EVALUATION OF PEANUT (*Arachis hypogaea*) SHELLING METHODS

BY

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2004/18418EA

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BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING

ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, NIGERIA.

FEBRUARY, 2010

DECLARATION

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 Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

....22-02-2010..........

Ezeh, Rita Chikodili — Date

CERTIFICATION

This project entitled "Evaluation of Peanut (*Arachis Hypogaea*) Shelling Methods" by Ezeh Rita Chikodili, meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

....	17/02/10
Engr. Dr. A. A. Balami Supervisor	Date
....	17/02/10
Engr. Dr. A. A. Balami Head of Department	Date
....	9/2/2010
External Examiner	Date

DEDICATION

This project work is specially dedicated to God Almighty for guidance, protection and divine wisdom throughout my course of study at the Federal University of Technology Minna. If not for you Lord, this would not have been a success.

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ABSTRACT

The study on the evaluation of peanut shelling method was carried out using three varieties of peanut hybrid (SAMNUT 10, SAMNUT 22, SAMNUT 23). The total.seed yield, the whole seed yield, the broken seed yield, shelling efficiency and output capacity were calculated. The results showed that higher percent total seed yield of 71 percent and whole seed yield of 99 percent were observed for the hand shelling method while the machine method had higher capacity output of 60kg/hr compare to those of mortar/pestle and hand method which had 12kg/hr and 2kg/hr respectively. Broken seed yield were also found to be significantly higher for mortar/pestle method of 40%. Peanut varieties SAMNUT 10 (V_2) recorded highest whole seed yield of 99 percent with hand shelling method while SAMNUT 22 (V_1) had the least whole seed yield of 60 percent with mortar/pestle method. Based on this result the machine method was found to be the most appropriate for peanut shelling were the peanut seed are to be used for industrial purposes such as oil and cake production because of it high output capacity and it cheaper to operate while hand method is recommended for shelling of peanut planting purpose since this method recorded the highest whole seed yield.

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CHAPTER ONE

1.0. INTRODUCTION

1.1. Background of the Study

The peanut crop (*Arachis hypogaea*) is a plant that bears seed. The seed produce oil that is widely consumed all over the world.

The seed itself is edible, inform of raw, roasted or boiled. Apart from consumption of the oil and seed itself, peanut can also be used in the production of margarine butter, soap, lubricant, and illuminants. Its bye product (Peanut Cake) is used in the peanut industries for the manufacture of biscuit and animal feed. The nutritional value present which is a vegetable seed has attributed to the diet of human beings in many countries serving as a good source of protein, lipid and fatty acids for human nutrition including the repairs of worn out tissues, new cells formation as well as useful sources of energy (Gaydou et al 1983, Grosso and Guzman 1995; Grosso et al, 1999).

Edible oils from plant sources are of important interest in various food and application industries. They provide characteristic flavours and textures to foods as integral diet component (Odoemelam, 2005).

The crop is a leguminous plant though it differs from others in the same family because it produces its pods in the ground; it is believed to have originated from Brazil and was introduced to West-Africa by the Portuguese in the 16th Century and to the East and South-eastern parts of Asia by Spaniards (Tindal 1982). Peanut crops grows well in fairly sandy loamy soil with an annual rainfall between 700 – 1000mm to grow to maximum height of 60cm. Peanut will grow in drier are if there is 500mm of rainfall when the plant is establishing itself (Mayhew and Penny, 1988).

A lot of varieties exist but the one popularly grown in Nigeria are 3-month old peanut and four months old. Apart from these there are other intermediate forms of hybrids that exist which include, SAMNUT10, SAMNUT 23, SAMNUT 38, IITA series, a 153, Mk 374, Spanish 205 and many others (Asiedu, 1989, NSPRI 2000). All of these have variation in their physical, biological and chemical properties.

The process of converting the peanut for direct consumption involves drying with the pods, decortications and re-drying to safe moisture content of 8 - 10 percent for storage. It is further processed into oils and cake in industries by subjecting the decorticated nuts to additional processes. These include oil extraction and refining.

In all of these form of processes involved in processing peanut to edible oil or other confectionaries and industrial purpose, shelling or clarification as a units operation has a very vital role in determining the quality of the finally processed product. This is because the shelling process mainly involves the application of manual or mechanical force on the seed to crack the pod in order to release the seed (kernel). The impact force on the seed has the ability to cause some damages which can attract microbes such as affloatoxin to deteriorate the kernels. These can eventually lead to low product quality and loss of market value.

Conventionally, the methods of shelling (decortications) has great influence on the degree of damage caused in the kernel, such methods of shelling includes the traditional and mechanical methods. Traditional method involves the shelling of peanut manually with bare hands and the application of simple tool (mortar and pestle); while the mechanical method involves the use of peanut shelling machine.

Since the method of shelling influences the quality on the processed product which has direct bearing in its marketability, it's worthwhile to critically understanding these different methods of peanut shelling with a view to recommend the optimum and most appropriate method of shelling for a particular purpose.

Peanut production in China leads in production of peanuts having a share of about 37.5 percent of overall world production, followed by India 19 percent and Nigeria 11 percent.

Table 1.1: Shows Peanut Producing Countries

Country	Production (tones)
People's Republic of China	13,090,000
India	6.600,000
Nigeria	3,835,600
United States	1,696,728
Indonesia	1,475,000
Myanmar	1,000,000
Argentina	714,286
Vietnam	490,000
Sudan	460,000
Chad	450,000
World	**34,856,007**

Graphically the peanut producing countries are also shown in fig. 1.1.

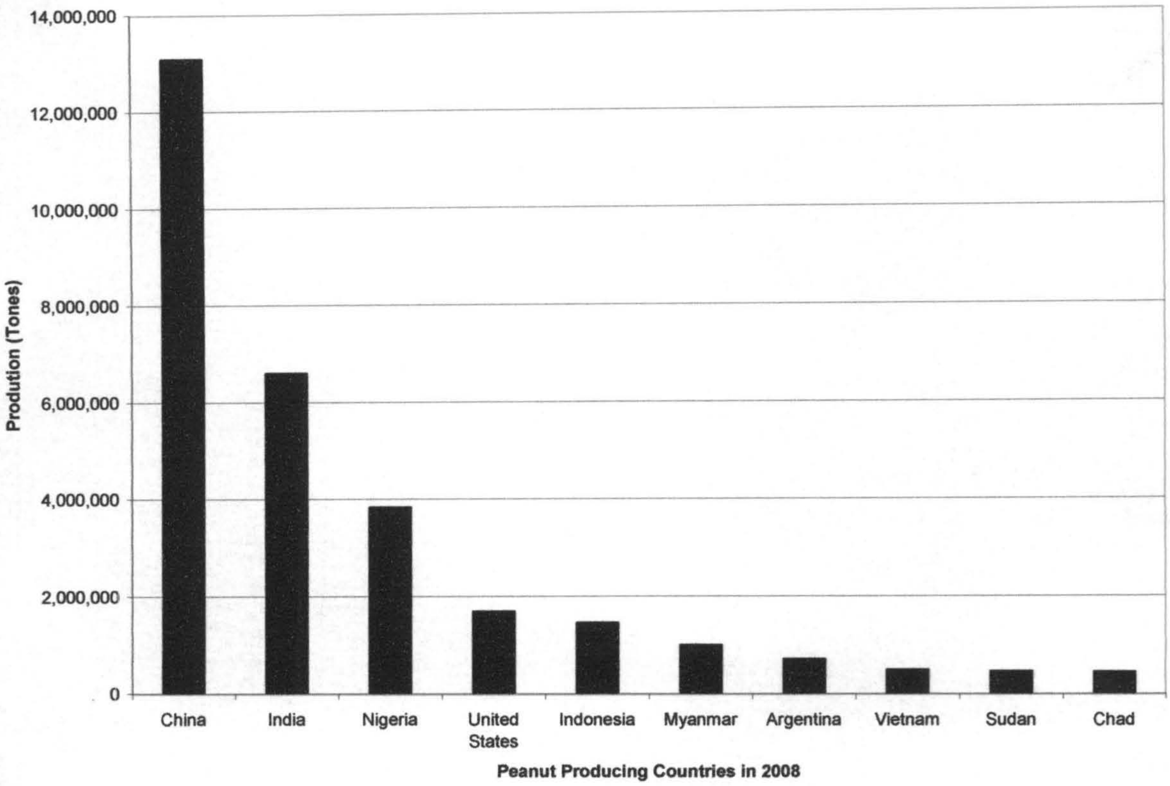

Fig 1.1: Peanut Producing Countries

1.2. Statement of the Problem

Seeds obtained from shelling of peanuts which are used for planting, in confectionaries, for oil production, soap production etc have been found to have varying degree of quality, this is attributed to damages caused to the seed during shelling or decortications. Therefore it is necessary to undertake a strict investigation for a more suitable method of shelling that can yield products of good quality.

1.3. Objective of the Study

The main objective of the study is to evaluate the various peanut shelling methods available in the country with a view to;

(i) Evaluate the different method of shelling peanut.

(ii) Shell different variety using different methods

(iii) Recommend the most suitable for a particular purpose

1.4. Justification of the Study

As already stated, the shelling method in both the traditional and mechanical method, involve the application of force to crack the pods. These forces usually impact some damages in the seeds which adversely affect the utilization of the seed for planting or industrial purposes. Since the methods differ from one another it is expected that the degree of damage on the seed will also vary. As the methods of shelling peanut differs the cost of shelling a particular kilogram of peanut, the time taken, and output capacity differ from another. Therefore there is need to undertake a study on different method of shelling peanut with a view to recommend the most suitable.

1.4. Scope of the Study

The scope of the study is to carry out the comparative study on the available methods of peanut shelling and recommending the most suitable for specific uses.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Peanut Origin and Types

Peanut (*Arachis hypogaea*) belongs to the division papilionacaea of the family leguminosae. It is an oil bearing nut that produce edible oil. Peanut is originated from Brazil and from there it was widely distributed throughout South America in an early date. In the sixteenth century, the Portuguese brought some from Brazil to West Africa and the Spaniards took these across pacific to the Philippines from where they are introduced to Japan, China, Malaysia, India and Malagasy Republic.

Peanut plant is a leguminous seed, sometimes termed "seed legume" because they are second only to the cereals as a source of edible oil, human food and provide the much needed proteins to our predominantly vegetarian population (Kochhar, 1981). Two types of peanut exist, the rnner and the bunchy types. Runner types are commonly grown in West Africa. Apart from the runner and bunchy types, there are several intermediate forms of hybrids that exist which include IITA series, Samnut 38, Samaru 23, Samara nut 22, 9153, Mk 374, Spanish 205 and many others (Asiedu 1989, NSPRI 2000). The crop is rated the second most important source of vegetable oil in the world. Salunkhe and Desai (1989), indicated that African countries contribute more than half of the total world production of peanut and average yield of peanut on farmers plot in Nigeria is about 750kg per hectare of shelled nuts.

2.2. Food Value of Peanut

Peanut has high nutritional value, one gram of peanut supplies 5.8 calories of food. Compare this with 4 calories from sugar, 3.5 calories from whole wheat, 2.6 calories from bread, 2.3. calories from beef steak, etc. The high caloric value of the peanut is due to its low moisture content. Peanuts are rich in some vitamins, almost wholly lacking in others. In general, the members of the B-complex, especially thiamin, riboflavin and nicotinic acid are present in significant amounts. Peanuts are also a good source of vitamin E, but amounts of vitamins A, C and D are negligible (Wrenshall, 1949). The food value of peanut is shown in table 2.1. below.

Table 2.1 shows food value of peanut

Protein Foods	Protein	Carbohydrate	Fat (percent)	Caloric Value
Milk (cow)	3.3	4.8	3.6	65
Eggs (fowl)	13.3	-	13.3	173
Mutton	18.5	-	13.3	194
Beef	22.6	-	2.6	114
Redgram	22.3	57.2	1.7	333
Peanut	25.33	10.2	40.5	500-600

Source; wrenshall, (1949)

2.3. **Utilization**

Peanuts especially those produced in the developing countries have been used traditionally since the origin of humanity. It is rich in oil and protein and has a high-energy value. Developing countries account for nearly 95 percent of world production. Asia accounts for about 70 percent of this amount where the major producers India and China together represent over two-thirds of global output. Other important producers are Nigeria, Senegal, Sudan and Argentina. In most of the developing countries kernels are used for oil extraction, food and as an ingredient in confectionery products. Following extraction, the residual cake is processed largely for animal feed, but is also used for human consumption. The quality-attributes that are important for end uses of peanut, vary among the developed and developing countries. Peanuts are mainly processed for oil in several developing countries.

Even though it is a good protein source, the cake obtained after oil extraction is not utilized to the best advantage

2.3.1. Peanut Butter

Peanut butter is mainly used as a spread for bread or biscuits, in cookies, in sandwiches, in candies and frostings or icings. It is fair sources of calcium, iron, thiamine, riboflavin and excellent source of niacin.

2.3.2. Peanut Cheese

Cheese like products have been made from peanut like protein isolate just as cheese is made from cow's milk. It has good quality protein, is easily prepared and low in cost. It is being used for "Mixed" feeding of undernourished groups in the developing countries.

2.3.3. Fermented Products

Peanut cake or meal can be used for human consumption after partial hydrolysis of the component protein by fermentation using certain moulds. Such products are readily digestible, tasty and nutritious.

2.3.4. Bakery Products

Peanut cake meal or defeated meal, can be used to prepare bakery products. Breads, biscuits, cookies and other products could be excellent vehicles for enhancing the utilization of protein in the diets of malnourished people in the developing countries.

2.3.5. Weight Watchers

Health-conscious consumers in the developed countries prefer low-fat peanut that is now being sold under the trade name Weight Waters. A commercial process that squeezes out about 50 percent of the oil from raw peanuts, which then regain their shape after being squeezed, makes low-fat peanut.

2.3.6. **Composite Flours**

Peanut is used to improve protein content and quality of several cereal-based food products in India, Kenya, Malawi, Nigeria, Senegal and Zimbabwe. In India alone, there have been several agricultural products with peanut as the protein enriching medium.

2.3.7. **Uses of Peanut Shell**

Of the several million tones of peanut produced each year, hulls form about 25 percent of the total mass produced and their utilization thus become very important. At present in the developing countries the majority of peanut hulls are either burned, dumped in forest areas or left to deteriorate naturally. Sufficient information is available to use peanut hull in cattle feed, as carrier of insecticide, in the manufacture of logs and production of pulp and as a fibre component in human diet. Shell can also be used in preparing activated carbon.

2.3.8. **Briquette and Pelletization**

Energy shortage in rural areas has several far-reaching ill consequences, the security of fuel wood forces people to use animal dung and crop residue as fuel, reducing the soil fertility and productivity. Following is the method for briquette and pelletization of peanut shell for fuel purpose. In India small-scale industries are forming briquette from peanut husk, which is being used in other industries as a fuel for boilers

2.4. **Agronomic Requirement**

Peanut plant is an annual crop that requires between 700 – 1000 mm of rainfall to grow to the maximum height of 60 cm it can also grow in drier area if there is 500 mm of rainfall when the plant is establishing itself.

Peanut grows well in fairly fertile soils that are moderately rich in soil nutrients (sandy loamy soils). However, peanut is not recommended for heavy or water logged soils with hard surface crust or cap because the peg will not be able to penetrate the (Mayhew and Penny 1988). The peanut crop has distinguishing characteristics which include the yellow flower like butterfly, that usually appear between 4-6 weeks after planting and it is borne in pods. It develops and mature below the soil surface (Asiedu, 1989) peanut is herbaceous.

Peanut is planted between March to April in the areas where there is heavy rainfall and between June to July in the Savannah Zone. The crops takes 3 to 5 months from the time of planting to maintain during which the leave turn brown and begin to fall on the grounds peanut is always grown from seed and is sown in either mixed cultivation with cereals (Pearls, millet, root crops or other legumes) or in pure stands.

The seed bed should be well worked and the seed placed at interval of 5-7cm with no spacing of 95cm. the normal seed rate is 30-60kg/ha of shelled nuts.

Peanut is most successfully grown and develops the best quality in a hot dry climate where the sunlight is high in degree and the growing season is long. Consequently, a large part of the crop is grown in an arid or semi-arid region under irrigation. It is possible to raise peanuts in areas having a short growing season. (Anonymous, 1979).

2.5. Varieties

There are two major varieties, these are the erect or bunchy types and the runner or spreading type. The erect or bunchy variety is common in the United States. It grows 30 – 40cm high and does not spread. The runner or spreading type is the most common in West Africa. It is shorter and spreads along the ground 60 cm. (Asiedu, 1989). The peanut pods are more or less an elongated pod and they contain between 1 - 6 seeds which are surrounded by a thick fibrous shell. Two major varieties; Virginia runner, Spanish and Valencia contains between (30 – 47) percent and (47 – 52) percent oil respectively.

Runner peanut tend to contain a higher percentage of Olei's acid and vitamin E, increasing their storage stability. Virginia produces the largest Kernels and provides the majority of in-shell roasted nuts. They find wide application in roasted, salted products, confections and other products where the large size from (204 - 386) perkg is important.

Spanish peanut have smaller kernels (408 - 726) perkg that are covered with a reddish skin. This variety contains slightly higher oil content than the other types. Spanish peanuts are grown in the Western states and are typically used in salted nuts and peanut butter production.

Valencia's provide three or more small kernels per nut. They exhibit a sweeter flavour than the other varieties, and are generally roasted and sold in-shell, although they may be boiled for fresh use. The common varieties of peanut planted in Nigeria re SAMNUT 38, SAMNUT 23, SAMNUT 22, SAMNUT 10 (Komolafe etal 1979).

According to Angasor et al, (2009) the following peanut varieties are found from three geographical zones in Nigeria. Northern, Eastern and Western and they are as follows; Boro red, Boro light, Mokwa, Ela, Campala, Guta, SAMNUT 10, SAMNUT 22 and SAMNUT 23 (IAR 2009).

2.6. Harvesting

The optimum time for harvesting is when most pods have a veined surface, seed coats are colored, and 78 percent of pods show darkening in the inner surface of the hull. Harvesting usually starts with chipping or culturing. Rotary mowers remove up to half of the top growth when plant growth is too great for efficient harvesting. Harvesting peanut can be done manually by pulling the plant with hand or mechanical by the use of machine, bullock-drawn digger. Among the field operations concerned with peanut cultivation, harvesting is the most laborious concerned with cultivation, harvesting in the must laborious and costly endeavour.

Harvesting usually consists of series of operations comprising digging, lifting widowing, stocking and shelling. Some of these tasks can be combined or eliminated depending on the system applied.

Harvesting may sometimes become a problem especially when the crop has passed the stage of full maturity and the soil had hardened. In this case, it is customary to lift the plant by loosening the soil either by working a hand hoe, a plough or a blade harrows along the plant rows. If after lifting the crop manually, it is observed that a good percentage of the pods have been left in the soil, the same implement may be used to pick the leftover pods. As compared to manual uprooting, the performance of the bullock-drawn digger is satisfactory and economical. The digger lifts peanut plants from a depth of (100 – 120)mm

2.7. Post Harvest Operations in the Field

From the literature it appears that in the developing countries, crop harvesting equipment available with the smallholder farmers have changed very little over the years. The search for more efficient, cost-effective ways of harvesting and shelling the crop is significant because of the extreme labour intensity of these tasks. For example, up to 40 percent of the total labour required to grow this crop is expended in harvesting operations. At peak harvest periods labour shortages often occur, even higher costs of production or reduced yields. Several factors other than capital costs affect decisions on using harvesting and shelling equipment. The size of the farm in physical and economic terms influences the scale of machinery and the appropriate investment. The following are the major postharvest operations of peanut production;

2.7.1. Curing

The terms curing and drying have been defined as two distinct phases marking the change in peanut composition following harvest. Because of common usage, the terms curing and drying are often used interchangeably. Curing is the process of water removal such that peanut biochemistry and physiology are optimum for food quality. Proper curing is essential for safe storage, milling quality and flavour quality. Extremely high temperature, while the crop is in windrows can promote far too rapid drying and may contribute to the development of off-flavours. The process of curing has not received much attention, especially in the developing countries, where the farmers lack education, quality consciousness or the proper facilities and knowledge.

2.7.2. **Drying**

The word drying is often used to describe all phases of moisture removal, including those already referred to under curing. Specifically drying is used only to describe the period when moisture is being removed after peanuts have been threshed from the haulms. Peanuts, after harvest is dried thoroughly either by following the natural or the artificial methods. The equilibrium between the pod moisture content and atmospheric relative humidity during the drying process has been investigated by several workers. The results showed that the shell, the test (skin of dernel) and the kernel have different equilibrium moisture contents at the same humidity (Table 2.2.). The rates at which pods lose water to the air during curing and drying and the rate at which they change in moisture content during storage, depend on the physical structure of the pods as well as the temperature, velocity and relative humidity of the air.

Table 2.2: Equilibrium Moisture Contents of Peanut at Various Relative Humidity

Components of Pods	**Percentage Relative Humidity**						
	44	53	64	70	75	86	92
Unshelled	6.2	6.9	8.2	8.2	9.0	12.8	19.3
Kernel	5.2	5.8	-	6.7	7.1	11.3	17.2
Shell	9.6	11.5	12.4	-	14.5	16.5	20.1
Skin (testa)	13.9	14.3	15.1	-	17.9	19.9	52.8

Source: Patee and Young, (1982).

Patee and Young, (1982). Made extensive surveys of the literature on drying methods for peanut in various countries. Some of the drying methods being followed in the developing countries are mentioned below.

2.7.2.1.**Natural Methods of Drying**

Windrows

This method is used for curing peanuts prior to further drying in stacks in South Africa, Israel and other developed countries. After harvest plants are dried in inverter windrows for 2 to 3 days.

DOR Method

For drying the pods under shaded conditions, Directorate of Oilseeds Research (DOR) Hyderabad, India, developed a method for maintaining seed viability. In this method two big heaps one-meter in diameter are tied near the base with a rope.

NRCG Method

In this method a tripod type structure (pyramid shape can be raised in the field with the help of three bamboo poles of about 1.5m long. A coir rope can be wound around the structure starting from the bottom to the top. Immediately after harvest, peanut plants are hanged on the rope of the structure in inverted position, pods up and haulms down an the structure is filled with peanut plants in a way that the pods of an upper ring covered the haulms of the lower ring thus forming a sloping structure like the roofing of a thatched house.

Stacks

A stack is structure formed by grouping a number of plants together. it can be used for the windrows.

Platforms

Platforms of various heights may be built to raise the plant off ground during curing and so reduce moisture damage in the bottom layer of pods and avoid damage by the cattle also.

On Ground Surface

Drying of pods by spreading them in a thin layer on the soil or woven matting or tarpaulin material is a common practice in many parts of India and Africa.

Trays: In some countries farmers are encouraged to spread their produce on trays, which they leave exposed to sun-drying during the day and shifts into the house at night.

Platforms: Well-cured pods after removal from the plants are practiced to heap on platforms to complete drying. Very often the pods are left on such platforms for an indefinite period of time and may, in some cases, even be stored there.

Racks: In the suspended bag trial, peanuts of 30 percent initial moisture content in open weave bags were suspended vertically from a horizontal wooden rack supported at both ends by strong vertical posts. A galvanized iron roof provided protection from the rain. Staggered hanging of bags at center distances of 56 centimeters, two bags rows deep is reported to have permitted safe drying of peanut from approximately 30 percent moisture content to safe storage moisture content in 10 days. As a result of this trial it was considered that in humid conditions, it might be necessary to use supplemental heat to achieve safe storage moisture content.

2.7.2.2. **Artificial Methods**

Most of the experience in artificial drying of peanut has been gained in the United States of America and only a few experiments have been conducted from time to time in other part of the world. In general, attempts to dry green (uncured) pods on the plant have given poor results in relation to the quality of both the kernels and the haulms. The total moisture percent was such that if drying was at a moderate rate, moulding quickly occurred and if drying was as a fast, quite considerable breakage of the kernels resulted. Unsatisfactory results were also obtained when the haulms were clipped at various periods before curing. It has been noticed that an initial period of curing which reduces moisture from about 50 to 60 percent to about 25 percent is necessary, if good quality peanuts are to be produced by subsequent artificial drying. After partial windrow curing, peanut on the haulms have been successfully dried artificially in the United States of America. The best results have been obtained using a temperature of 27 to 32^{O}C and discontinuing drying when moisture content reaches below 7 percent.

2.7.3. **Cleaning**

When peanuts are harvested, they contain wide range of foreign materials. Foreign material at 5 percent and above results in a deduction in the value of farmer's stock peanut brought to market.

During storage, foreign material interferes with airflow, reducing the ventilation that is necessary to remove moisture from the warehouse. They cleaning of threshed peanuts are normally done when there is no blower in the thresher or the cleaning efficiency of the thresher is low. In general most of the threshers have blowers, which perform the cleaning operation by the process of winnowing.

2.7.4. Packaging

Pods after grading to the requisite normal size are packed in gunny bags. Seed are seldom shelled and packed because in the kernel (seed) form they lose viability quickly than in-shell (pod) form. Therefore, seed is mainly sold in the form of pods and a small pack of thiram or captan is also kept in the gunny bag with the instruction to treat the seed (kernels) at the time of sowing. Packing for the milling or seed purpose in polyethylene bags is generally recommended, as it helps in maintaining the quality during storage. Similarly in several developing countries the roasted kernels are sold loose in the market, packaging of the confectionery peanut in polyethylene bags may add to the value and quality of the product in the local market.

After filtration, peanut oil is packed in big drums or tanks, and in tins of 15kg capacity. A part of the population in the developing countries living below the poverty line, purchase unbolted or unpackaged peanut oil for their consumption from the market daily. This practice boosts the risks of adulteration.

2.7.5. Storage

Peanut following proper drying are either packed in gunny bags or stored in heaps in big rooms in the farmhouse. Eighty percent of the farm produced reaches the market to be crushed for oil extraction by the millers via the local market or cooperative societies. Due to storage problems, the oil mills also do not store peanut for a long time. When pods are stored at ambient farm storage condition, they interact with the storage humidity (RH percent) and temperatures. At high RH>80 percent and temperatures > $40^{O}C$ the process of ageing accelerates and the kernels start deteriorating.

Peanut pods are generally stored at the moisture content between 6 and 8 percent after harvest or may be stored for (1 – 2) months taking utmost care. For example the produce may be stored in polyethylene bags with desiccant like silica gel or calcium chloride ($CaCl_2$, anhydrous) and sealed.

Peanut are semi-perishable and are subject to quality losses during storage through microbial proliferation, insect and rodent infestation, biochemical changes, i.e. flavour change, rancidity, viability loss; physical changes, i.e. shrinkage, weight loss, and absorption of odours and chemicals. When subjected to suitable storage environments, clean peanut can be stored for several years. High moisture and temperature regulates the rate of deterioration of kernels in storage. During shelling serious losses in milling quality may result, if peanut kernels are dried below 7 percent moisture content (w.b.) or stored at a temperature less than $7^{O}C$. thus, best storage conditions for normal dry bulk storage of unshelled peanuts is about 7.5 percent kernel moisture content (w.b) at $10^{O}C$ and 65 percent RH. If these storage conditions are maintained, unshelled peanut can be stored without significant loss in quality for about 10 months (Patee and Young, 1982).

2.8. Processing

2.8.1. Concept of Shelling

Decorticating is the process of freeing peanut kernels from the shells by cracking the shell. The kernels are removed by applying finger pressure, pounding in mortars or by beating with sticks. The method is effective bit slow, it is time consuming, require much energy and a lot of seeds are being wasted during the process. Various types of machines have been designed for shelling peanut of which are manually and electrically operated. The machine used for this operation is called a Sheller or Decorticator (Kaul and Egbo 1985).

2.8.2. Methods of Shelling Peanut

(i) Traditional Method

(ii) Mechanical Method

1. **Traditional methods**

The mode of shelling done under this methods are;

(i) **Hand Shelling:** This done by applying finger pressure on the pods to crack the pods

(ii) **Mortar and Pestle:** This is done by pounding the pods in mortar with pestle to crack the pods. This method is also used for rice milling in rural areas of Nigeria such as some communities in Enugu State where it is known as ''*Ikwe*'' (Chukwu 1999). In this method, the friction force generated due to relative grain movement helps in dehusking operation. A friction type mill (black stone machine steel huller) dehusks and whitens the rice by friction whereas an abrasive type machine (under-run disc Sheller. Rubber-roll dehusker and other abrasive type stone whitener) does the same job through abrasive effect.

Bending Stress in Seed that Result to Brakeage

Loses are bound to occur due to brakeage of peanut seed arising from the mechanical action of the machine or object used for shelling. Similarly to the force that rises is been subjected to during rice milling. The bending stress in the rice grain as given by (Chukwu, 1999) can be computed as;

$$S = {}^{My}/_{I} \qquad \text{............ (2.7)}$$

Where S = Bending Stress, M = Bending Moment, y = depth and I = Moment of Inertia. The following equation can be derived to describe the bending stress that may be acting upon a rice grain during milling;

$$S = \frac{3FI}{Wt^2} \qquad \text{............ (2.7)}$$

2. **Mechanical Methods**

(i) **Manually Operated Peanut Sheller**

A hand operated peanut Sheller was originally developed by Dandekar brothers in Maharashtra India. It consists of a shelling cylinder which is rotated by hand. It has been modified by the department of Agricultural Engineering, Khomkaen University Thailand to shell about seven times the amount of hand shelled per day (10kg) to ease shelling. If pods become dry in arid conditions of the dry season, the shells will be difficult to shell by hand or machines. In this case they should be moistened by mixing the pods with (8 – 10) percent of their total weight of water allowing them to equilibrate. This may decrease the proportion of split kernels from 90 percent to less than 5 percent (Kishore et al 1990).

A semi rotary type hand operated peanut Sheller was originally developed at the Tropical Product Institute and is now produced in many countries. It consists mainly of a hopper, wire mash, shelling bar, and reciprocating arm. Across its center and towards the top is fixed a shaft carrying a lever savings a pair of plates with shoes or beater bars, which have blunt spikes on their under sides. The semi-rotary action of the shoes is effected by swinging them backwards and forward using lever manually. In this way the nuts are shelled or decorticated against the screen. The mixture of kernels and shells may be subjected to air suction for separation of the tow components (Gajendra and Pinai 1999).

The advantage of the semi rotary type machine is that it is cheap, it does not need any special training for operation, it does not require electricity for operation.

The disadvantage of the semi-rotary type machine is that is requires great effort to operate and cannot separate the kernels with shells.

Foot operated peanut Sheller is another manually peanut Sheller. It was developed in India by Hindson Private Limited, Punjab, India. It is fitted with a flywheel for easier operation and a blower to separate shells from kernels. It is operated by one person and has capacity of 25kg/h (Asiedu 1989).

The advantage of foot operated peanut Sheller is that it can separate the shells from the kernels.

UPLB peanut Sheller was developed at the University of Philippines at Los Banos, Laguna. The shelling unit consists of a stationary hopper with built-in spring-loaded shelling bar and underneath it is a reciprocating slotted screen. It is if fitted with a bicycle chain drive and a blower to separate the shells from the kernels. Its capacity is about 40 – 80kg/h (Kishore et al 1990).

Development and performance evaluation of a pedal-operated peanut Sheller was carried out in Bhubansenwar, University of Agricultural Engineering and Technology Orissa, India. A pedal-operated Sheller was developed to shell peanut economically with minimal manual effort. The major components of the Sheller are Sheller, sheller shaft, sieve, pedal decortication chamber and Hopper with shutter.

The performance of the Sheller was evaluated at different sieve clearance taking IC95-44, Kadri-3, KGS-11 and AK-12-24 varieties of peanut at 7.45, 5.6, 11.45 and 13.2 percent moisture content, respectively. The optimum shelling capacity was found to be 72kg/h. the pedal operated Sheller is simple in construction and easy in operation with less cost and minimum repair and maintenance (Ajayi et al 1994).

The rotary and semi-rotary type peanut hand shellers were evaluated in the IAR Ahmadu Bello University Zaria. The semi rotary types were basically alike except for differences in the manner and number of fixing sheller bars. Shellers needed one operator each with whole kernel count ranging from 73.5-94.3 percent under various test conditions. Such as speed, moisture content and varieties. Sheller basically comprises of beaters and a perforated concave (IAR 2000).

(ii) **Power Operated Peanut Sheller**

Some available power operated peanut Shellers are as follows:-

BPI peanut Sheller with cleaner was developed at the Bureau of Plant Industry Metro Manila, Philippines. It is powered by a 2.2kw electric motor and has the capacity of 30kg/h. it has assembly of three oscillating screens. The shells of peanut are sucked upwards by the sunction fan and blown in to the duct for discharge. This machine could perform shelling without causing damage to the nut (Kishore et al 1990).

Kittichai (1984) developed a power operated peanut sheller at AIT, Bangkok. The Sheller cylinder consist of 12 sets of 10 X 10cm rubber tire shoes (30^{O}) which are 30 degrees apart. The diameter width of shelling bar are 54cm and 22cm respectively. The best performance of the Sheller was achieved at 20mm clearance and shelling bar speed of 180rpm. The capacity, shelling efficiency and breakage were 21.05kg kernels/h. 98.0 percent and 5.3 percent respectively. The power requirement of the Sheller was about 1.0 to 1.1kw.

TNAU peanut Sheller was developed by the Tamilnadu Agricultural University, Coimbatore, India. The machine consist of a hopper, double crank lever mechanism, oscillating unit and a blower assembly, all fitted to a frame. In the Oscillating unit, a number of cast iron pegs are fitted, the peanut pos are shelled between the Oscillating unit and a perforated concave sieve. The husks are blown away by a blower and clean kernels are collected through a spout at the bottom. The clearance between the Oscillating unit and the concave is adjustable. It has capacity of 400kg/h of pods or 260kg/h or kernels. The percentage of breakage shelling efficiency and cleaning efficiency were 4.5 percent, 95 percent and 98 percent respectively (Kishore et al 1990).

The disadvantage of TNAU peanut Sheller is that it has a very high maintenance cost which makes it unaffordable to peasant farmers.

An automatic peanut Sheller machine was manufactured by Harrap, Willinson Ltd; Sanford, U.K. It consists of a hopper, beating chamber and cleaning fan. A ribbed feed roller feeds the pods in to the beater chamber below. From the feed roller, the pods fall in to the beater chamber where these are struck by rotating flexible beaters. The machine shells peanut and separate the shells from kernels (Asiedu, 1989).

A motorized Bambara peanut Sheller was developed and evaluated. It consists of a feed hopper, frame, beater mounted on rotating disks, concave, blower and a delivery chute. The machine is powered by an auxiliary engine. A shutter inside the hopper regulates the feed rate. Whole kernels are drawn by the rotating beaters against a perforated concave for shelling action. No sieving action is included but a winnowing fan percentage seed shelled, shelled, but broken and unshelled seeds. The best performance combination was obtained at 93 percent, 86 percent, 75 percent, 14 percent, and 11 percent for shelling efficiency, cleaning efficiency, unbroken kernel respectively at 62kg/hr feed rate, 300rpm drum speed and optimum moisture content of 7.7 percent weight basis. (Phillip, 1998).

One of the recent studies was carried out to evaluate the performance efficiency of a reciprocating peanut Sheller at various shelling box speed of 1, 1.4, 1.7 and 2m/s, feed rates of 60, 80, 100 and 120kg/hr, air velocities of 4.43, 6.25, 8.37 and 10.11m/s and peanut moisture contents of 11.6, 117.12 and 23.52 percent. The shelling efficiency, mechanical damage and unshelled seeds (total losses) Sheller productivity; unit energy consumption, seed recovery and degree of cleaning were estimated. The results showed that these indices were 95.44 percent, 5.55 percent, 4.56 percent, 70 x 10^{-3}mg/h, 3.36kw.h/mg, 99.67 percent and 96.11 percent respectively, at shelling box speed of 1.4m/s, feed rate of 80kg/h, air velocity of 8.37m/s and peanut moisture content of 117.12 percent (d.b) as an optimum condition of the peanut Sheller. Feeding and shelling box were constructed from wood and steel sheets, the separating screen was fixed under the feed box and clearance between the feed box and the separating box could be adjusted by using four bolts. The blower fan has four straight blades and two inlet openings, the frame was constructed from wood, steel, angle and steel sheets, it is powered by 4kw (5hp-3-phase, 1425rpm) electric motor (Helmy, 2001).

There are also some peanut shelling machines that are designed and constructed by students of Agricultural Engineering Department in Federal Polytechnic Bida. There are also manual peanut Sheller and power peanut Sheller. The manual peanut Sheller was designed by Adelakun 1998. The machine is hand operated. The efficiency of the machine is 65 percent and the capacity is 51kg/hr. the machine is made with locally available materials. The spare parts are easily available.

The disadvantage of this machine is that it requires much human labour, time consuming and cleaning of shells from kernels is done separately after shelling.

The power operated peanut Sheller which is to be used in this project work was designed and constructed. The machine was constructed with locally available materials. The efficiency of shelling is 50 percent and cleaning efficiency is 30 percent. Fan is mounted below the machine to blow off the shells to provide clean kernels. The capacity of the peanut Sheller is 166.6kg/hr.

The advantage of this machine is that its capacity is more than the manually operate peanut Sheller and it can separate the shells from the kernels. This machine was developed and a performance evaluation was carried out by Kuku, (2002).

(iii) **Combine Harvester**

The **combine harvester,** or simply **combine,** is a machine that *combines* the tasks of harvesting, threshing, and cleaning grain crops. The objective is the harvest of the crop; corn (maize), soybeans, oats, wheat, peanut, among other.

The farmer leaves the peanuts in the field for a few days to dry in the sun. When peanuts are dry, a combine harvester collects and cleans the crop putting peanuts into a hopper. It also separates the leaves and stems from the peanuts and throws this back onto the field. Here it is used to fertilize the peanut field or to feed cows and pigs. From the combine hopper, peanuts are dumped into drying trailers where hot air circulates around the peanuts and dries them further.

Despite great advances mechanically and in computer control, the basic operation of the combine harvester has remained unchanged almost since it was invented.

2.9. **Post-Harvest Contamination**

During drying, in most of the peanut-producing countries the weather remains warm, wet during the drying period and the risk of afiatoxin contamination is increased. At harvest, peanut pods contain moisture content about (45 – 55) percent and a complex of microorganisms, the endocarp micro-flora, which include *A.flavus* also. When moist pods are lifted and cured/dried in windrows or heaps there may be considerable invasion of seed by *A.flavus* and other fungi already existed in the shell. This process is encouraged, if drying is slow because seed remain in very susceptible range of (12 – 30) percent moisture content for extended period. A rain shortly after lifting is not particularly harmful, but a rain after the peanuts are partially dried, followed by poor drying is likely to result in aflatoxin contamination Troeger., et al, (1970). Rains in the evening may keep the peanuts wet all night, thus providing fungi with needed moisture to multiply. Rains early in the morning are less likely to slow down drying and accelerate mould growth, because of effective daytime drying. In Nigeria, in the areas where rains continue after harvest, field drying of peanuts is serious problem of aflatoxin contamination McDonald and Harkness, (1965). The use of inverted windrows compared to random windrows or heap had shown to speed the curing and drying process Pettit, et al, (1971). Peanut pods positioned at the top of inverted windrows reside where air currents move more rapidly and the atmosphere humidity is low as compared with positions close to soil surface. Thus the pod at the top of inverted windrows has less chances of invasion by *A.flavus* than the pods close to soil surface.

Lower levels of *A.flavus* infection and aflatoxin contamination have been reported in peanut dried in inverted windrows than in inverted random windrow. Thus inverted windrows shorten the time required to cure peanuts in field and help to reduce the number of kernels invaded by *A.flavus* and other fungi. However, to avoid infection and aflatoxin contamination because of prolonged period of rain, peanut should be threshed as soon as possible with final drying achieved under controlled conditions, if peanuts cultivated in large scale. In case the drying facilities are inadequate peanuts should be left in the inverted windrows rather than combine and held for dying. Peanuts in inverted windrows than for those held in dryers without proper ventilation. In India lot of work on the aflatoxin problem has been conducted by the, from other developing countries the report are sporadic, however, more systematic studies are required to prevent the invasion of *A.flavus* during curing and drying.

2.10. **Effects of Aflatoxin in Human Health**

Aflatoxin has been known to cause liver damage, cirrhosis and liver cancer (Hong Kong Food and Environmental Hygiene Department 2001), the specie, Aflatoxin B, is the most dangerous toxin for both animal and human health (Syarief et al 2003). Aflatoxin has further been recognized as a substance that resist high temperature, therefore researchers are struggling to overcome the negative effects of aflatoxin B, by adding promising natural substances or microorganisms such as soybean paste, Lactic acid, and antagonist fungi of A.Flavour (Beta and Latsztigy 1999; Henry et al, 1999).

2.11. Level of Aflatoxin

Aflatoxin contamination of groundnut is a widespread serious problem in most groundnut-producing countries where the crop is grown under rainfed conditions. The aflatoxin contamination does not affect crop productivity but it makes produce unfit for consumption as toxins are injurious to health. The marketability of contaminated produce, particularly in international trade is diminished to nil due to stringent standards of permissible limits on aflatoxin contamination set by the importing countries. The aflatoxin-producing fungus, *Aspergillus flavus* and *A. parasiticus*, can invade groundnut seed in the field before harvest, during postharvest drying and curing, and in storage and transportation. The semi-arid tropical environment is conducive to preharvest contamination when the crop experiences drought before harvest, whereas in the wet and humid areas, postharvest contamination is more prevalent. Most of the peanut producing countries like Nigeria has been banned from export of peanut because of aflatoxin contamination. Nevertheless, some countries have been regularly monitoring groundnut and its products for aflatoxin at different stages (farm, markets, and storage). Aflatoxin contamination can be minimized by adopting certain cultural, produce handling, and storage practices. However, these practices are not widely adopted particularly by the small farmers in the developing countries, which contribute about 60 percent to the world groundnut production.

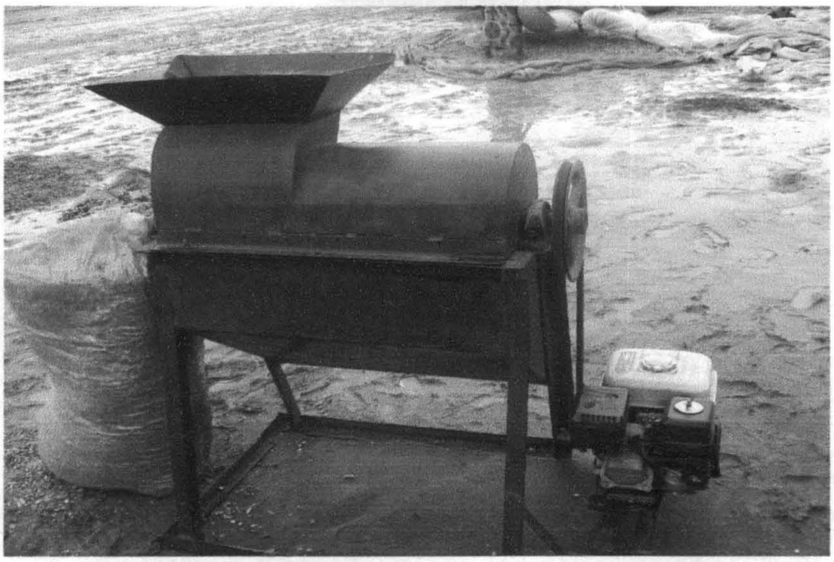

Plate 2.1: Peanut Sheller in Dawano Grain Market Kano, Nigeria.

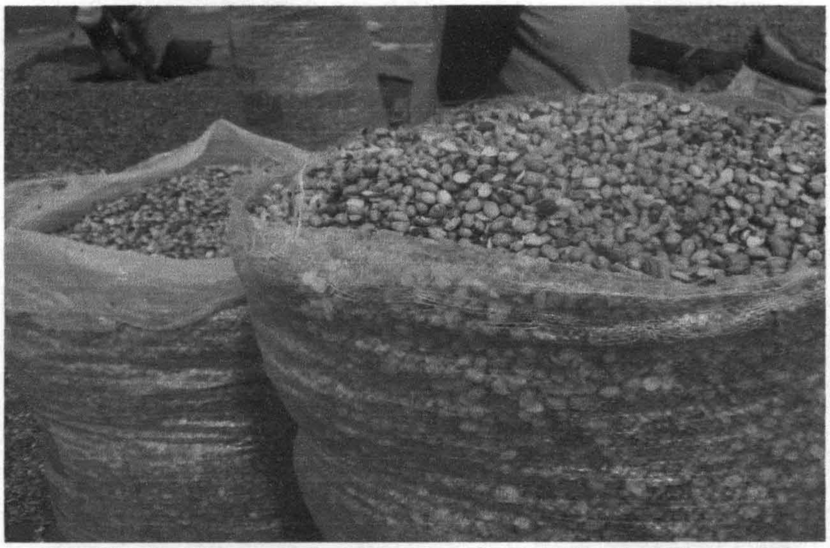

Plate 2.2: Shelled Peanut in Dawano Grain Market Kano, Nigeria.

Plate 2.3: Women Winnowing at Dawano Grain Market Kano, Nigeria.

CHAPTER THREE

3.0. MATERIALS AND METHODS

In carrying out the project on the evaluation of peanut shelling methods in Nigeria, the following investigations were conducted.

i) Study on the effect of different available methods (Machine, Mortar and Pestle, and hand shelling) of shelling on the quality of peanut.

ii) Study on the effect of variety in quality using the three methods

The quality parameter that were investigated for each of the experiments are

i) Total seed yield

ii) Whole seed yield

iii) Broken seed yield

iv) Shelling efficiency

v) Output capacity

3.1. Materials

i) Peanut Sheller

A peanut Sheller that was designed, fabricated, modified and perfected by the Agricultural Engineering Department Federal Polytechnic Bida was used and it is made up of the shelling and winnowing section. The machine uses 3 hp electric motor to supply power the to the shelling and winnowing units through pulleys and belts.

ii) Mortar/Pestle

This is a traditional instrument that was used as an advanced method over the hand shelling before the advent of machine. It is made up of a wooden beater called pestle and wooden carved vessel known as the mortar.

3.2. Description of Shelling Methods

3.2.1. Hand Method

In this method, the pods of the peanut is individually opened with the application of force using the fingers from both hands, the nut is then separated from the pod. Plate 3.1 shows the peanut that was hand shelled.

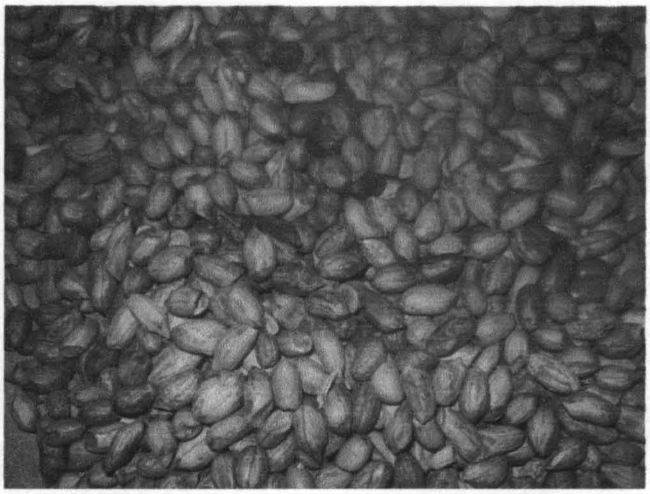

Plate 3.1: Hand Shelled Peanut

3.2.2. Mortar/Pestle Method

This method involves the application of force lightly using a wooden beater on the peanut introduced into the specially carved wooden vessel called the mortar beating ends when all or almost all of the pods are cracked opened as shown in plate 3.2.

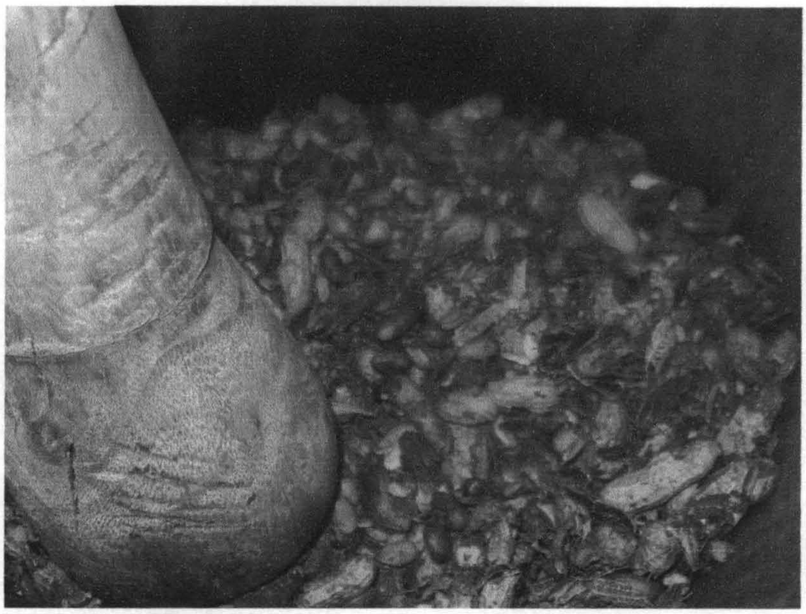

Plate 3.2: Mortar/Pestle Method of Shelling

3.2.3. Machine Method

In the machine method, 1kg of peanut pods are introduced to the machine through the hopper, the pods are beaten in the shelling assembly with the aid of a rotating spike or toothed metal cylinder at a speed of about 500rev/min. A sieve is incorporated below the rotating cylinder. At a clearance of about 15mm which enables the pods to be properly shelled before passing through it to the seeds from the shells. The speed of the air draft generated by the fan blade of the winnowing unit is controlled with the aid of an air intake sucker. This is to prevent blowing of the shelled seeds as shown in plate 3.3.

Plate 3.3: Peanut Shelling Machine

3.3. Experimental Design

The two experiments carried out were done based on the available two independent variables; these two independent variables are;

1. Method of shelling
2. Seed variety

Three levels each of these parameters were taken into consideration. For the methods of shelling machine (M_1), Mortar/Pestle (M_2) and Hand shelling (M_3) were selected while SMANUT 10 (V2), SAMNUT 22 (V1) and SAMNUT 23 (V3) Machine, Mortar and Pestle, and hand shelling were selected as peanut varieties as shown in Plates 3.4 a, b and c. below

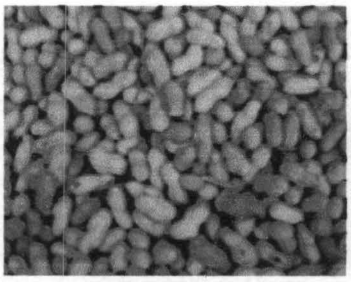

Plate 3.4 (a)
SAMNUT 10 (V_2)
Unshelled

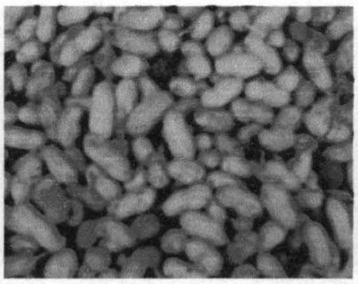

Plate 3.4 (b)
SAMNUT 22 (V_1)
Unshelled

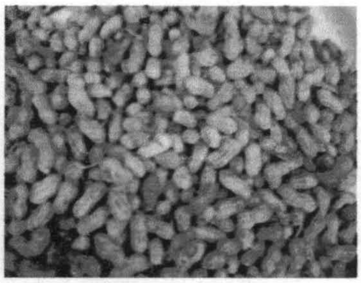

Plate 3.4 (c)
SAMNUT 23 (V_3)
Unshelled

These independent variables were combined using a split plot experimental design method as shown in the experimental layout (Table 3.1). The method of shelling was considered as main plot while varieties are considered as sub-plot.

Table 3.1: Experimental Layout

METHODS	VARIETIES		
	V_1	V_2	V_3
M1	M_1V_1	M_1V_2	M_1V_3
M2	M_2V_1	M_2V_2	M_2V_3
M3	M_3V_1	M_3V_2	M_3V_3

Where M_1 = Machine Shelling Method

M_2 = Mortar/Pestle Shelling Method

M_3 = Hand Shelling Method

V_2 = Peanut Varieties (SAMNUT 10)

V_1 = Peanut Varieties (SAMNUT 22)

V_3 = Peanut Varieties (SAMNUT 23)

3.4. Preparation of Research Materials

Three cleaned varieties of peanuts; SAMNUT 10, SAMNUT 22, and SAMNUT 23 were collected from the Institute of Agricultural Research (IAR) Zaria. A total of 27kg of peanuts for nine treatment of these replication of each were obtained, the peanuts are once commonly used in Nigeria.

The samples were dried to about 9 percent moisture content and left in shade for about 24hours before shelling. A moisture content of 7.5percent was selected because it is the recommended value for storage (Patee and Young 1982). The samples were sprinkled with 8 – 10 percent water allowing them to soften and left for about 5minutes before shelling. This is done in other to decrease the proportion of split kernels or broken kernels from 90 percent to less than 5 percent (Kishore et al 1990).

3.4.1. Experimental Procedure

The experimental procedure for the two experiments are presented in the experimental layout in table 3.1, and explained as follows:

(i) **Experiment One:** Effect of method of peanut shelling (Machine, mortar/pestle and hand shelling) on the quality; each of the samples were shelled with the use of machine, mortar/pestle and Hand (finger tips). For each method, the time take for completion of the shelling procedure; quantity of whole seed, broken seed and total recovered seeds were recorded.

(ii) **Experiment Two:** Effect of varieties on quality using the three different method. In this method, the three different peanut varieties were shelled suing a particular method similar to the above experiment. The time take for completion of the shelling procedure, quality of whole seed, broken seed and total recovered seeds were recorded.

3.5. **Determination of Quality Parameters**

The shelled peanuts were analyzed for the following physical qualities;

(i) **Total seed yield:** each of the shelled samples were weighed, the total seed yield was expressed as percentage of total shelled peanut as shown below;

$$\text{Percentage total seed yield} = \frac{\text{Mass of shelled peanut}}{\text{Mass of peanut samples before shelling}} \times 100\% \quad \text{......... (3.1)}$$

(ii) **Whole Seed Yield:** The total shelled peanut was separated into whole and broken seeds in two passes with the aid of two sieves, having different hole diameters of 0.6mm and 0.8m. This tow different sieves allow passage or separation of less than half broken seed for both bold and slingler sieve variety. The whole seeds and broken seeds were then weighed with a precision balance BC340. The percent whole seed yield and broken seed yields where computed as follows;

(a) $$\text{Whole seed yeild} = \frac{\text{Mass of whole seed}}{\text{Total mass of shelled seed}} \times 100\% \quad \text{......................... (3.2)}$$

(b) $$\text{Percent broken yeild} = \frac{\text{Mass of broken seed}}{\text{Total mass of shelled seed}} \times 100\% \quad \text{......................... (3.3)}$$

(iii) **Shelling Efficiencies:** This is the ratio of the total weight of shelled peanut to the total weight of peanut before shelling, expressed in percentage. It is also the difference between 100 percent and the percentage of unshelled pods.

$$\text{Shelling Efficiency (SE)} = \frac{\text{Total wieght of shelled peanut}}{\text{Total weight of peanut before shelling}} \times 100\% \quad \text{............... (3.4)}$$

Or

$$\text{Shelling Efficiency (SE)} = 100 - \text{percent of unshelled seed} \quad \text{......................... (3.5)}$$

(iv) **Output Capacity:** This is the quantity of the seed shelled relative to the time spent. It is expressed as;

$$\text{Output Capacity} = \frac{\text{Quantity of the shelled seed}}{\text{Timet taken}} \times 100\% \quad \text{......................... (3.6)}$$

CHAPTER FOUR

4.0. RESULTS AND DISCUSSION

4.1. Presentation of Results

The three peanut shelling methods; machine, mortar pestle and Hand (finder tips) shelling are investigated in relation to some physical quality attributes. The results one the effect of the shelling methods as they affect the quality attributes are presented as follows; in tables 4.1 – 4.5

Table 4.1: Average Percent Total Seed Yield for Various Shelling Methods and Peanut Varieties

Shelling Method	Total Yield for various Varieties (percent)			Time (Sec)
	V_1	V_2	V_3	
M_1	63	67	66	40
M_2	51	58	54	180
M_3	68	71	69	1,200

Table 4.2: Average Percent Whole Seeds for various Shelling Methods and Peanut Varieties

Shelling Method	Whole Seed Yield for various Varieties (percent)		
	V_1	V_2	V_3
M_1	63	76	74
M_2	60	74	71
M_3	98	99	98

Table 4.3: Average Percent Broken Seeds for Various Shelling Methods and Peanut Varieties

Shelling Method	Broken Seed for Various Verities		
	V_1	V_2	V_3
M_1	37	24	26
M_2	40	25	29
M_3	2	1	2

Table 4.4: Efficiency of Various Shelling Method on Varieties

Shelling Method	Shelled Peanut for various Peanut Varieties (percent)		
	V_1	V_2	V_3
M_1	86	100	96
M_2	73	77	77
M_3	98	99	98

Table 4.5: Average Percent Capacity Utilization for Various Shelling Methods and Peanut Variety

Shelling Method	Capacity Utilization for Various Varieties (kg/hr)		
	V_1	V_2	V_3
M_1	56.7	60.03	59.4
M_2	10.2	11.6	10.8
M_3	2.04	2.13	2.07

4.2. Discussion of Results

4.2.1. Total Seed Yield

The effect of shelling method on total yield of peanut is presented in Appendix I and table 4.1. The highest percent total seed yield of 71 percent is observed with the manual method for varieties SAMNUT 10 (V_2) while the mortar/pestle method recorded the least total yield of 51 percent for variety SAMNUT 22 (V_1). The hand method seem to have the highest value as present in Fig 4.1 because almost no seed lost was recorded because of low absence of damages, unlike that of mortar/pestle method where a lot of losses were observed when winnowed as a result of direct heavy impact force of the pestle on the pods of seeds. Table 4.1 shows the Average Percent Total Seed Yield for Various Shelling Methods and Peanut Varieties.

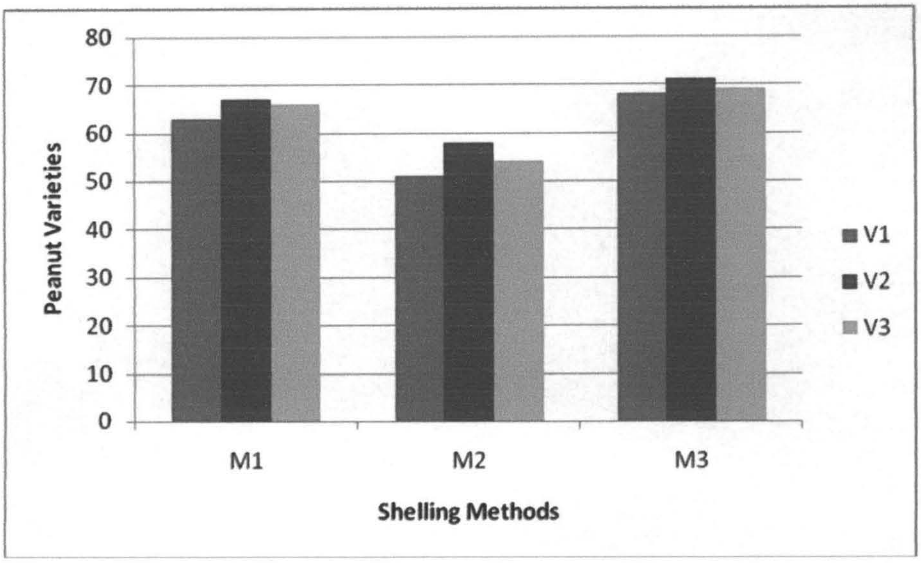

Fig. 4.1: Total Seed Yield for various shelling methods of Peanut

4.2.2. **Whole Seed Yield**

Whole seed yield were greatly dependent on shelling method as shown in fig 4.2. the manual method has the highest whole seed yield of 99 percent for variety SAMNUT 10 (V_2) while the lowest whole seed yield of 60 percent was obtained from the mortal/pestle method. The machine method has relatively higher whole seed yield than the mortar/pestle method as seen in the figure. The lower whole seed yield were recorded, the mortar/pestle and machine method had the loses whole seed yield probably as a result of the impact forces applied in the seed during the shelling processes. Though sufficient pressure is exerted in the pods using the hand method it was not high enough to effect breakages, therefore the hand method had the highest whole seed yield. Table 4.2 shows the Average Percent Whole Seeds for various Shelling Methods and Peanut Varieties.

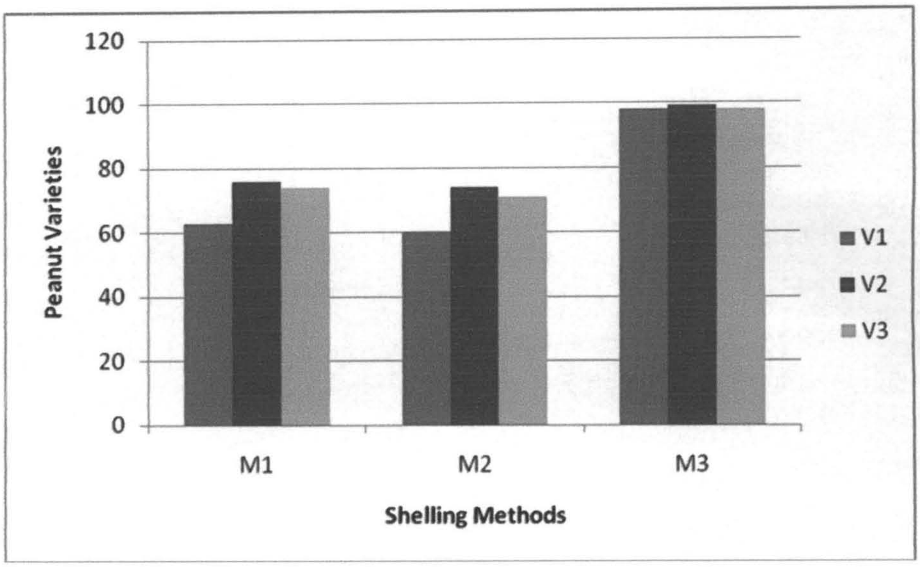

Fig. 4.2: Whole Seed Yield for various shelling Methods

4.2.3. Broken Seed Yield

The result in Appendix 3 shows how broken yield of peanut were affected by different methods of shelling, broken seeds were higher in mortar/pestle method and machine methods for all the varieties. The hand method of shelling has the least broken yield of 1 – 2 percent as shown in Fig. 4.3. This may be as a result of the forces applied in the pods with both the machine and mortar/pestle method had direct impact effect on the seed and pos resulting in high damages and breakages while the force applied with the hand method is easily controlled such that minimal effect force is exerted on the seed thereby yield less breakages. Table 4.3 shows the Average Percent Broken Seeds for Various Shelling Methods and Peanut Varieties.

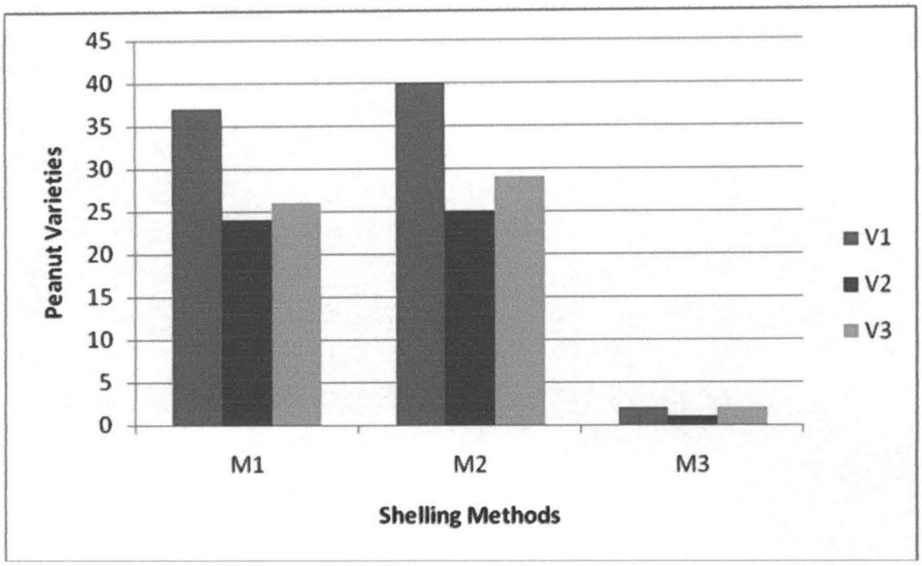

Fig. 4.3: Broken Seed Yield

4.2.4. **Shelling Efficiencies**

The shelling efficiencies of the various methods were found to vary significantly as presented in table 4.5, shelling efficiencies were high for hand and machine method, for all the varieties. The hand method had 100 percent shelling efficiencies while that of machine method had 86 – 100 percent depending on the varieties. The least efficiency of 73 percent was recorded for mortar/pestle method. This is as a result of the fact that in the hand method of shelling all seeds are carefully shelled are after the other while for the mortar/pestle method, and attempt to shell all the pods by the extension of beating process was resulting to higher breakages thus further beating of the pod has to stop at an optimum level. Similarly for the machine some unshelled pods pass through the screen were observed. Table 4.4 shows the Efficiency of Various Shelling Method on Varieties.

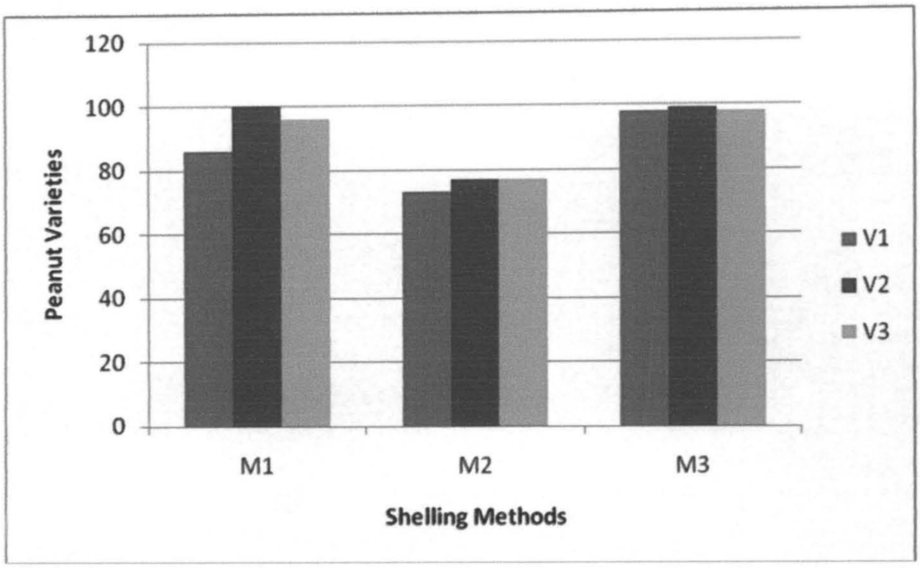

Fig. 4.4: Shelling Efficiency

4.2.5. **Output Capacity**

As seen in table 4.6, the output capacity is highest for the machine method. It recorded about 57 to 60kg/hr while the hand method had the least output-capacity of about 21g/hr for all the varieties. The mortar/pestle method had moderately higher value of about 10-12kg/hr. Table 4.5 shows the Average Percent Capacity Utilization for Various Shelling Methods and Peanut Variety.

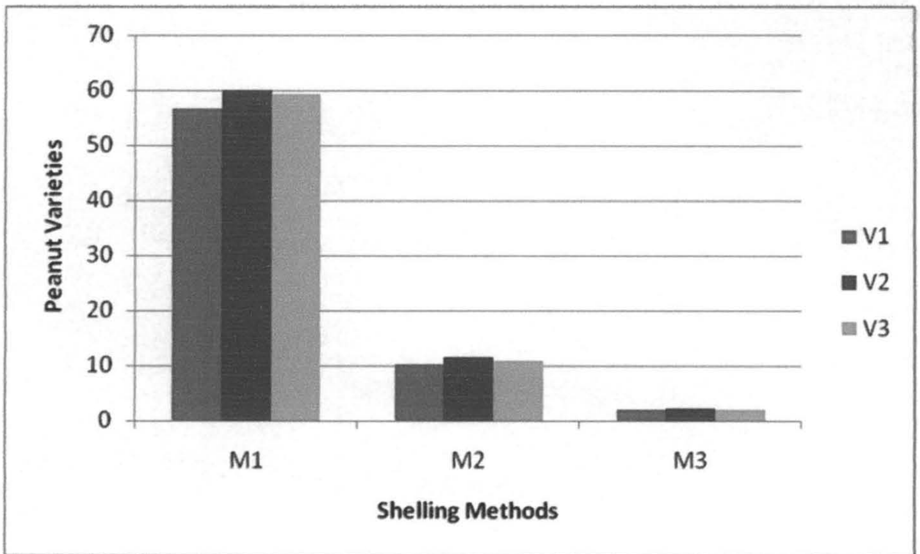

Fig. 4.5: Output Capacity

CHAPTER FIVE

5.0. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The study on the evaluation of different peanut shelling method using three varieties is included as follows;

The machine shelling saves time, cost and energy as compared with mortar/pestle and hand method of shelling, peanut shelling machine can shell 25kg of peanut for ₦60 for 17 minutes (0.28 hrs) and it can shell 60kg/hr of peanut. Hand shelling cost ₦162 for 480 minutes (8 hrs) of 25kg of peanut.

The Total Seed yield was highly affected by shelling methods. The hand method has the highest seed yield of 99 percent. Because the total seed input was recovered with hand shelling while some were lost during the shelling with both machine and mortar/pestle method.

The whole seed yield was also higher for hand method of shelling while the least whole seed yield was recorded for mortar/pestle method of 51 percent this was because in hand method of shelling there was minimum breakage of the seed.

The Mortar/pestle method had higher broken seed yield compared to the machine and hand method that had relatively lower broken broken seed yield of 24 percent and 1 percent respectively.

Peanut variety (SAMNUT 10) V_2 has the least broken seed yield of 1 percent and higher percent whole seed yield of 99 percent and total seed yield 71 percent.

5.2. Recommendations

From this study, it is recommended that machine method of shelling peanut is more appropriate in situation where peanut is being used as industrial raw materials such as oils and cake production, confectionaries etc. This is because of it high output capacity.

It is also recommended that combine harvester should be implored in the case of mass production. This is because of the high output capacity associated with this method. Combine harvester do harvesting, shelling, cleaning and grading at the same time, this saves time cost and energy. However the seeds need to be properly dried for safe storage in other to avoid microbial attack on the bruised/damaged seeds if the seeds are not immediately utilized. This is because the microbial attack on the seed can cause aflatoxin contamination.

Hand method of shelling is recommended for seeds that are supposed to be used for planting because it records minimal or no broken/bruised seeds. This is because broken or bruised seeds which are associated with the other two methods, machine, mortar/pestle would not germinate properly when planted.

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Appendix I

Total Seed Yield for Various Shelling Methods and Peanut Varieties

Shelling Methods	Total Yield for Peanut Varieties (kg)		
	V_1	V_2	V_3
M1	0.6,0.65, 0.65	0.65, 0.69, 0.68	0.65, 0.66, 0.68
M2	0.5, 0.54, 0.5	0.58, 0.55, 0.6	0.5, 0.54, 0.58
M3	0.7, 0.68, 0.68	0.71, 0.70, 0.72	0.7, 0.68, 0.70

Appendix II

Whole Seed Yield for Various Shelling Methods and Peanut Varieties

Shelling Methods	Whole Seed for Peanut Verities (kg)		
	V_1	V_2	V_3
M1	0.4, 0.4, 0.35	0.50, 0.53, 0.35	0.45, 0.5, 0.45
M2	0.3, 0.35, 0.3	0.45, 0.4, 0.45	0.4, 0.41, 0.4
M3	0.7, 0.66, 0.65	0.7, 0.69, 0.7	0.7, 0.65, 0.68

Appendix III

Broken Seeds for Various Shelling Methods and Peanut Varieties

Shelling Methods	Broken Seeds for Peanut Varieties (Kg)		
	V_1	V_2	V_3
M1	0.2, 0.25, 0.3	0.15, 0.16, 0.18	0.2, 0.16, 0.3
M2	0.2, 0.19, 0.2	0.13, 0.15, 0.15	0.1, 0.13, 0.18
M3	0.0, 0.02, 0.03	.01, 0.01, 0.01	0.0, 0.03, 0.02

Appendix IV

Total Shelled Peanut For Various Methods of Shelling

Shelling Methods	**Broken Seeds for Peanut Varieties (Kg)**		
	V_1	V_2	V_3
M1	0.9, 0.9, 0.8	1.0, 1.0, 1.0	1.0, 1.0, 0.9
M2	0.7, 0.7, 0.8	0.8, 0.8, 0.7	0.7, 0.8, 0.8
M3	1.0, 1.0, 1.0	1.0, 1.0, 1.0	1.0, 1.0, 1.0

Appendix V

Total Unshelled Peanut for Various Methods of Shelling

Shelling Methods	**Broken Seeds for Peanut Varieties (Kg)**		
	V_1	V_2	V_3
M1	0.1, 0.1, 0.2	0.0, 0.0, 0.0	0.0, 0.0, 0.1
M2	0.3, 0.3, 0.2	0.2, 0.2, 0.3	0.3, 0.2, 0.2
M3	0.0, 0.0, 0.0	0.0, 0.0, 0.0	0.0, 0.0, 0.0