Sale of Unshelled Groundnuts

Time of Sale	Average Price at Time of Sale/100kg bag	Profitability in percentage	Number of Respondents
Immediately after harvest	GH¢25.36	N/A	93
3-months after harvest	GH¢30.44	16.71	120
6-months after harvest	GH¢41.91	27.37	152

Source: Field Survey, 2011

Also, a grain storage project may make it possible to hold produce from the time of harvest, where the price is at its seasonal low, until later in the year. The benefit of storage investment thus emanates out of this change in temporal value (Gittinger, 1982). Ninety three of the respondents indicated selling groundnuts immediately after harvest, 152 respondents stored and sold groundnuts three months after harvest and 146 farmers stored and sold groundnuts six months after harvest. Albeit, groundnut storage enables farmers to obtain better prices by withholding the sale of their produce; they also stand the risk of flavor changes, rancidity and physical changes like shrinkage and weight loss (Table 4.3).

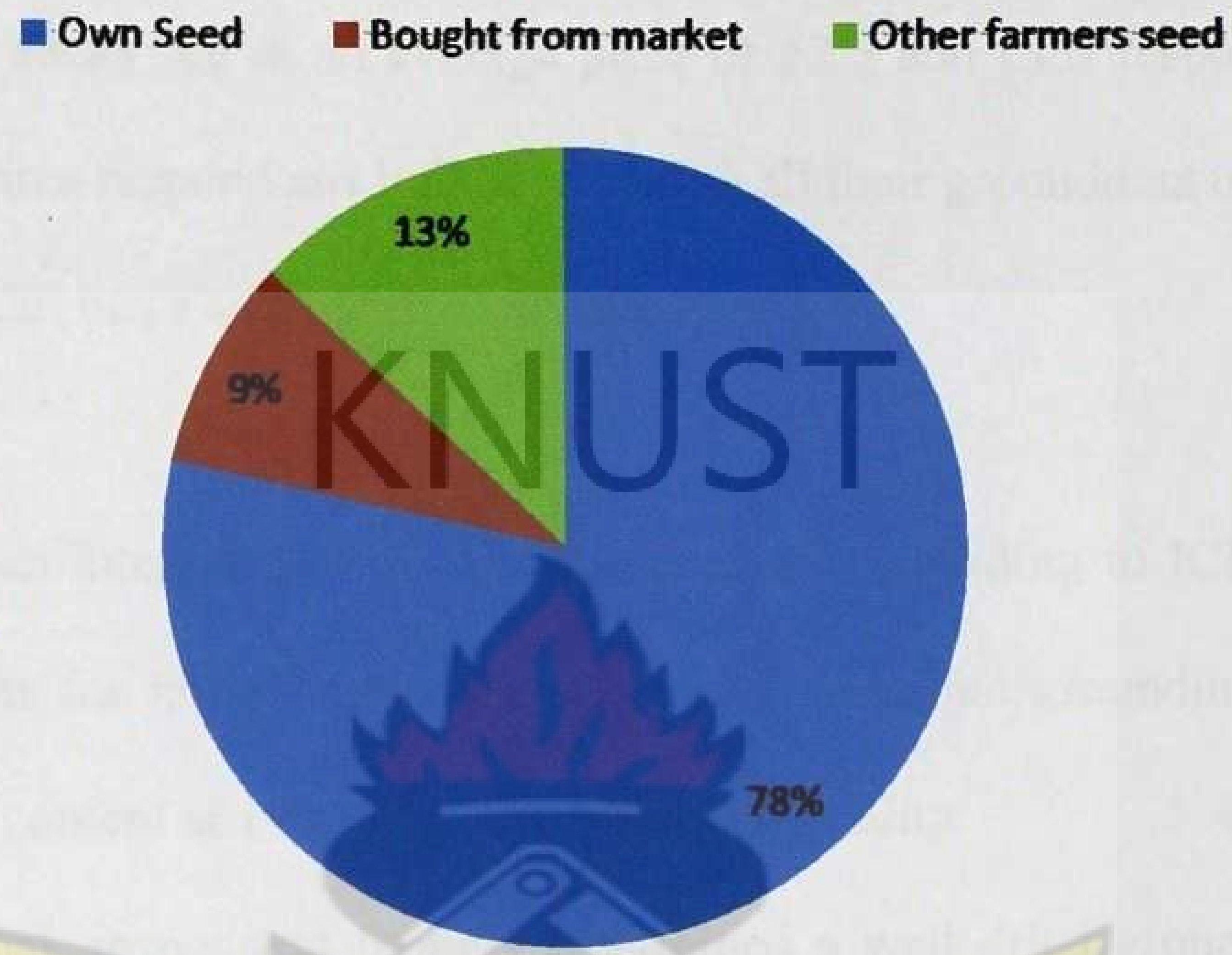


Figure 4.1: Respondents Source of Seeds

In addition stored groundnuts could be subject to insect and rodent attack and fungal development prior to aflatoxin infestation and viability loss. The latter is of utmost importance to the ultimate consumer, since of the 200 farmers interviewed, 157 used their own seed from previous harvest for sowing whiles 26 used another farmers' seed and 17 bought from the open market (Figure 4.1). Taking into consideration their current storage structures, practices and technologies; this risk is very high. This risk could be transferred to consumers if contaminated groundnuts end up in the market.

The average cost incurred in storing groundnuts for a maximum period of six months was ¢35.648 for the 200 respondents. This cost emanates chiefly from jute and polythene sacks used in bagging groundnuts both for storage and "commando" pesticide. The relatively low cost incurred could be attributed to reuse of sacks employed in storing other product, for example, maize, millet and cassava (Florkowski and Kolavalli, 2013). This according to the authors is a potential source of aflatoxin contamination. These sacks sell at an average price of ¢2.5 and ¢1.5 respectively and ¢1for the pesticide. Three respondents indicated selling all their groundnuts immediately after harvest thus did not incur any cost for storage.

Groundnut drying is an integral part of aflatoxin control. According to ICRISAT, the best storage conditions for normal dry bulk storage of unshelled groundnuts is about 7.5% kernel moisture content at 10°C and 65% relative humidity.

The study revealed that, respondent farmers determined a well dried groundnut either by: How hard the shell is and therefore difficult to crack; sharpness of the rattling sound from the kernels; darkening of the inner surface of the pod; chewing sample of groundnut or; and applying pressure to determine the ease with which the scale peels off from the kernel. Sixty seven percent of respondents indicated that they shake for sound to determine a well dried groundnut, 15% chewed sample, 11.5% used difficulty to crack, 6% apply pressure on seed to determine the ease with which scale peels off from kernel and 1% percent used darkening of inner surface of kernel as an indication for a well dried groundnut. In the absence of mechanical driers in the study area, these practices tend to introduce variations in determining a well-dried groundnut (Figure 4.2).

Table 4.4: Respondents Sorting and Storage with other Products

Activity		Frequency	Percentage
Sorting	Yes	115	57.5
	No	85	42.5
Total		200	100
Store groundnuts with other products	Yes	134	67.0
	No	61	30.5
Not applicable	N/A	5	2.5
Total		200	100

Source: Field Survey, 2011

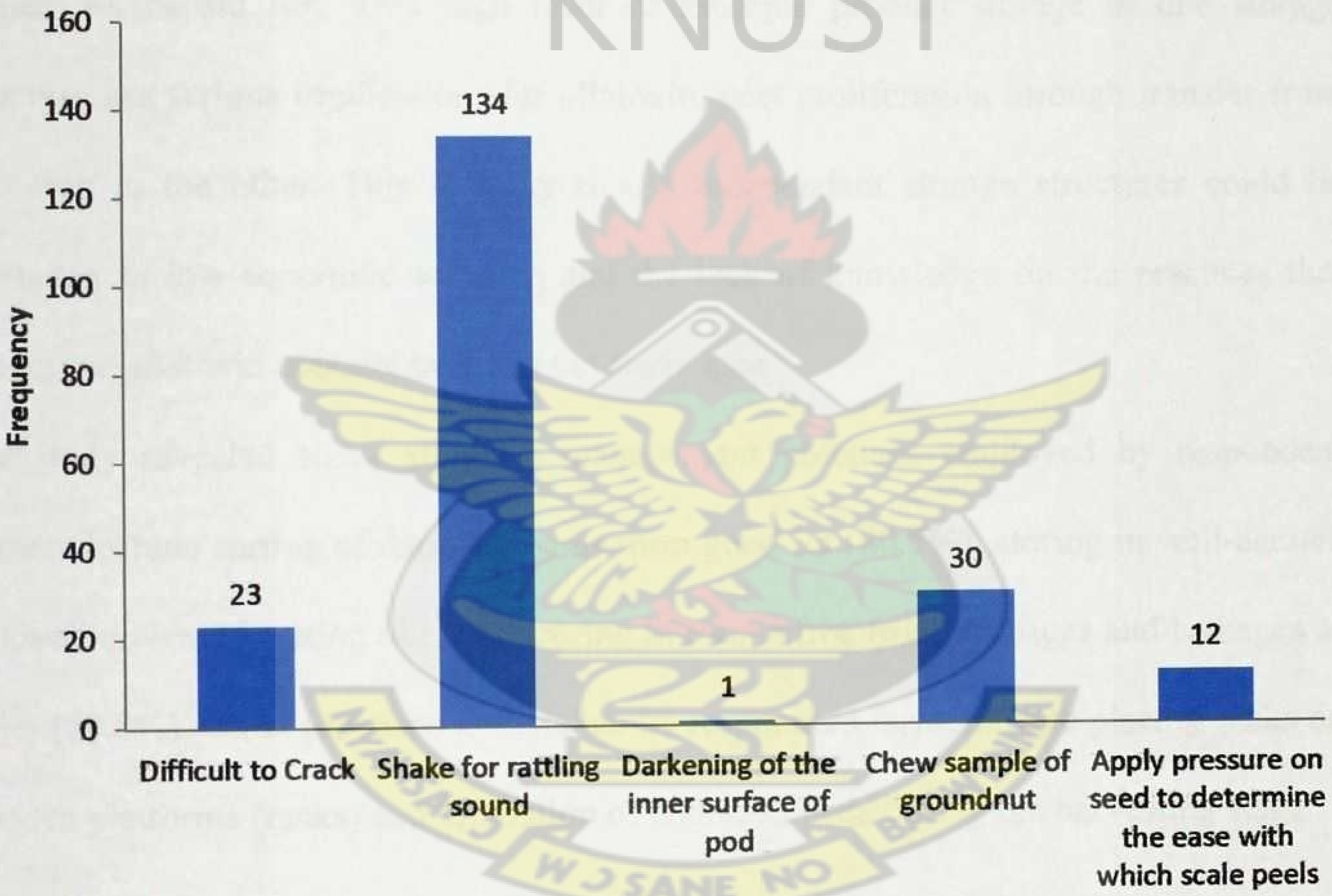


Figure 4.2: Respondent Farmers' Determination of a Well Dried Groundnut

The study further revealed that 57.5% of respondent farmers sorted groundnuts before storage. This activity was undertaken basically during drying; where broken, insect and pest burrowed and mouldy nuts are separated (Table 4.4).

Majority of farmers (57.58%) interviewed employed the traditional barn for storage as opposed to 42.42% adopted the improved barn. Eighty four respondents used jute sacks placed on wooden platforms for storage with 114 indicating using only jute sacks. Furthermore, 71.5% used polythene sacks placed on wooden platforms to 27.5% using only polythene sacks. The study therefore revealed jute and polythene sacks as the predominant storage materials.

Due to lack of storage space, 67% of respondents stored groundnuts with other products whiles 30.5% did not. This high level of multiple product storage in one storage structure has serious implications for aflatoxin, pest proliferation through transfer from one crop to the other. This inability to use independent storage structures could be attributed to low economic standing and the lack of knowledge on the practices that encourage aflatoxin contamination in the study area

The study revealed some aflatoxin management practices employed by respondent farmers include sorting of damaged pods from good lot (80.5%), storing in well-aerated and well-covered location (42.5%), storing in rooms free from seepages and leakages of water (58.8%). Other practices undertaken by respondent farmers were placing sacks on wooden platforms (racks) and separation of damaged pods during the harvesting stage.

Table 4.5: Socio-economic Characteristics of Adopters and Non- adopters

Variable		Non-Adopters (144)			Adopters (84)		
		Mean	SD	N	Mean	SD	N
Age		37	2		36	12	
Gender	Male			86			2
	Female			28			22
Educational Background	Educated			26			20
	Otherwise			88			64
Average Income per month from all sources		61	69		54	55	
Years as Groundnut farmer	1-3			19			3
	4-6			32			22
	7-10			27			25
	11-14			1			2
	>14			35			22
Belongs to Farm Group	Yes			49			27
	No			65			57
AEA contact in last two months	Yes			93			72
	No			21			12
Aware of storage conditions on aflatoxin growth	Yes			46			38
	No			44			41
Awareness on the ill-effects of consumption of aflatoxin contaminated groundnuts	Don't Know			24			5
	Not serious			28			33
	Not so serious			40			20
	Serious			46			31

Source: Field Survey, 2011.

4.2 Factors Influencing the Adoption of Improved Groundnut Storage Technology

This section discusses estimates from the Logit model developed to determine factors influencing farmers' adoption of improved traditional storage technology. The results are presented in Table 4.6.

The parameter estimates that AEA contact had a significant and positive effect on the adoption of improved groundnut storage technology. This is in agreement with the a priori sign and significantly different from zero.

The results further revealed that respondent farmers who had contact with Agricultural Extension Agents (AEA's) in the last two months were 1.97 ($p<0.05$) times more likely to adopt the improved groundnut storage technology than those who have not. This observation underscores the importance of AEA's in technology adoption. AEA's are information carriers and the link between the famers and researchers. This is especially so, since this technology was developed by the local people with the help of the AEA's. This finding is consistent with the findings of Okoeda-Okoje and Onemolease (2009) who reported a 1.79 ($p<0.05$) chances of farmers with extension contact to adopt improved yam storage technology in the Edo Sate of Nigeria.

Furthermore, household size had a significant and positive impact on the adoption decision of respondent farmers. This outcome is in agreement with the a priori expectation and significantly different from zero as well. The results further revealed that, respondent farmers with household size less than eight members were 2.89 ($p<0.1$) more likely to adopt the improved groundnut storage technology. This could be occasioned by the fact that famers with fewer mouths to feed have extra disposable income for which they can invest in the improved groundnut storage technology (Table 4.6).

Table 4.6: Parameter Estimates of the Adoption of Improved Groundnut Storage Technology

Dependent Variable: Adoption of improved groundnut storage technology
(N: Yes 84, No 114)
Rsquare / MaxRsquare : 0.0847 - 0.1138

Variable	Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Odds Ratio Estimate	Lower 95% Confidence Limit for Odds Ratio	Upper 95% Confidence Limit for Odds Ratio
Contact with AEAs in the last two months	0.4837	0.1567	9.5319	0.0020***	1.9705	0.3801	0.7024
Age Group <= 35Yrs vs. > 35 Yrs.	0.2457	0.3668	0.4485	0.5030	0.6740	1.2785	2.6239
Lack of Awareness on the ill-effects of consumption of Aflatoxin contaminated groundnuts	0.1037	0.1636	0.4016	0.5263	0.6381	1.2304	2.3363
Average Income per Month from all Sources	(0.0758)	0.3131	0.0587	0.8086	2.5241	0.9270	1.7123
Educational Background	0.0827	0.1939	0.1821	0.6696	1.8657	1.1800	2.5233
Belongs to Co-operative Society or Farm Group	0.2692	0.1654	2.6483	0.1037	1.2416	1.7132	3.2763
Gender	0.1956	0.2207	0.786	0.3753	2.4226	1.4788	3.5121
House Hold Size	0.0825	0.0447	3.4114	0.0647*	2.8854	1.0861	1.1855
Years as Groundnut Farmer	0.1603	0.1813	0.7818	0.3766	2.7467	1.3780	2.8049

Source: Field survey, 2011 *, **, *** indicates significance at 10%, 5%, and 1% respectively

4.3 Factors Influencing the Cost Incurred in Storing Groundnuts

This section presents and analyses Logit estimates of the factors that influence the cost incurred in groundnut storage obtained. Three different models are presented in this section: Top 75th Percentile versus the Bottom 25th Percentile, Top 75th percentile versus the middle 25th -50th Percentile, and the middle 25th-50th Percentile versus the bottom 25th Percentile representing the high, medium and low models respectively.

The results of the High model (Top 75th percentile versus bottom 25th percentile) revealed that, membership of a farm group had a significant and positive effect on the cost incurred in storage. In other words, farmers who belong to farm groups are 5.71 times more likely to be in the 75th percentile of cost incurred in storage ($p< 0.01$). This implies that farmers who are members of farm groups incur more cost than their counterparts who are not. This could be occasioned by the fact that, membership of such groups comes with the acquisition of additional knowledge on groundnut storage and some these practices may come with additional cost. For example, fumigation of storage room before storage, insect and pest control, storage in well-aerated room among others all come with some amount of cash outlay that could affect the overall cost incurred during groundnuts storage.

Drying groundnuts in shell had a positive and significant effect on the cost incurred in groundnut storage. Respondent farmers who dried their groundnuts in shell are 5.16 times more likely to incur more cost than those who do not and thus likely to be in the 75th percentile of average cost ($p<0.01$). This invariably means this category of farmers incur more cost than their counterparts who do not dry their groundnuts in shell. Drying groundnuts in shell draws it advantage from the fact that, it prevents direct moisture and sunlight contact with the seed and thus forestalls aflatoxin contamination and quality and viability loss.

Storage of groundnuts in well-aerated room had a positive and significant effect on the cost incurred. The results further revealed that farmers who store groundnuts in well-aerated room are 7.07 times more likely to be in the 75th percentile of cost incurred in groundnut storage ($p<0.01$). This implies that farmers who engage in this critical aflatoxin management practice are more likely to incur more cost but stand to benefit from the reduction in the aflatoxin contamination (Table 4.8a).

Table 4.8a: Parameter Estimates of Cost incurred in Groundnut Storage (75^{th}-30 vrs 25^{th} -10 Percentile)

Dependent variable: Average Cost incurred in groundnut storage (N:84)
Rsquare: 0.25

Predictor	Estimate	Standard Error	Wald Chi-Square	Pr> Chi-Square	Odds Ratio Estimate	Lower 95% CI for Odds Ratio	Upper 95% CI for Odds Ratio
Belongs to Co-operative Society or Farm Group	0.87141	0.27117	10.32635	0.00131***	5.71342	1.97355	16.54033
Form Groundnuts were Dried at Home	0.82057	0.31131	6.94776	0.00839***	5.16109	1.52322	17.48715
Months Groundnuts were Stored Last Harvest	(0.31620)	0.24260	1.69885	0.19244	0.53131	0.20528	1.37515
Sort Groundnut Before Storage	(0.13657)	0.27248	0.25121	0.61622	0.76099	0.26152	2.21437
Storage in Well-Aerated and well-Covered Location	0.97817	0.31431	9.68492	0.00186***	7.07335	2.06317	24.25024
Storage Room Free from Seepages or Leakages of water	(0.39791)	0.29107	1.86877	0.17162	0.45121	0.14416	1.41224
Store on Racks	0.06107	0.25710	0.05642	0.81225	1.12991	0.41244	3.09548
Store Other Products with Groundnuts	0.27195	0.27055	1.01034	0.31482	1.72271	0.59651	4.97512
Throw Away Damaged Nuts	0.06756	0.28383	0.05667	0.81185	1.14468	0.37627	3.48234
Years in Groundnut Farming	(0.34874)	0.23456	2.21061	0.13706	0.49784	0.19851	1.24852

Source: Field survey, 2011 *, **, *** indicates significance at 10%, 5%, and 1% respectively

Parameter estimates from the Top 75th Percentile versus the Middle 25th-50th Percentile model revealed that farmers in the Top 75th percentile of cost incurred in groundnut storage are 3.34 times more likely to store groundnuts in a room free from seepages and leakages of water. Groundnut storage in room free from leakages positive and significant effect impact on the cost incurred ($p<0.05$). This implies that, respondent farmers who undertake the aflatoxin management practice of storing in room free from seepages and leakages of water are more likely to incur more cost during groundnut storage. However, they stand the added on advantage of limiting aflatoxin contamination of their groundnuts and thus likely to obtain better prices on this ground.

The storage of groundnuts with other products had a significant but negative effect on the cost incurred. Farmers who store groundnuts with other products are 0.30 times less likely to be in the 75th percent of average cost incurred. This implies that famers who undertake multiple product storage in a single store room incur less cost in storing than their counterparts who do not. This category of farmers, however, stands the risk of pest transfer and aflatoxin contamination possibly from other crops (Table 4.8b).

Table 4.8b: Parameter Estimates of Cost incurred in Groundnut Storage (75^{th} -30 vrs 25^{th}-50^{th}- 10:20 Percentile)

Dependent variable: Average Cost incurred in groundnut storage (N: 98) Rsquare: 0.099							
Predictor	Estimate	Standard Error	Wald Chi-Square	Pr> Chi-Square	Odds Ratio Estimate	Lower 95% CI for Odds Ratio	Upper 95% CI for Odds Ratio
Belongs to Co-operative Society or Farm Group	0.05736	0.18643	0.09465	0.75834	1.12155	0.54007	2.32911
Form Groundnuts were Dried at Home	0.41102	0.22655	3.29167	0.06963	2.27516	0.93613	5.52952
Months Groundnuts were Stored Last Harvest	(0.02587)	0.19452	0.01769	0.89419	0.94957	0.44297	2.03556
Sort Groundnut Before Storage	(0.10969)	0.22188	0.24437	0.62106	0.80302	0.33651	1.91630
Storage in Well-Aerated and well-Covered Location	(0.14234)	0.23488	0.36726	0.54450	0.75225	0.29957	1.88898
Storage Room Free from Seepages or Leakages of water	0.60320	0.26939	5.01373	0.02515 **	3.34142	1.16231	9.60594
Store on Racks	(0.21963)	0.19844	1.22497	0.26839	0.64452	0.29609	1.40299
Store Other Products with the Groundnuts	(0.59512)	0.24672	5.81846	0.01586 **	0.30415	0.11563	0.80002
Throw Away Damaged Nuts	(0.10931)	0.22283	0.24063	0.62375	0.80363	0.33551	1.92489
Years in Groundnut Farming	(0.07837)	0.18992	0.17029	0.67986	0.85492	0.40607	1.79990

Source: Field survey, 2011 *, **, *** indicates significance at 10%, 5%, and 1% respectively

Parameter estimates of the 25th-50th percentile versus the 25th percentile showed a positive relationship between membership of farm group or cooperative society. The results further revealed that farmers who belonged to cooperative or farm groups are 3.29 times more likely to be in the 25th-50th percentile of cost incurred in groundnut storage. In other words, farmers whose cost incurred in groundnut storage lies within the 25th-50th percentile are more likely to belong to farm groups and enjoy the social and economic benefits that come with membership of such groups (Table 4.8c).

Table 4.8c: Parameter Estimates of Cost incurred in Groundnut Storage (25^{th}-50^{th} vrs 25^{th} Percentile)

Dependent variable: Average Cost incurred in groundnut storage (N: 118) Rsquare: 0.128							
Predictor	Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Odds Ratio Estimate	Lower 95% CI for Odds Ratio	Upper 95% CI for Odds Ratio
Belongs to Cooperative Society or Farm Group	0.59487	0.22400	7.05282	0.00791***	3.28621	1.36573	7.90726
Form Groundnuts were Dried at Home	0.25281	0.26679	0.89796	0.34333	1.65801	0.58265	4.71806
Months Groundnuts were Stored from Harvest	(0.14635)	0.20133	0.52843	0.46727	0.74624	0.33895	1.64295
Sort Groundnut Before Storage	0.05672	0.23652	0.05752	0.81046	1.12013	0.44322	2.83090
Storage in Well Aerated and well-Covered Location	0.02483	0.24577	0.01020	0.91954	1.05091	0.40102	2.75399
Storage Room Free from Seepages or Leakages of water	0.30370	0.28041	1.17297	0.27879	1.83563	0.61152	5.51009
Store on Racks	0.22121	0.21510	1.05756	0.30377	1.55647	0.66980	3.61689
Store Other Products with the Groundnuts	0.25241	0.27015	0.87299	0.35013	1.65669	0.57457	4.77683
Throw Away Nuts Damaged	(0.07502)	0.24800	0.09151	0.76227	0.86068	0.32557	2.27525
Years in Groundnut Farming	(0.22572)	0.20807	1.17681	0.27801	0.63671	0.28166	1.43935

Source: Field survey, 2011 *, **, *** indicates significance at 10%, 5%, and 1% respectively

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The study examined the factors influencing the adoption of improved traditional storage technology and estimate the relationship between cost incurred in producing good quality groundnuts and knowledge of good practices in groundnut storage. The study further examined some practices undertaken by groundnut farmers and their role in aflatoxin reduction. The key objective of the study was to analyze factors influencing farmers' choice of groundnut storage technologies and determine whether practices employed in groundnut storage influences cost incurred.

The descriptive statistics revealed that majority of the farmers interviewed were still employing the traditional storage technology.

The econometric results of this study generally indicate that factors influencing adoption of improved groundnut storage technology are extension contact and household size (<8). These factors significantly and positively influenced the adoption of the improved groundnut storage technology amongst respondent farmers.

The econometrics results again confirmed that practices employed during groundnut storage have an influence on the average cost incurred during storage. Farmers who belong to farm groups; dry groundnuts in shell; store in well aerated locations; store in rooms free from seepages or leakages of water; and do not store groundnuts with other products incur cost above GH¢11.

5.2 Recommendation

Based on the findings of this study, more emphasis should be placed on extension contact to boost the adoption of the improved storage technology. For that matter, the Ministry of Food and Agriculture (MoFA) and other related agencies should increase their contact with farmers through their AEA's which invariably has been proven by the study to increase adoption of improved groundnut storage technology. Awareness campaigns and workshops should be organized to bring farmers and stakeholders together to educate them on new practices and technologies to minimize aflatoxin contamination of groundnuts when the need arises.

Furthermore, famers should be encouraged to dry groundnuts in shell; store in well aerated locations; and store in rooms free from seepages or leakages of water albeit these may increase the average the cost incurred in groundnut storage.

5.3 Limitation of the Study and Suggestions for Further Research

The study like all others was bedeviled with one major challenge. The study involved three separate districts of the Northern Region of Ghana, the Tamale Metropolis, Savelugu Nanton and the Tolon Kumbungu districts; and this made the field work costly financially and in terms of time. Further to this, was the language barrier, which challenged effective communication with the respondent farmers. Groundnut samples should be taken from respondent famers in subsequent studies in the study area to determine the level of aflatoxin contamination in the study area and the study conducted between September and February – the period of storage.

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APPENDICES

APPENDIX A: Questionnaire

DEPARTMENT OF AGRICULTURAL ECONOMICS, AGRIBUSINESS AND EXTENSION-KNUST

Name of Enumerator:……………………………………………Date:………………………

Questionnaire Number:………………………………………………………………………………

This research titled '**THE ANALYSIS OF FACTORS INFLUENCING THE ADOPTION OF IMPROVED GROUNDNUT STORAGE TECHNOLOGY'** is done by Festus Selorm Kofi Attah, a graduate student at KNUST. The research is in partial fulfillment of the requirements for the award of Master of Philosophy Degree in Agricultural Economics. I am seeking for information in order to make the study a success and therefore would need your consent. Your responses will solely be for academic purposes and would be kept confidential. Supervisor of the research is Dr F.C. Fialor. Your support will be very much appreciated; questions and matters of concern should be directed to me via isoselorm@yahoo.com or 0208247723. Thanks for cooperating.

SECTION A: DEMOGRAPHY

1. Name of respondent farmer………………………………Code / / / /
2. Gender: 1=Male 2=Female
3. _____ Age

4. Formal educational background:

   1=None 2=Primary 3=JHS 4=SHS 5=Technical

5. Marital status: 1=Single 2=Married 3=Divorced 4=Widowed 5=Separated

6. Household size: ……………………….

7. Number of children in Primary School ……………….

8. Number of children in JHS............................

9. Number of children in SHS...............................

10. Religion: 1=Christianity 2=Islam 3=Traditionalist 4= other specify……………….

11. Ethnicity:………………………………………………………………

12.________________ Average income per month from all sources

13.________________ Average income from groundnut sales per annum

14.________________ Number of individuals in the household who work on farm

    1= 1-3 2= 4-6 3= 7-9 4= 10-12 5= 13-15

15.__________ Number of individuals who help with post harvest activities

    1=1-3 2=4-6 3= 7-9 4= 10-12 5=13-15

16.__________ Number of male labour 1=1-3 2=4-6 3= 7-9 4= 10-12 5=13-15

17. _______________ Number of female labour

    1=1-3 2=4-6 3= 7-9 4= 10-12 5=13-15

18. _______________ Number of paid labour who help with post-harvest

19. _______________ How many days each worked in Post- harvest

20. _______________ How many days each worked in Pre- harvest

21. _______________ Average wage per labourer

22. _______________ Total amount spent on post harvest labour

23. _______________ Total amount spent on pre harvest labour

24. _______________ How would you describe your living quarters: 1= Own home 2= Rent 3=Live with family/friend 4=other: Specify...................

SECTION B: BACKGROND IN GROUNDNUT FARMING

25. __________ What is your main occupation?

1= Groundnut farming

2= other (specify)..............................

25. b. What is your secondary occupation?...................................

26. _____________ How many years have you been a groundnut farmer?

1=1-3yrs 2= 2-6yrs 3= 7-10yrs 4=11-13 5=14 and above

26.b. Number of years in farming / / /

27. __________ The groundnut produced is it primarily for sale or for home consumption

1= Sale 2= home consumption 3= home consumption but sell surplus 4= other (specify)

28. ___________ Do you belong to a cooperative society or farm group? 1= Yes 2= No

29. _________ How many times do you come into contact with AEAs in the last two months?

1= once 2= Twice 3=Thrice 4= Four times and above

30. __________ Do you have access to credit facility? 1= Yes 2= No

31. __________ If yes, is the credit facility used for groundnut farming? 1= Yes

2= No

32. __________ Do you sell groundnuts immediately after sale? 1= Yes 2= No

33. __________ Quantity of groundnuts harvested last year?(in bags)

	Price after harvest	Price 3-months after harvest	Price 6-mths after harvest	Quantity consumed	Quantity given as gifts	Quantity saved as seed
Quantity in bags						
Price in cedis/bag						

SECTION C: GROUNDNUT PRODUCTION

34. __________ Size of your land under cultivation

35. __________ How many acres of groundnut did you grow?

36. __________ Quantity of seeds used per acre in bowls

37. __________ Cost of seeds per acre

38. _____ Did you grow groundnut during the last short season (dry season)? 1= Yes

2= No

39. ________ Do you grow groundnuts with any other crop on the same land?

1=Yes 2= No

40. If yes,

Crop	Acres under cultivation	Mode of cultivation (Mixed Cropping/ Crop Rotation/Land Rotation) 1 2 3

41.______________ Have you continuously cultivated your present field? 1= Yes 2=No

42.______________ If yes, how many years is it to date?

43. Inventory of production equipment

Name of equipment	Cost of equipment	Age of equipment

44. Information on seed variety used in farming

a) Name of variety……………………

b) ___________ Variety: 1= Local 2= Improved

c) ___________ Certification: 1= Certified 2= Uncertified

d) ___________ Source: 1=Own seed 2= bought from store 3= Other farmers seed

e) ___________ Do you treat seed before planting? 1=Yes 2= No

f) Chemical used for seed treatment. (If yes, show bag for product used)…………

45.______________ Do you use fertilizer? 1= Yes 2= No

46. If yes, which fertilizer? ....Quantity per acre ___________

47.______________ Do you rotate crops on your land? 1= Yes 2= No

48. If yes, what crops do you rotate with? List……………………………

49. What is the length of the rotation period ______________________

SECTION D: HARVESTING PRACTICES

50. When is the groundnut ready for harvesting?

a.______________ Yellowing of foliage 1= Yes 2 = No

b.______________ Dropping of older leaves 1= Yes 2 = No

c.______________ Hardening and toughening of pods 1= Yes 2 = No

d.______________ Blackening of inner surface of pods 1= Yes 2 = No

Other please, indicate ……………………………………

Indicate month of harvest ……………………………………..

51. ___________ Are you able to harvest as soon as the crop is mature? 1= Yes 2= No

52. ______ If no, why no: 1= No labour available 2= indicate……………………

53. _______ Principal method of harvest: 1= hand 2= hand tools 3=machine 4= other

54. _________ Do you dry harvested crop on the field? 1=Yes 2= No

55. _____ If yes, how long.

1=1-3 days 2= 4-7 days 4= 1 week 4= two weeks

56. __What method of drying did you employ on the field? 1= windrow 2= heaping together

57. ___________ Did you turnover on the field? 1= Yes 2= No

58. _____ If yes, how many times did you turnover on the field?

59. _________ Are damaged kernels separated out in the field? 1= Yes 2= No

60. If yes, what attacks crop in field?

a.____________ Insects 1= Yes 2 = No

b.____________ Mice/rats 1= Yes 2 = No

c.____________ Birds 1= Yes 2 = No

d.____________ Fungi 1= Yes 2 = No

Other, indicate...

61. ________________ Do you sort groundnuts before storage? 1= Yes 2= No

62. If yes, how important are these in sorting? 1= not important 2= important 3= extremely important 4= don't know

1. Colour 1 2 3 4
2. Kernel size 1 2 3 4
3. Damaged nuts 1 2 3 4
4. Insect borrowed nuts 1 2 3 4

63. After sorting, what do you do with the bad groundnuts? ....

SECTION E: STORAGE

64. _____ When is the harvested groundnut stored? 1= Drying before storage 2= After harvest

65. ________ Where do you store? 1= Field 2= In the house

65.a. **Type of storage method employed by farmer**

a.__________ Traditional Banko 1= Yes 2 = No

b.__________ Improved Banko 1= Yes 2 = No

c.__________ Over the fire-place 1= Yes 2 = No

d.__________ In a store room 1= Yes 2= No

65.b. **Method of Storage**

a.____________ Jute bags stacked on wooden platform 1= Yes 2 = No

b.____________ Polythene Sacks stacked on wooden platform 1= Yes 2 = No

c.____________ Kitchen floor 1= Yes 2 = No

d.____________ Heap the groundnuts on the floor of the store house 1= Yes 2 = No

e.____________ Store in Baskets 1= Yes 2 = No

65.c. **Storage Practices**

1. ____________ Disinfect 1= Yes 2 = No
2. ____________ Fumigate using smoke or any fumigant 1= Yes 2 = No
3. ____________ Store on racks 1= Yes 2 = No
4. ____________ Floor of the store house 1= Yes 2 = No

65.d. **Cost of Storage**

1.__________ Average cost incurred in storing your present groundnuts

2.__________ Average cost in building your present store house (labour)

66. ________ How many months did you store groundnuts from the last harvest?

67. __________ What form did you dry groundnuts at home? 1= shelled 2= unshelled

68. ___________ On what did you dry the groundnuts? 1= ground 2= on polythene laid on ground 3= raised platform

69. ________ How long did you dry groundnuts before storage?

70. ______________________________ How did you determine a well dried groundnuts

71. ____________ Where is your storage structure located?

1= Field 2= in the house 3= Courtyard

72. __________ What material did you use?

1= Wood 2= Clay 3= Metal 4= Gravel 5= don't know

73. ____________ For how many seasons have you used the store?

74. ____________ Do you store other products in the store together with groundnuts?

1= Yes, List...2 = No

SECTION F: STORAGE PROBLEMS

75. ___________ Do you have storage problems? 1= Yes 2= No

76. Indicate the importance of the storage problems and the losses caused

1= not important 2= important 3= very important 4= don't know

Rodent damage 1 2 3 4 /___/ percent loss /___/___/

Insect damage 1 2 3 4 /___/ percent loss /___/___/

Mould damage 1 2 3 4 /___/ percent loss /___/___/

Loss of weight 1 2 3 4 /___/ percent loss /___/___/

77. _________ When did you observe this problem?

1= at the beginning of storage 2= after few months 3= at the end of storage

78. What did you do to solve this problem: List ....

79. __________ Do you clean the storehouse before storage? 1= Yes 2= No

80. ___________ Do you remove old pods/nuts? 1=Yes 2= No

81. What else did you do to clean the store before storage?

List………………………………

82. If you treated the store house before storage what method(s) did you use:

1. _________ Ash + pepper 1= Yes 2 = No

2. _________ Local leaves 1= Yes 2 = No

3. _________ Neem 1= Yes 2 = No

4. _________ Smoke (fumigation) 1= Yes 2 = No

5. __________ Pesticides 1= Yes 2 = No Indicate name of pesticide………………………Others, indicate………………………

83. ________ What is the method of stripping? 1= hand 2= machine 3= other

SECTION G: KNOWLEDGE ON AFLATOXIN

84. ________ Do you know the difference between traditional and improved storage?

1= Yes 2= No

85. _________ Have you adopted new storage techniques in the last year?

1= Yes 2= No 3= don't know

86. _________ Are you aware of storage conditions on aflatoxin growth (mould)?

1= Yes 2= No 3= don't know

87. ___________ Where did you obtain your knowledge on aflatoxins?

1= AEAs 2= Colleague farmer 3= Literature 4= radio 5= others

88. How long ago did you hear of aflatoxins? …………………

89. Did you employ any of the aflatoxin management practices below

a.________ Did you throw away damaged to pods during harvesting? 1= Yes 2= No

b.________ Did you throw away damaged to nuts after cracking? 1= Yes 2= No

c.________ Separation of damaged pods from the good lot 1= Yes 2= No

d.________ Use of polythene–lined bags for storage 1= Yes 2= No

e.________ Storage in well-aerated and well-covered location 1= Yes 2= No

f.________ Storage room free from seepages or leakages of water 1= Yes 2= No

g.________ Fumigation of storage room 1= Yes 2= No

90. To what extent do these limit the use of aflatoxin management practices during groundnut storage?

3= serious 2= not so serious 1= not serious

1) Lack of premium price for aflatoxin-free groundnuts /___/
2) Lack of awareness on the ill-effects of consumption of aflatoxin contaminated groundnuts /___/
3) availability of sufficient quantity of quality seed for sowing /___/
4) Inadequate knowledge on the biological control measures /___/
5) Uncertainty of rains affecting timely sowing /___/
6) Inability of farmers to identify aflatoxin contamination /___/
7) Lack of knowledge on grading /___/

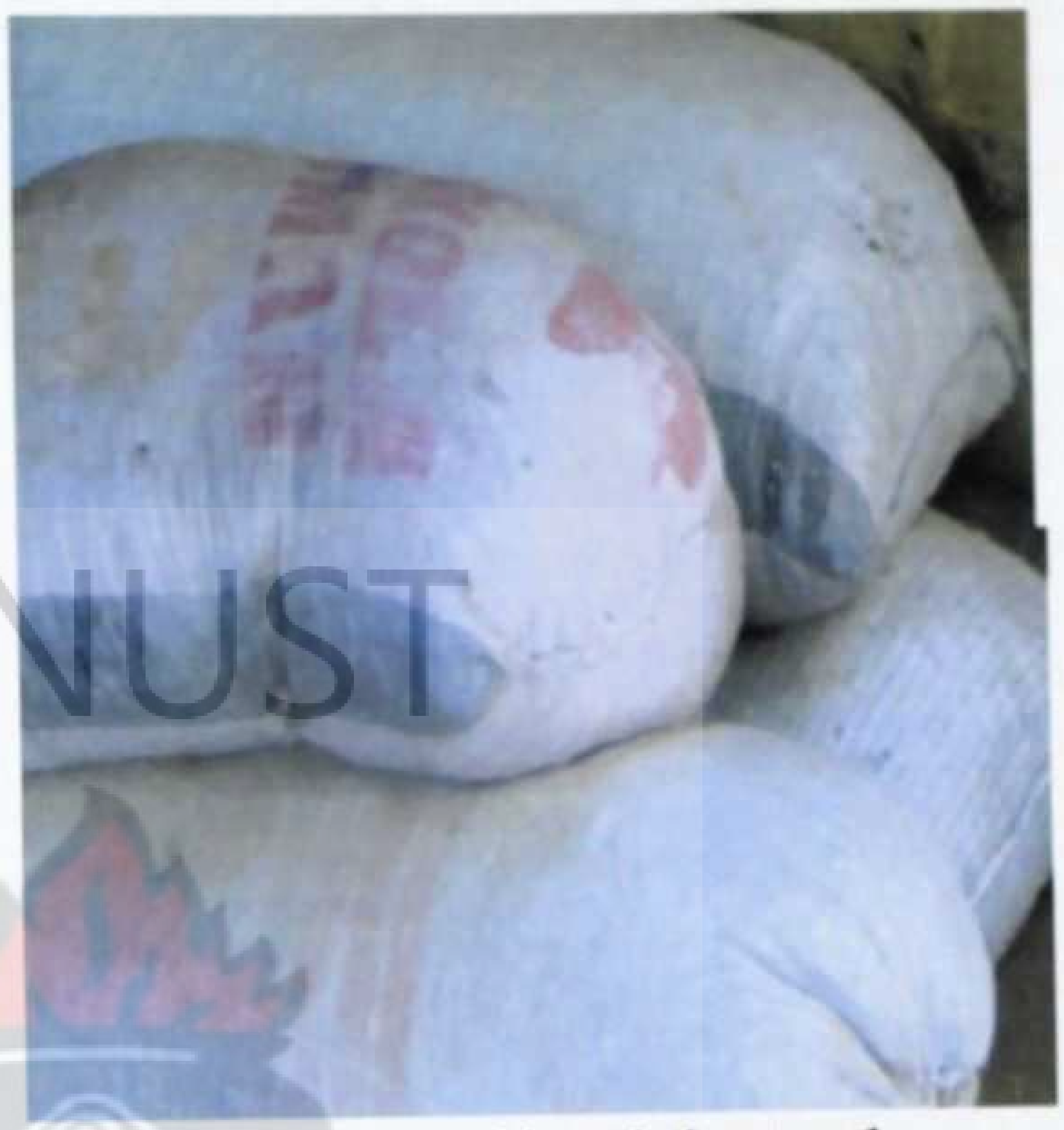
8) Inadequate knowledge on proper drying and stacking of plants /____/

9) Lack of knowledge on fumigation of storage room /____/

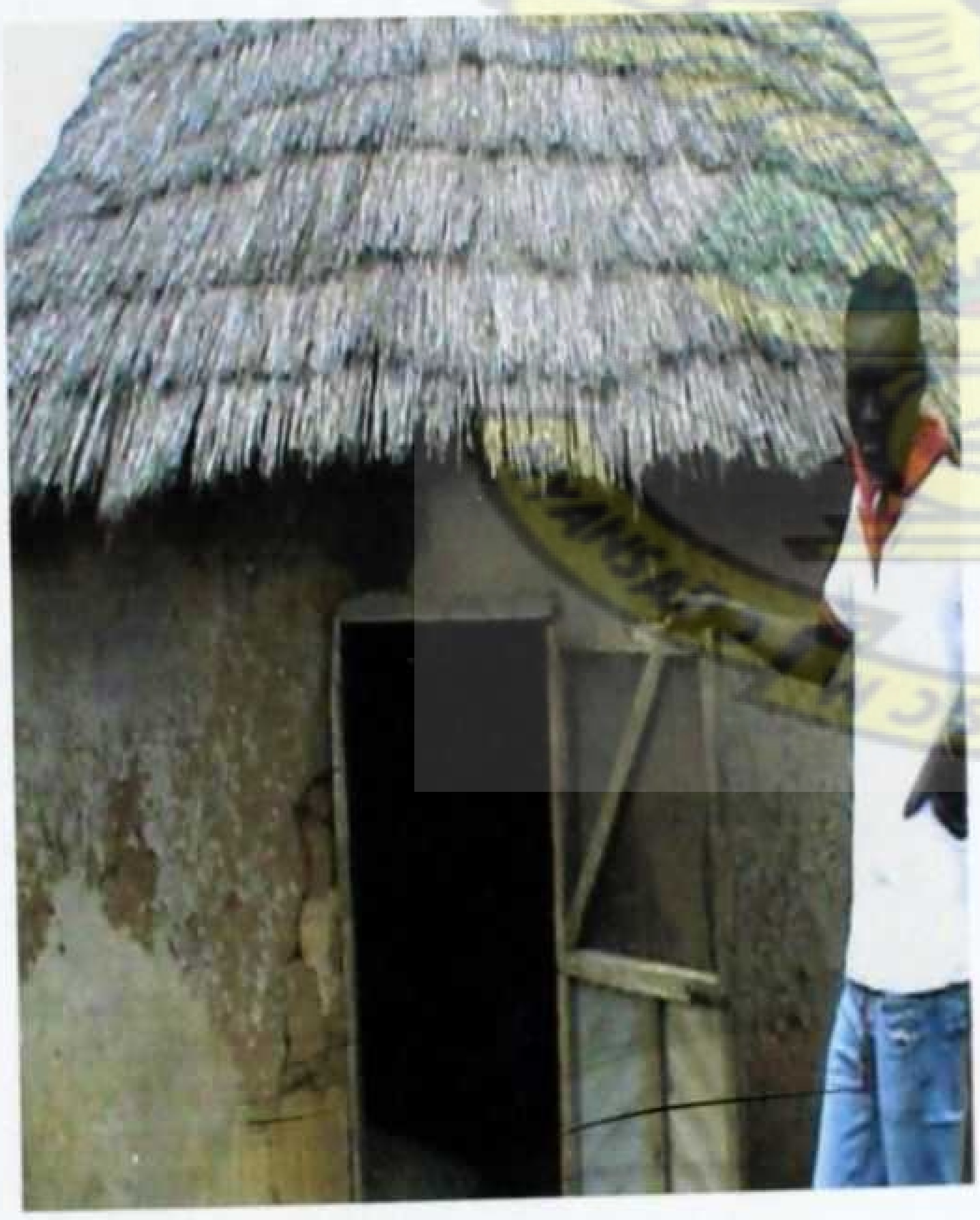
10) Lack of efficient facilities /____/

APPENDIX B: Improved and Traditional Groundnut storage technology

Improved Groundnut storage technology



Groundnuts stored in polythene sacks



Traditional Groundnut storage technology

Jute sack for storing groundnuts