E-ISSN: 1116 - 3240 P-ISSN: 3026-9334
MPRI-JAIMR | INTERNATIONAL JOURNAL OF AFRICAN INNOVATION & MULTIDSCIPLINARY RES.
VOL. 04 NO. 2 – APRIL, 2024

# EFFECT OF GROWING AND STORAGE CONDITIONS OF CASHEW NUTS IN OKE OGUN AREA OF OYO STATE, NIGERIA

**ADEDOJA, SULAIMAN ADEWALE [1], RAHAMAN, ALIYU[2], AYANDELE, AYANBUKOLA OLUWASEUN[3] & MUIDEEN, RAHEEM ADEOLA[4]**

[1]Department of Science Laboratory Technology, School of Science, The Oke-Ogun Polytechnic, Saki. P.M.B. 21, Saki Oyo State. Nigeria. [2]Department of Mathematics & Statistics, School of Science, The Oke-Ogun Polytechnic, Saki. P.M.B. 21, Saki Oyo State. Nigeria. [3]Department of Agricultural Technology, School of Agricultural and Natural Resources, The Oke-Ogun Polytechnic, Saki. P.M.B. 21, Saki Oyo State. Nigeria. [4]Department of Agricultural and Bio-Environmental Engineering, School of Engineering, The Oke-Ogun Polytechnic, Saki. P.M.B. 21, Saki Oyo State. Nigeria.
*rahamanaliyutops@gmail.com*

## Abstract

The effect of growing and storage condition of cashew nuts need to be studied because Cashew nuts is a good source of protein, fiber, healthy fats and globally consumed. Technical investigation on the study condition of cashew nuts in Oke-Ogun area of Oyo State, Nigeria was carried out by means of distributing 300 questionnaires during field trip to the respondents. The main aim of this paper is to investigate the challenges facing people in Oke-Ogun are facing while storing the cashew nuts. The paper used primary data and the responses from the target population were run and analyzed using a Statistical software called Statistical Package for Social Sciences (SPSS), version 21. The adopted statistical methodology were Descriptive Statistics and Pearson Chi-Square Test. Most of the respondents participated in this survey averagely produced between 7 kg and 11 kg yield of cashew nuts per year. People in Oke-Ogun area of Oyo State preferred using sealed jar container to store their cashew nuts. Also, the target population preferred

**Keywords:** Cashew Nuts, Storage Condition, Oke-Ogun, Anacardium occidentale L, Pearson's Chi-Square Test.



EDITOR-IN-CHIEF
Prof. A.I. Mteiye [MALAWI]

using 24.9 $^{oc}$ and 24 $^{oc}$ as the average temperature and humidity for storing cashew nuts. The paper revealed that people in Oke-Ogun area preferred using 2 years to store their cashew nuts. The Pearson's chi-square test was used to investigate this issue and the results showed that: People in Oke Ogun area of Oyo State are really facing challenges with the storage of their cashew and they do normally experienced pests/diseases problems with their cashew nuts. There was a specific standards that people in Oke-Ogun area of Oyo State must follow when growing and storing their cashew.

## Introduction

### Background of the study

Cashew nuts is one of the most important edible nuts in the international trade, is the fruit of cashew tree (*Anacardium occidentale L.)* and is kernel is the most widely industrialized cashew product (Pinto *et al.,* 2014, Soares *et al.,* 2012).The real fruit is the cashew is commonly a nut , composed of kern and pericap or shell. The kernel is slightly curved back on itself and form two cotyledons, representing about 20-25% of the nut weight .It is wrapped in a thin and hard removing peel, which is about 5% of the whole nut (Ogunwolu *et al.,* 2009). Cashew nuts are globally consumed for their desirable nutritional and sensory attributes, being good source of protein ( 20%), carbohydrate ( 28%) and fat (45%) (Das *et al.,* 2014). The cashew tree, native to Brazil, was introduced to Mozambique and then India in the sixteenth century by the Portuguese, as a means of controlling coastal erosion. The cashew fruit is unusual in comparison with other tree nuts since the nut is outside the fruit. The cashew apple is an edible false fruit, attached to the externally born nut by a stem. In its raw state, the shell of the nut is leathery, not brittle. It contains the thick vesicant oil, Cashew nut shell liquid (CNSL), within a sponge-like interior. A thin test a skin surrounds the kernel and keeps it separated from the inside of the shell. The primary products of cashew nuts are the kernels which have value as confectionery nuts. CNSL is an important industrial raw material for resin manufacture and the shells can be burned to provide heat for the decorticating operation (Enwelu *et al.,* 2014).

The harvesting and processing of cashew is very labour intensive. After producing clusters of flowers, cashews produce the edible apple and also a nut encased in a heavy shell, which is the true cashew fruit. The cashew tree flowers for two or three months and fruit mature about two months after the bloom. When fully ripe, it falls to the ground. Harvesting generally involves collecting the nuts, as shown in figure 1 once they have dropped to the ground after maturing. Workers scour the area and detach the nut from the fruit. If fruit are picked from the trees, the cashew apple will be ripe, but the kernel will still be immature (Wikipedia, 2015).



***Figure 1:*** ***Matured harvested cashew nut (Salunkhe and Desai 2014).***

Cashews are more prone to become rancid due to fat degradation and protein coagulation. Nagaraja (2012) reported that any bruise makes the fats liable to become rancid, and as such the integrity of kernels is lost. Environmental factors like temperature, moisture, light, gaseous composition, pressure within the storage atmosphere influence changes in lipid, protein and carbohydrate content of stored seeds. The primary product formed by oxidation of oil is a peroxide or hydro-peroxide and are measured as a peroxide value. The secondary products are aldehydes and ketones. These secondary oxidation products, especially aldehydes, have the off-flavors associated with rancid oils Improper post-harvest handling and storage of nuts, such as high moisture, temperature and insect or mechanical damage can influence the incidence of the fungus that produces toxins like afflatoxin and deterioration of kernel nutrients and rancidity can be occurred (Salunkhe and Desai 2014).

Traditional method of sun drying and storage has been followed in cashew processing industries for RCN storage. Storage life of cashew kernels can be increased up to 2months by using 50ppm (0.005%) of BHA applications (Sabna *et al.,* 2011). Shelf life determination can be carried out in the laboratory by assessing the quality of the cashew nuts when stored under specific storage condition and no scientific studies has been conducted so far to determine the shelf life of RCN. Hence the present study is aimed to assess the effect of humidity and temperature on physical and chemical changes in raw cashew nuts during storage and to recommend suitable conditions for storage of raw cashew nuts.

**Statement of the Problem**

Improper post-harvest handling and storage of nuts, such as high moisture due to improper drying, temperature and insect or mechanical damage can influence the incidence of fungus that produces toxins like aflatoxin and deterioration of kernel nutrients and rancidity can occur (Adeigbe *et al.,* 2015). This research was carried out to provide solution to the packaging problems of both the nuts and the kernels with the view to achieving better post-harvest management of cashew. Therefore, this study was conducted to assess the effect of different storage condition, packaging methods on the shelf life of cashew nuts.

**Scope and Limitation of the Study**

The scope of this research solely lies on investigation of the effect of temperature, humidity and time interval of storage on the nutritional value and taste of cashew nuts. This research was limited to the age of cashew nuts, which may have affected their nutritional value and taste and the variety of cashew nuts used which may not be representative of all types of cashew nuts.

**Aim and Objectives of the Study**

The main aim of this research work is to determine how the storage condition affect cashew nuts in Oke-Ogun area of Oyo state and the specific objectives are to:

1. determine how long the people in Oke-Ogun area of Oyo State are have been in growing cashew nuts.
2. know the average yield of cashew nuts per individual/people in Oke-Ogun area of Oyo State per year.
3. determine best storage condition for maintaining the quality of cashew nuts in Oke-Ogun area of Oyo State
4. determine the average temperature and humidity in the storage area in Oke-Ogun area of Oyo State.
5. measure the average length of time that people in Oke-Ogun area of Oyo State store their cashew nuts.
6. identify the challenges facing the people in Oke-Ogun area of Oyo State when storing their cashew nuts.
7. determine the specific regulations or standards that people in Oke-Ogun area of Oyo State must follow when growing and storing their cashew nuts.

**Research Questions**

1. How long the people in Oke-Ogun area of Oyo State are have been in growing cashew nuts?

2. What is the average yield of cashew nuts per individual/people in Oke-Ogun area of Oyo State per year?
3. What storage methods do the people in Oke-Ogun area of Oyo State currently use for your cashew nuts?
4. What type of containers do the people in Oke-Ogun area of Oyo State use for storing cashew nuts?
5. What is the average temperature and humidity in the storage area of the people in Oke-Ogun area of Oyo State?
6. What is the average length of time that people in Oke-Ogun area of Oyo State store their cashew nuts?
7. Are the people in Oke-Ogun area of Oyo State facing any challenges with their storage of cashew nuts?
8. Have the people in Oke-Ogun area of Oyo State experienced any pest or diseases problems with your cashew nuts?
9. Is there any specific regulations or standards that people in Oke-Ogun area of Oyo State must follow when growing and storing their cashew nuts?

**Research Hypotheses/Test of the Hypotheses on the effect of Storage Condition of Cashew Nuts in Oke-Ogun, Area of Oyo State**

$H_{o1}$: People in Oke Ogun area of Oyo State are not facing any challenges with the storage of cashew nuts.

$H_{o2}$: People in Oke Ogun area of Oyo State does not experienced any pests or diseases problems with their cashew nuts.

$H_{o3}$: There is no specific regulations or standards that people in Oke-Ogun area of Oyo State must follow when growing and storing their cashew nuts.

**Justification of the Study**

The cashew nuts are usually separate from cashew fruit before storage. This will help to determine the effect of the storage condition of cashew nuts.

**Literature Review**

Because of its excellent nutritional characteristics and technologies involved in the processing, the cashew high value added products being marketed as a whole almonds, designed especially for the foreign market augmented and broken used in the internal market industries of ice cream,cake and chocolate market industries of ice cream, cakes and chocolates (Kross, 2008). It is an important delicacy which is mainly used in confectionery and as a dessert nuts, such as cakes, pastries, candies and chocolate by enriching their taste and appearance (Ogunwolu and Akinwale 2013). Cashew nut is also

vulnerable to deterioration over time and this result goes from improper packaging to advance storage conditions. The rate of spoilage depend on the moisture content of the stored nut relative humidity of the storage environment, permeability of packaging material, room temperature and insect infestation. According to Irtwange and Oshodi (2019), roasted cashew nuts deteriorate mainly by mould growth, rancidity and insects attack.

Taking into account the damage arising from this reaction the use of packaging to minimize permeability to oxygen and moisture are viable alternatives to minimize the reaction during storage period, thereby ensuring a longer shelf time. The packaging materials used must be appropriate and specific to comply with the food preservation criteria and nutrients; as well as avoiding the action of environmental factors such as light, moisture oxygen and microorganism preventing or hindering this contracts between the external environment and product inside. Furthermore the packaging and assured the integrity of food during transport and storage (Sarantopoulos *et al.,* 2012). The main factors that determine the shelf life of processed food are; type of food ,the degree of destruction during processing and packaging, barrier properties of packaging materials and the temperature during the processes and distribution/transportation package (Adebayo and Diyaolu 2013).

In Tanzania, Naliendale which is one of 17 Agricultural Institute (TARi) is the only Centre with the mandate to produce cashew seeds to farmers inside and outside the country. The Centre distribute seeds of the current season and demand vary between years. In some cases seeds of the previous season can remain when the demand are low. However, the Centre does not distribute seeds of the previous years following high demands with the supposition that their germination could be poor .This the aim of this was to find out the effect of storage condition of cashew nuts on germination and the performance of cashew seedling (Bulterj *et al.,* 2012).

**Description of Fruit**

The nut is attached to the lower portion of the cashew apple which is conically shaped .The cashew nuts (seed) hangs at the bottom of the apple, and is C shaped. The cashew seeds has within the outside shell the edible kernel or nut in it raw from the cashew kernel is soft, white and meaty. When roasted it changes color and taste .Cashew apple and cashew nuts excellent sources of nutrition .The cashew nuts contain five time more vitamin C than an orange and contain more calcium, iron and vitamin B than other fruit such as citrus, avocados and bananas. Cashew nuts shell oil (CNSL) extraction from the shell is caustic and causes burns on the skins. The mucous membrane of the mouth and throat are severely affected when it come into contact with shell oil or the irritating fumes emitted during roasting.


EDITOR-IN-CHIEF
Prof. A.I. Mteiye [MALAWI]



*Figure 2: Cashew fruits (Bulterj et al., 2012).*

**Cashew Trees, Kernels and by-Product**

The cashew industry is based on and focused on the production of cashew kernels. However, the cashew value chain contains a number of by-product that have the potential to add value to and diversity revenue from cashew production.

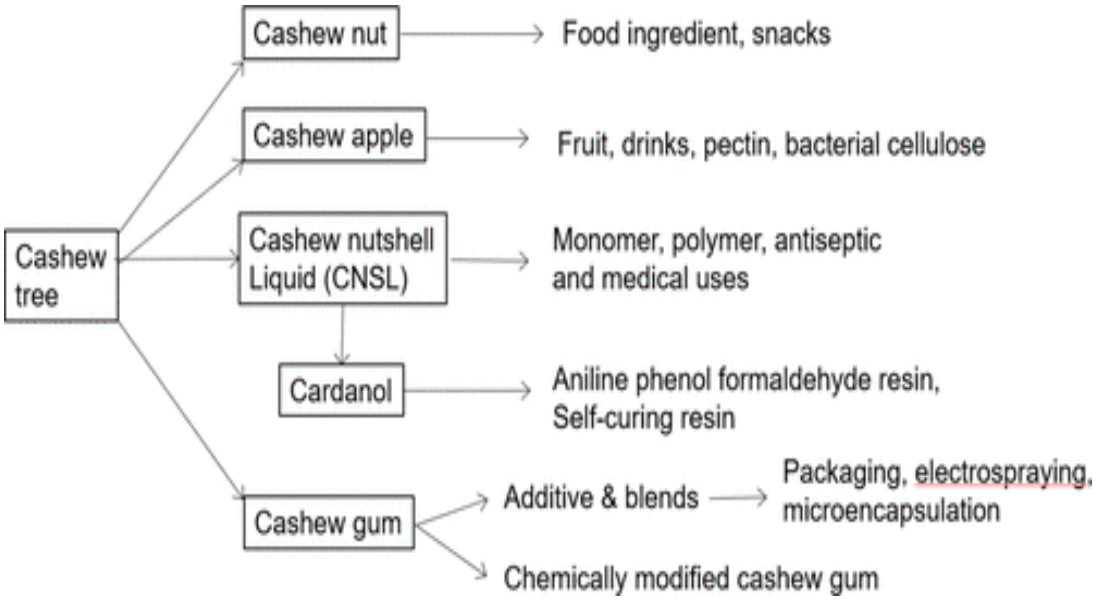


*Figure 3: The flow diagram of cashew tree products*

**Source: UNCTAD 2014**



**EDITOR-IN-CHIEF**
**Prof. A.I. Mteiye [MALAWI]**




*Figure 4: Cashew Nut Product.*
**Source: UNCTAD**

**Cashew Trees:** Cashew are found in different climatic regions between the 27th parallel north and 28th parallel south ,but the bulk of commercial plantation take place between the 15th parallel north and 15 parallel south. Cashew trees thrive in moist tropical climates and not tolerate frost. An average monthly temperature of 26-28 degree is optimal for cashew tree growth (Paul and Duarte 2011). In addition to the natural soil and climatic conditions cashew growth and yield are also linked to plantation management. For instance, water and soil conservation appropriate fertilizer use and supplementary irrigation have been shown to have the potential to improve yield (Prabhakaran Nair, 2010).

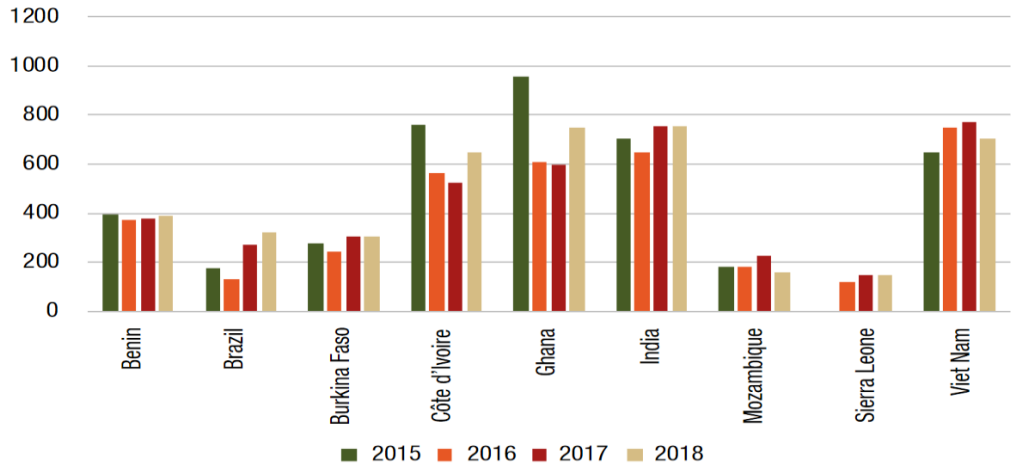


*Figure 5: Raw cashew nut yields, selected countries*
**Source:** UNCTAD calculations based on data from the Brazlan Institute of Geography and Statistics the Competitive Cashew



**EDITOR-IN-CHIEF**
**Prof. A.I. Mteiye [MALAWI]**

Due to the factors highlighted above, cashew yields vary greatly between and within countries and fluctuate from season to season. Figure 5 shows the average yields of new cashew producers in different regions in the period 2015-2018. It should be noted that these average yield figures can mask large disparities between different areas within these countries. The large disparities and fluctuations in cashew yields are partially due to differences in soil and climatic conditions that cannot be controlled by farmers. However, strengthen farm management practices and improving the genotypical composition of cashew orchards can contribute to higher and more stable cashew yields (Dadze *et al.,* 2014; Mangalassery *et al.,* 2019; Nayak *et al.,* 2018). In this context, the low average yields in many cashew growing countries including in many countries in Africa, point to a significant potential to boost productivity and increase revenues for cashew farmers.

**Cashew Kernels:** Cashew kernels represent the main product of the cashew industry. They are consumed in various forms, including as a salty or sweet snack or an ingredient in desserts and savory dishes, or are further processed as cashew butter or as an ingredient in a variety of spreads sauces bars and drinks. In addition cashew oil can be extracted from cashew kernels.

**Shelling:** A number of processing steps must be undertaken to extract the kernel from raw cashew nuts (RCN). In the first step, RCN are exposed to thermal treatment in order to make the outer shells brittle. The three man methods are steaming, roasting and immersing RCN are shelled, that is, the kernels are separated from the outer shells. This process can be done manually, mechanically or in a fully automated manner. The next step involves drying the kernel, followed by peeling off the testa. The testa and cashew shell are by-products of the cashew-processing industry and can be further processed to generate numerous products. Cashew kernels are often sold in bulk and typically undergo secondary processing, including roasting, frying and the addition of salt, sugar or flavoring, and may also be mixed with other nuts before being packaged for retail sale.

**Grading Raw Cashew Nuts:** The quality and therefore the price of RCN depends on several factors that are typically determined through a sampling process. A key quality indicator for RCN is their kernel out turn ratio, which is the weight in pounds of usable kernels per 80 kg of RCN. A higher kernel outturn ratio yields a higher price since it means that more kernels can be extracted from RCN. Another indicator for assessing the value of RCN is the nut count, which measures RCN/kg. A smaller nut count corresponds to larger kernels which generally yield a higher price. Furthermore the defective rate is an important indicator of RCN quality; it measures the share of nuts that are not useable for various reasons, such as missing, stunted or moth-eaten kernels. Sampling also includes the measurement of the moisture content of RCN using a moisture meter the moisture content should not exceed 9 per cent to limit degradation during storage. Other indicators that determine the value of RCN are the share of foreign matter and the float

rate, that is the share of RCN that float in water, with a lower float rate corresponding to a higher quality.

**Grading Cashew Kernels:** There is a spectrum of cashew kernel qualities. The United Nations Economic Commission for Europe (2013) standards for the commercial quality of cashew kernels provide a system to categorize unprocessed kernels. The standards include a number of general quality requirements for commercial kernels such as a maximum moisture content of 5 per cent. They also define characteristics to enable the categorization of cashew kernels into the three main quality cases of extra, class I and class. Whose nuts are further classified into seven categories ranging from 150 to 500 according to the maximum number of kernels per pound. Broken nuts are classified according to the sizes of the pieces, ranging from large (not passing through a sieve with an aperture of 4.75 mm) to baby bits or granules (not passing through a sieve with an aperture of 1.70 mm). In addition to the United Nations Economic Commission for Europe standards, there are other quality classification systems for cashew kernels. These include the industry standards of the Association of Food industries, which apply to the United States market, as well as standards developed by kernel exporting countries, including Brazil and India. These systems generally also grade the quality of cashew kernels based on color and size and whether the kernels are whole or broken.

**Cashew By-products: Cashew Nut Shell Liquid**

The cashew nuts shell contain a viscous and dark liquid known as cashew it's shell liquid (CNSL), which is extremely caustic .it is contained in the thin honey comb structure between the soft outer skin of the nut and the harder inner shell .The CNSL Content of raw nut varies between 20 and 25 percent. Cashew nut shell liquid (CNSL) is an important and versatile industrial raw material (Cashew, 2019) and mainly composed anacardic acid, carclol and cardanol (Kumar *et al.,* 2009). CNSL based polymer have numerous desirable properties such as low fade characteristics, water repellence, wear and electrical resistance , solubility in common organic solvents, compatibility with many other polymers and antimicrobial activity, which make the suitable raw material for range of industrial, chemical and pharmaceutical application ( Telescrea *et al.,* 2014).

CNSL is also used in plant and coating industries in which it is potential substitute for petroleum-based raw material (Balgude and Sabrils 2014). Furthermore the potential use of CNSL as a biofuel or additive to biofuel has been demonstrated (Sanjeeva *et al.,* 2014). In addition, CNSL has a range of applications materials. Finally research has shown the potential of CNSL as a component of non -toxigenic insecticide (Vani *et al.,* 2018). The biggest producers of CNSL are Brazil, India and Viet Nam. There is also some degree of commercialization of CNSL in many countries that process cashew nuts, including Benin, Burkina Faso, Côte d'vore, Ghana, Indonesia and Mozambique

**Cashew Shell cake:** Cashew shell cake is the de-oiled cashew shell and thus a by-product of CNSL production. It can be used as a raw material for several products. In particular, shell cake can be carbonized and mixed with a binder to produce briquettes that can be used to fire industrial boilers (Sawadogo *et al.,* 2018).

**Cashew Apple:** The cashew apple is often referred to as the false fruit or pseudo fruit of the cashew tree. Botanically, the cashew apple is a swollen stalk, which carries the true fruit of the cashew tree: the cashew nut. Since the ripe cashew apple starts to ferment and degrade quickly after falling from the tree, it is often discarded during the cashew nut harvest. However the cashew apple is rich in vitamin C and antioxidants and can be used to produce a range of food products, including pectin and juices, alcoholic beverages, vinegars, syrups and jams. In addition to these products, the fibrous residues of the cashew apple juice-making process can be further processed to produce animal feed (Gomes *et al.,* 2018).In Brazil, the majority of harvested cashew apples are processed into cashew apple juice, which is widely consumed domestically and also exported Cashew apples are also sold as fresh fruit or processed into candy and cajuina, a clarified juice. In India a small share of cashew apples is used to produce juices candies, jams, pickles and chutneys .An alcoholic beverage known as feni is also made from cashew apples in Goa. In 2014, the Pepsi Company announced plans to add cashew apple juice to fruit juice blends for the market in India (Strom, 2014), which could increase the share of utilized cashew apples Cashew apples.

**Cashew Testa:** The cashew testa or husk is the thin skin covering the kernel. It contains a high concentration of tannins and can be used to produce tanning agents for the leather industry. There has also been research on the potential of the use of testa as animal feed (Fang *et al.,* 2018).

**Cashew Gum:** Cashew gum, also known as Anacardium gum is an exudate from the bark of the cashew tree. It can be harvested from natural exudate or after tapping, that is, incision of the trunk or branch. Cashew gum is a complex polysaccharide that has a range of industrial applications, including in pharmaceuticals and the food industry (Kumar *et al.,* 2012). For instance, it can be used as a pharmaceutical excipient in drug delivery systems (Ribeiro *et al.,* 2016). Research has also shown the potential of cashew gum as an encapsuating agent, clarifying agent and emulsifying agent in the food and beverages industry (Porto and Cristianini, 2014).

This section has highlighted that there are several by-products in the cashew kernel value chain that have the potential to contribute to diversification of the cashew-related economy and to value addition in communities involved in cashew production and/or Processing. Overall, value addition to and utilization of cashew by-products remains low, except for in Brazil and India, which have actively promoted the development of cashew by-product industries.



**EDITOR-IN-CHIEF**
**Prof. A.I. Mteiye [MALAWI]**

**Economic Importance and Production**

Cashew tree (*Anacardium occidentale*) it is an important nuts crop that provide food, employment and hard currency to many in developing Nation (Rosengarteen 2018). Cashew nuts are high value edible nuts and are usually dried immediately after harvesting to avoid adverse changes due to metabolic processes as well as microbial deterioration. About 47% of total weight of cashew nuts constitutes it's fat and has the right combination of fat the ratio of saturated is 1:2:1 which is ideal for human consumption (Achal, 2012). Africa produced more than half of the global cashew nuts output in the period of 2014-2018, with West Africa and East Africa accounting for average annual share of 42% and 10% of global RCN production, respectively. Asia accounted for an average share of 43% and Latin America and the Caribbean, for the remaining 5%.

**Cashew nut processing: Post Harvesting Handling**

The nut is encased in a rock hard shell that is virtually impossible to penetrate after harvest. In order to extract the nut, the whole shell is soaked in water, softened by steaming and carefully air-dried to the final moisture content (9 per cent). Each nut is hand massaged and cracked via a manual process that entails putting the nut against one sharp blade and bringing another blade, which is on a foot powered lever, through the outer shell. The blade on the foot lever is raised by an enthusiastic stomp allowing the outer shell to separate from the nut. The nut inside is carefully picked out of the outer shell using a nut pick. Cashew have served nutritional, medicinal and wartime needs more recently, they have been used in the manufacture of adhesive, resin and natural insecticides (Ogah, *et al* 2020). The cashew kernel is a rich sources of fat (46 per cent) and protein (18 per cent) and is a good source of calcium, phosphorus and iron. It has high percentage polyunsaturated fatty acid linoelic acid. The tarts apple is a source of vitamin C, calcium and iron. The bark, leaves, gum and Shell are all used in medicinal application. The leaves and bark are commonly used to relieve toothache and sore gums and boiled water extract of the leaf or bark is used as a mouth wash. A paste of background in water is used in tropical application for the cure ringworm in this form it can however act as an irritant and should not be applied to sensitive skin or children (India institute of food processing technology).

**Uses of Cashew Nuts**

Most cashew kernels are probably used in snacks, as roasted and salted nuts alone or in mixture with other nuts. In Bangor, raw cashew kernels are sold in several shops, mostly packed, sometimes as brand "Indian cashew kernels". No reference is made to grades, only broken kernels are sold as "splits". Chinese restaurants sell a variety of meals with cooked cashew kernels. Broken kernels are used in confectionery and sometimes as

substitute for almonds. Ground cashew kernels can replace peanut butter in exotic dishes. In Kenya cashew kernels are integrated in delicious chocolates. Most uses are, however, restricted by the relatively high price of cashew kernels, but a wide variety of local uses including soap making is reported from Mali (Traore, 2014). Recipes for cashew uses are given in each number of the Indian. The cashew nut kernel is constituted of three different portions namely the shell, the kernel and the adhering testa. The primary product of cashew nuts is the kernel, which is the edible portion of the nut and is consumed in three ways:

1. Directly by the consumer,
2. As roasted and salted nuts,
3. In confectionery and bakery products, for example, finely chopped kernels are used in the production of sweets, ice creams, cakes and chocolates, both at home and industrially and as paste to spread on bread.

The relative importance of these uses varies from year to year and country to country, but it is estimated that at least 60 percent of cashew kernels are consumed as salted nuts. Separately packed cashew nuts are a good selling line, mainly as an appetizer to cocktail drinks. Salted cashews are part of the snack food market. They compete mainly with other nuts, although chips, salted popcorn and other savoury snacks can impinge on the nut market. The price of cashew nuts is much higher than the price of peanuts or other snacks so those sales must be based on a strong taste preference by the consumer. Cashew nuts are generally considered a luxury product and an element of their appeal may lie in this status (Traore 2014).

**Table 1: Composition of Cashew Kernels**

| Author | Protein % | Fat% | Carbohydrate% |
|---|---|---|---|
| Franke (1976) | 21 | 47 | 24 |
| Ohler (1979) | 21 | 47 | 22 |
| Ohler (1979) | 21 | 44 | 29 |
| Nomisma (1994) | 22 | 25 | 27 |

**Storage of Cashew using different Packaging Methods**

Two hundred kilogram (200 kg) of dried RCN (10% ml) taken from 50kg each from across the state were thoroughly mixed and we're divided into two lots of 100 kg each. The first lot of 100 kg was processed into kernels while the remaining 100kg was used for raw cashew nuts (RCN) storage studies. Technical requirements for storage are dependent on weather conditions. As cashew nuts are usually produced in climates with a long dry season, simple buildings with concrete floors and walls and roofs of corrugated metal, should provide adequate storage. Certain prerequisites must be satisfied to ensure safe storage:


EDITOR-IN-CHIEF
Prof. A.I. Mteiye [MALAWI]

1. A waterproof, dry floor.
2. A firm and secure roof.
3. Openings in the wall must be protected in order prevent water from entering the room.
4. Headroom must be adequate to allow the bags in a stack to be moved around if large quantities are to be stored.
5. The store should be easily inspected: there must be sufficient clearance between the wall and the bags, to allow individuals to walk around and check the condition of the stack.
6. The stack must be placed on a raised wooden platform, in order to prevent moisture from being drawn from the floor to the nuts.

**Raw Cashew Nuts Drying and Storage**

Cashew nut are dried in the sun for two reasons:

1) To reduce the moisture content of the nut
2) To mature the seed in the infrared and ultraviolet Rays of sun.

Cashew Nuts should be kept for12 months or more, provided that they are dried to moisture content of cashew nuts at harvest is dependent on climatic conditions, moisture content of the soil on which the nuts are fallen, weed growth density under the tree and the time between nut fall and harvest. High moisture content may cause deterioration of the kernels due to bacterial attack or enzyme action. Drying the nut immediately after harvesting is essentially in preserving the quality but this process is often neglected (Sawadogo *et al.,* 2018). Sun drying of cashew nuts can be done on specially prepared drying floors or mats made of bamboo or palm leaves. The drying areas should be smooth and slightly sloping so as to allow rain water to run off. The Cashew nuts layer on the drying floor should not be thicker than 10cm, thus allowing for about 60kg oh nuts per square meter. The nuts should be constantly raked in water to ensure that they all receive the same benefits of sun's Ray's and therefore they are dried evenly.

Dried cashew should make a rattling when falling. Drying make take between one and three days depending upon local climatic conditions. As soon as the nuts are dry, they should be stored and protected from rain (Des *et al.,* 2014). The Raw Cashew Nuts (RCN) were stored using three different methods of packaging namely: jute bag (j) paper-lined-jute bag (paj) and paper-lined -carton (pac), Eighteen 4.0kg lots of RCN were packaged in each of the packaging materials (stated above) and arranged on the laboratory floor of the Nigeria stored product: Research institute on pallets. Destruction sample were taken once in two months for analysis.

**Cashew Kernel Storage**

Processed cashew kernel were stored using five different packaging methods namely : polythene (pt) polythene-lined -polypropylene (ptpr), paper -lined -polythene ( papt), polythene-lined - carton (ptc), paper-lined-carton (pac) 18packs of one (1)kg of the kernel packaged in each of the various packaged stated above were also stored on the laboratory bench of NSPPRI. Low guage polythene lined poly polypropylene (LGptpr) stored kernel served as the control .The same sampling procedure was done for the kernel storage as was done for RCN.

**Effect of Temperature and Humidity**

Studies have shown that temperature has a significant effect on the quality of cashew nuts during storage .For example, a study by the international institute of Tropical Agriculture found that exposure to high temperature (above 25 degrees Celsius) for even short periods, of time can cause significant losses in the quality of cashew nuts. The study also found that exposure to lower temperature (below 15 degree celcius) can help to maintain the quality of cashew nuts during storage. A study by the national Research institute for pulses, oil and special crops in India found that storage at low temperature (below 10degres celcius) significantly reduced the rate of oxidation and maintained the nutritional quality of cashew nuts. The studies also found that storage at high temperatures (above 25 degree Celsius) caused rapid decline in the quality of cashew nuts. The effect of humidity on the quality of cashew nuts have been studied extensively. Research has shown that high humidity level (above 75%) can cause the development of mold and spoilage in cashew nuts. On the other hand, low humidity level of 45-50% can help to maintain the quality not cashew nuts during storage.

**Effect of moisture content on cashew nuts.**

Influence of moisture content on the physical and chemical properties of cashew nuts during storage. (Nair and Singh 2017).The study found that moisture content had a significant effect on the sensory properties such as flavor and texture, of cashew nuts. The study also found that physical properties, such as weight loss and shrinkage of cashew nuts were also affected by moisture content. The effect of moisture content and storage temperature on physical and microbiological quality of cashew nuts (Sarma, 2014). The study found the moisture content and storage temperature had a significant effect on the physical and microbiological quality of cashew nuts. For example high moisture content and high storage temperature led to a rapid loss of quality, while low moisture content and low storage temperature maintained the quality of cashew nuts for a longer period of time. High moisture content during storage can lead to a loss of flavor in cashew nuts, due to degradation of volatile compound that contribute to flavor. This

can result in a bland or off flavor in cashew nut low moisture content during storage can help to preserve the flavor of cashew nuts, as it prevents the degradation of volatile compound (Amoah, 2014).

**Physical, Chemical and Biological Contaminant in Cashew Nuts**

The main sources of physical contamination in cashew nuts are dust, hair, insect and other foreign objects. Dust and hair can come from the harvesting and processing of the cashew nuts, while insect can come the storage facilities on the environment. There are several potential sources are soil, water and insects. Soil can contain a variety of microorganisms including bacteria, fungi and viruses. These microorganisms can be transferred to cashew nuts during harvesting or processing. Water can also contain microorganisms, which can also contaminant cashew nuts during washing or processing. Insect can also contain microorganisms, which can contaminate the nuts when they land on them or crawl on them (Dorsu 2017). Chemical contamination in cashew nuts. The main source are application of agricultural chemicals such as pesticides and herbicide and the use of process aids, such as fungicide and fumigants. Agricultural chemicals can be applied to the cashew trees or to the soil around the tree. During processing chemical can be added to the nuts to prevent Spoilage or enhance appearance. The chemical can then contaminate the cashew nuts. These are three (3) main types chemical contamination in cashew nuts: Residue, Migration and Interaction. Residue are chemical that remains on the surface of the nuts after processing. Migration is a transfer of chemical from packaging materials, such as plastic or paper, to the nuts. Interaction is the chemical reaction between the nuts and the environment, such as air or the storage container. Each of this types can pose a risk to human health (Adegoke 2012).

There are three (3) types of biological contamination in the cashew nuts, bacteria fungi and viruses. Bacteria can cause food borne illnesses such as salmonellosis and campylobacteriosis. Fungi can produce toxins, such as aflatoxin which can cause liver damage and even death. Viruses, such as hepatitis A, can also be transmitted through contaminated food. The presence of these microorganisms can make the cashew nuts unsafe to eat (Bhatia and Shankar 2016).

**Way to Prevent Biological Contamination in Cashew Nuts**

1) Proper hygiene practice. Such as washing hands and surfaces before handling the nuts.
2) Proper storage condition such as keeping the nuts at low temperature and a low humidity level.
3) Using processing aids, such as fumigants and fungicides, to kill or inhibit the growth of microorganisms.

4) Finally using irradiation or exposing the nuts to a controlled amount of radiation.

**Health Benefits of Cashew Nuts**

Cashew nuts are great source of several important nutrients and they have been linked to a number of potential health benefits. For example cashew nuts are good source of protein, fiber and healthy fats. They also high in several vitamins and minerals, including copper, manganese, magnesium and zinc. The research has suggested that eating cashew nuts may help to lower cholesterol, improve heart health and reduce the risk of chronic diseases found that cashew nuts are good source of antioxidants, which are important for protecting the body from oxidative stress and reducing the risk of chronic diseases (Samihah, et al 2016).

1) Cashew nuts are good source of protein, fiber and healthy fat.
2) Cashew nuts are high in several vitamins and minerals including copper, manganese, magnesium and zinc.
3) Cashew nuts may help to lower cholesterol and triglycerides level.
4) Cashew nuts may help to reduce the risk of cardiovascular disease.
5) Cashew nuts may have anti-cancer properties.
6) Cashew nuts may have anti-inflammatory properties.

**Side Effect of Cashew Nuts**

While cashew nuts are generally considered to be safe, there are a few potential side effect to be aware of:

1) Cashew nuts contain a compound called urushiol, which caused an allergic reaction in some people, this reaction can cause symptoms such as rash, hives, or itching.
2) Cashew nuts are high in fat, so eating too many of them can lead to weight gain.
3) Cashew nuts may interact with medication.
4) Cashew nuts should be consumed in moderation.

**How to Consumed Cashew Nut Moderate**

1) By paying attention to serving size.
2) A serving of cashew nuts is about 1ounce.
3) Include cashew nuts as part of balanced diet.
4) Choose unsalted or lightly salted cashew nuts.
5) Consider enjoying cashew nuts as a snack or adding them to dishes, such as stir-fries or salad.


EDITOR-IN-CHIEF
Prof. A.I. Mteiye [MALAWI]

**Research Methodology for the Study**

The source of data for this research work is primary source by administered 300 questionnaires to target population. The responses of those respondents were run and analyzed using a Statistical software called Statistical Package for Social Sciences (SPSS) i.e. IBM SPSS version 21. The adopted statistical distribution/methodology is Chi-Square distribution- (Pearson's Chi-Square test) and each research hypotheses were interpreted accordingly based on the probability value popularly known as P-value.

**The Chi-Square Distribution**

All of the inferential statistics we covered in the previous lectures are called parametric statistic. To use these statistics, we make some assumptions about the distributions they come from, such as they are normally distributed. With parametric statistics, we also deal with data for the variable that is at the interval or ratio level of measurement, i.e. test scores, physical measurements, etc. We shall now consider a widely used non-parametric test, Chi-square, which can use with data at the nominal level, that is, data that is classificatory. The symbol $\chi$ is the Greek letter "chi". The sampling distribution of $\chi^2$ is called $\chi^2$ – distribution. The chi-square distribution was first discovered by Helmert in 1876 and later independently by Karl Pearson in 1900.

**The Chi-Square Distribution:**

The chi-square $(\chi^2)$ distribution is obtained from the values of the ratio of the sample variance and population variance multiplied by the degrees of freedom, n. this occurs when the population is normally distributed with population variance, $\sigma^2$.

$$\chi^2=\frac{(n-1)s^2}{\sigma^2} = \frac{df \times s^2}{\sigma^2}.$$

**Properties of the Chi-Square Distribution:**

1. Chi-square is non-negative. It is the ratio of two non- negative values; therefore, it must be non- negative itself.
2. Chi-square is non- symmetric.
3. There are many different chi-square distributions, one for each degree of freedom.
4. The degree of freedom when working with a single population variance is n – 1.
5. For degrees of freedom greater or equal to 30, the curve approximates to the normal curve.
6. The mean of chi-square distribution is n and variance is 2n.

**Conditions for the Application of $\chi^2$– Test**

The following are the basic conditions for the applications of Chi-Square:

1. The sample must be randomly drawn from the population.
2. Data must be reported in raw frequencies **(not percentage or ratios)**.

3. Measured variables must be independent.
4. Values / categories on independent and dependent variables must be mutually exclusive and exhaustive.
5. Observed frequencies or values cannot be too small. It should contain at least 5 observations.

**The Chi-Square Test Statistic**

The chi-square statistic is used to compare the **observed frequency** of some observations with an **expected frequency**. The comparison of observed and expected frequencies is used to calculate the value of the chi-square statistic which in turn can be compared with the distribution of chi-square to make an inference about a statistical problem.

The symbol for chi-square and the formula / test statistic are as follows:

$$\chi^2_{cal} = \sum \frac{(0-E)^2}{E}$$

Or

$$\chi^2_{cal} = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{(O_{ij}-E_{ij})^2}{E_{ij}}$$

Where:

O = the observed frequency

$O_{ij}$ = the observed frequency in the ith row and jth column.

E = the expected frequency.

$E_{ij}$ = the expected frequency in the ith row and jth column.

**Remarks:**

(i) $E = E_{ij} = \frac{Row\ Total \times Colomn\ Total}{Grand\ Total} = \frac{R_i \times C_j}{n}$

Where:

R = Row and

C = Column.

(ii) The degrees of freedom for the one dimensional chi-square statistic is **df = n-1**. Where **n** is the number of categories or levels of independent variable.

(iii) In case of using contingency table, the degrees of freedom become
df= (r-1) (c -1)
Where: r = Number of rows,
c = Number of columns

(iv) The chi-square tabulated/ critical value is
$\chi^2_{tab} = \chi^2_{\alpha,(r-1)(c-1)df}$.

**Applications of Chi-Square Test**

A few important application of $\chi^2$ – test are as follows:

1. Test of independence of attributes.
2. Test of goodness – of – fit.
3. Yate's correction continuity.
4. Test of population variance.
5. Test of homogeneity.

**Applications of Chi-Square Distribution**

The $\chi^2$statistic plays an important role in tests dealing with count data, or enumeration data. This is the data required in dealing with problems where information is obtained by counting rather than measuring. In this lecture, we shall examine the following important applications of $\chi^2$– test:

(1) Test of independence of attributes and
(2) Goodness-of-fit test.

**Test of Independence of Attributes**

The test of independence uses the contingency table format and is also referred to as a ***"Contingency Table Test".*** Then, what is contingency table?

Contingency table – A (r × c) contingency table shows the observed frequencies for two categorical variables arranged in a**r** rows and **c** columns. The sum of all observed frequencies is **n**, the sample size. The contingency table format is displayed as follows:

**r× c Contingency Table**

| | Variable X | | | | |
|---|---|---|---|---|---|
| Variable Y | $X_1$ | $X_2$ | ... | $X_c$ | **Row total** |
| $Y_1$ | $O_{11}$ | $O_{12}$ | ... | $O_{1c}$ | $R_1$ |
| $Y_2$ | $O_{21}$ | $O_{22}$ | ... | $O_{2c}$ | $R_2$ |
| . | . | . | ... | . | . |
| . | . | . | ... | . | . |
| . | . | . | ... | . | . |
| $Y_r$ | $O_{r1}$ | $O_{r2}$ | ... | $O_{rc}$ | $R_r$ |
| Column Total | $C_1$ | $C_2$ | ... | $C_c$ | **N** |

**Remarks:**

(i) The variables X and Y have been classified into mutually exclusive categories.
(ii) The values $O_{ij}$ in row i and column j of the table shows the frequency of observations fallen in each joint categories i and j.
(iii) The row and column totals are the sums of the frequencies.
(iv) The row and column totals add up to a grand total or overall total **n**, which represents the sample size.

(v) The expected frequency, $\boldsymbol{E_{ij}}$, corresponding to the observed frequency in row i and column j in each cell of the contingency table, is calculated as follows:

$$E_{ij} = \frac{Row\ i\ Total}{Sample\ size} \times \frac{Column\ j}{Sample\ size} \times Grand\ Total.$$

$$= \frac{R_i}{n} \times \frac{C_j}{n}$$

$$E_{ij} = \frac{R_i \times C_j}{n}$$

However, the $\chi^2$ –test statistic measures how much the observed frequencies differ from the expected frequencies when variables are independent.

**Test Procedures:**

**Step 1:** State the null and alternative hypothesis i.e.

**$H_o$:** No relationship or association exists between two variables i.e. they are independent.

**$H_A$:** A relationship exist i.e. they are dependent.

**Step 2:** Select a random sample and record the observed frequencies (i.e. O values) in each cell of the contingency table and calculate the row total, column total and grand total.

**Step 3:** Calculate the expected frequencies (i.e. E values) for each cell.

**Step 4:** Define the chi-square test – statistic and obtain its value which is called chi- square calculated value ($\chi^2_{cal}$ ) i.e.

$\chi^2_{cal} = \sum \frac{(0-E)^2}{E}$.

**Step 5:** Calculate the degrees of freedom df = (r – 1) (c – 1), where r = number of rows and c = number of columns.

**Step 6:** Obtain the critical values or chi-square tabulated value.

$\chi^2_{tab} = \chi^2_{\alpha,(r-1)(c-1)df}$.

Where $\alpha =$ the level of significance and then, this value of $\boldsymbol{\chi^2_\alpha}$ corresponds to an area in the right tail of the distribution.

**Step 7:** Write the Decision Rule i.e.

Reject $H_o$ if $\boldsymbol{\chi^2_{cal} > \chi^2_{tab}}$. Otherwise do not reject $H_o$.

Alternatively based on Probability value called P-value,

Reject $H_o$ if $P - value \leq \alpha\%$ $(Alpha = 5\% = level\ of\ significance)$. Otherwise do not reject $H_o$.

**Step 8:** Compare the $\chi^2_{cal}$ and $\chi^2_{tab}$ and then decide whether the variables are independent or not, using the decision rule in step 7 above.

**Analysis of Statistical Data and Test of Hypotheses: Result and Discussion**

The responses of the 300 respondents on the effect of storage condition of cashew nuts in Oke-Ogun, area of Oyo State were run and analyzed using a Statistical software called

Statistical Package for Social Sciences (SPSS) i.e. IBM SPSS Statistics version 21. The adopted statistical methodology are Descriptive Statistics and Pearson Chi-Square distribution/Test. Also, each research hypotheses were interpreted accordingly based on the probability value popularly known as P-value.

**Descriptive Statistics on Demographic Details of the Respondents**

**Table 2: Statistics on Demographic Details of the Respondents**

**Statistics**

| | | Sex of the Respondent | Age group of the respondents | Marital Status of the respondents | Educational Status | Year of company establishment | Year of experience in your workplace |
|---|---|---|---|---|---|---|---|
| N | Valid | 300 | 300 | 300 | 300 | 300 | 300 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 |

**Source: 2023 Field Survey**

**Table 3: Frequency and Percentage for the Sex of the Respondents**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | Male | 138 | 46.0 |
| | Female | 162 | 54.0 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**

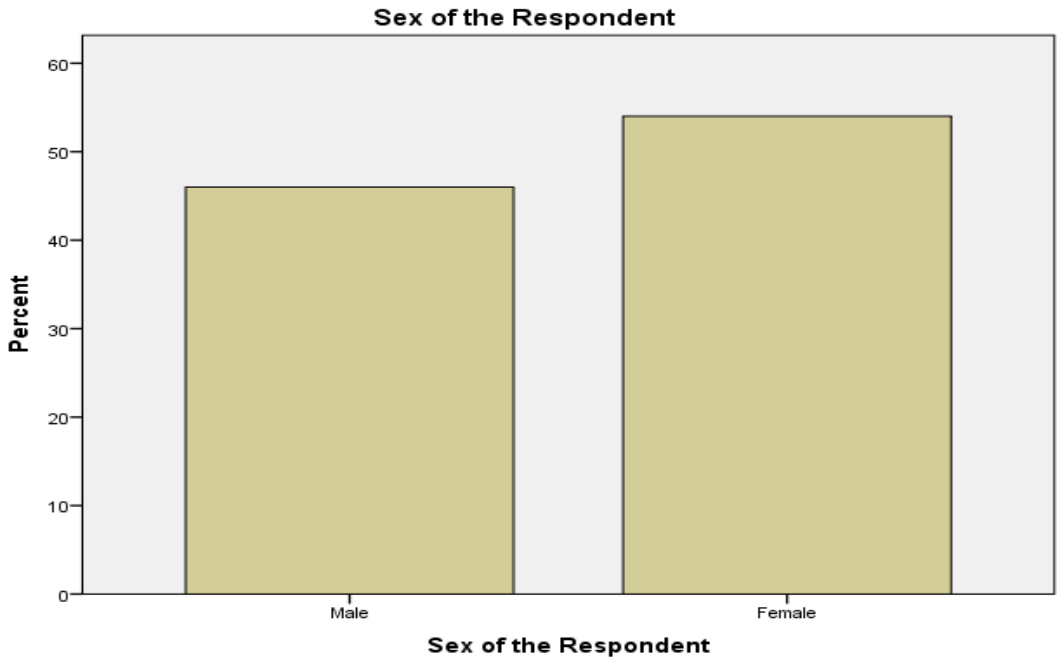


*Figure 6: Simple Bar Chart for the Sex of the respondents*

The percentages of the male and female respondents on the effect of storage condition of cashew nuts in Oke-Ogun, area of Oyo State, Nigeria were about 46% and 54% respectively (see Table 3). That is to say the Table 3, and figure 6 above revealed that there are more females' respondents on the effect of storage condition of cashew nuts in Oke-Ogun, area of Oyo State, Nigeria than males' respondents.

**Table 4: Frequency and Percentage for the Age group of the Respondents**

| | | Frequency | Percent |
|---|---|---|---|
| Valid | 0-30 years | 114 | 38.0 |
| | 31-40 years | 113 | 37.7 |
| | 41-50 years | 67 | 22.3 |
| | 51-60 years | 6 | 2.0 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**

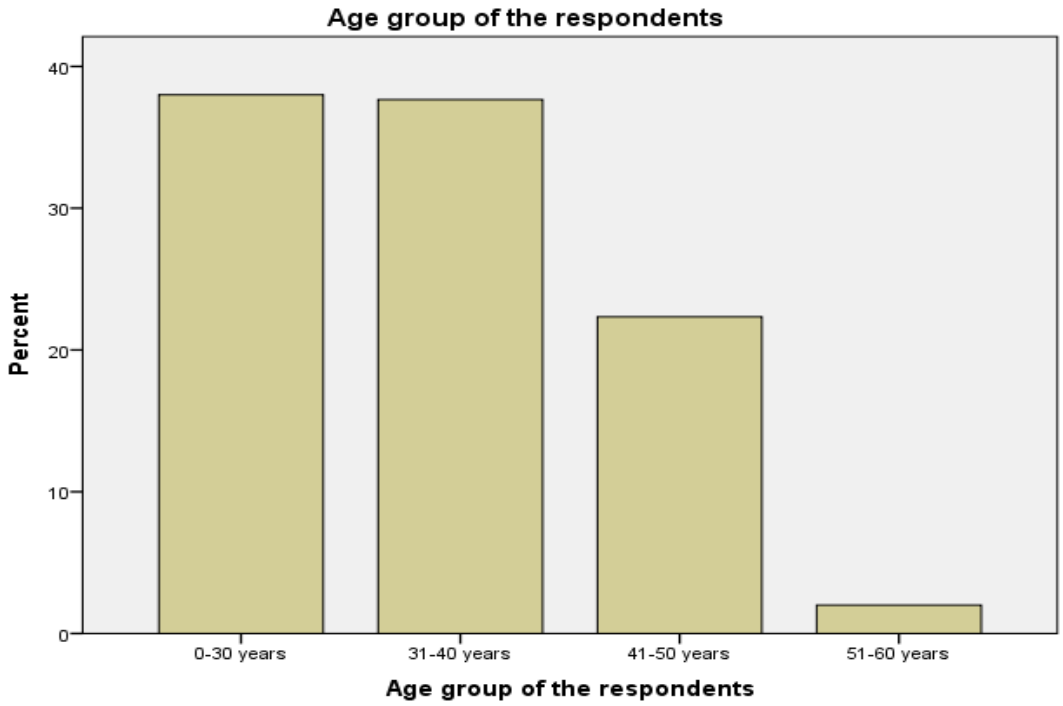


*Figure 7: Simple Bar Chart for the Age of the respondents*

The percentage of the age group (0 – 30) years, (31 – 40) years, (41 - 50) years, (51 – 60) years and (61 – 70) years and were 38%, 37.7%, 22.3%, and 2.0% respectively. The age of the most of the respondents participated in this survey lies between 0 and 40 years of age.

However, this research work revealed that the percentage of the age group (0 – 40) years is more than that of others age groups on the effect of storage condition of cashew nuts in Oke-Ogun, area of Oyo State with the highest percentage of 38% (see Table 4, and Figure 7).

**Table 5: Frequency and Percentage for the Marital Status**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | Single | 78 | 26.0 |
| | married | 199 | 66.3 |
| | widow/ widower | 6 | 2.0 |
| | Divorce | 17 | 5.7 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**

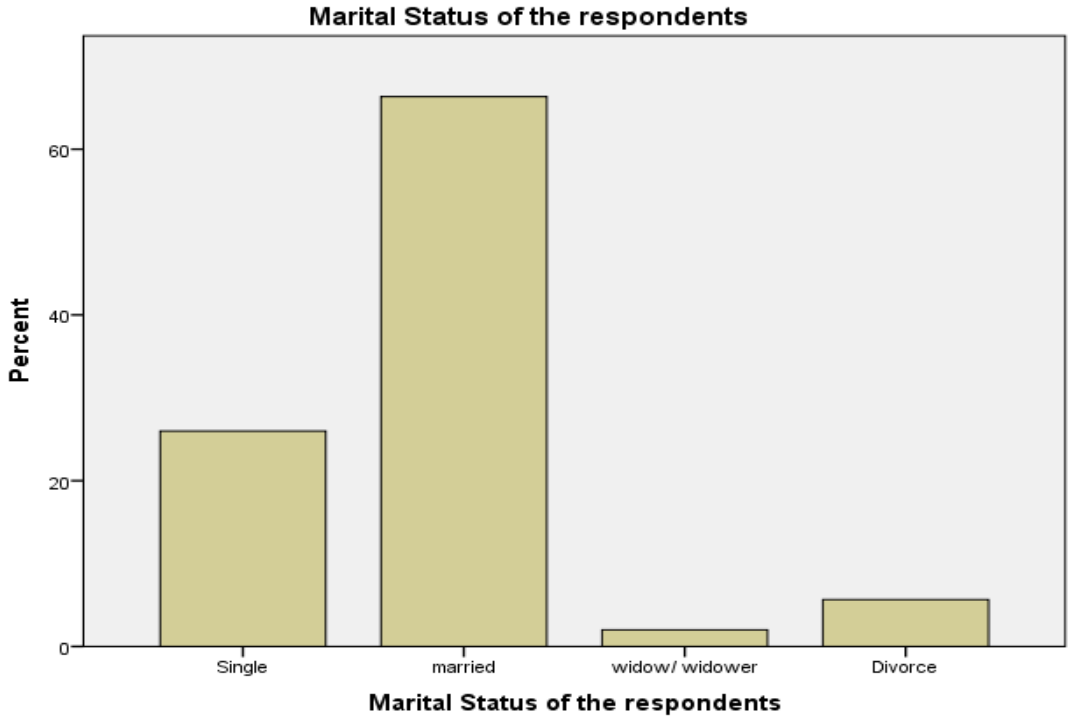


***Figure 8: Simple Bar Chart for the Marital Status of the respondents***

The percentages of the marital status of the respondents on the effect of storage condition of cashew nuts in Oke-Ogun, area of Oyo State for Single, married, widow/widower and divorce were 26%, 66.3%, 2% and 5.7% respectively. Therefore, this study revealed that most of the respondents participated in the research work were married respondents with about 66.3% (see Table 5, and Figure 8 above).

**Table 6: Frequency and Percentage for the Educational Status of the respondent**

| | | Frequency | Percent |
|---|---|---|---|
| Valid | University | 41 | 13.7 |
| | NCE | 76 | 25.3 |
| | Polytechnic | 66 | 22.0 |
| | Secondary | 87 | 29.0 |
| | Primary | 30 | 10.0 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**

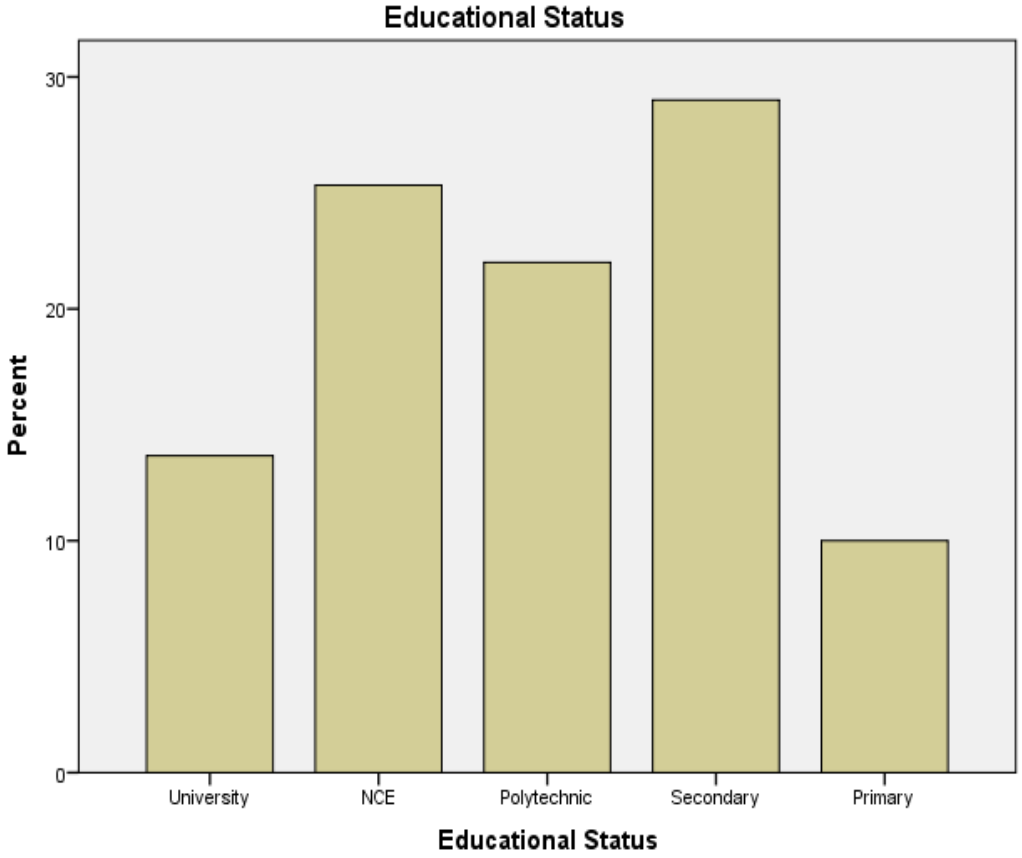


***Figure 9: Simple Bar Chart for the Educational Status of the respondents***

The percentages of Educational Status/Qualification of the respondents on the effect of storage condition of cashew nuts in Oke-Ogun, area of Oyo State for University, NCE, Polytechnic, Secondary and Primary education were 13.7%, 25.3%, 22%, 29% and 10% respectively. Therefore, this research work revealed that most of the NCE, Polytechnic and Secondary School holders participated in the survey (see Table 6, and figure 9).

**Table 7: Frequency and Percentage for the year of Company Establishment**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | 1-5 Years | 99 | 33.0 |
| | 6-10 Years | 170 | 56.7 |
| | 11-15 Years | 27 | 9.0 |
| | 16 Years and above | 4 | 1.3 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**




***Figure 10: Simple Bar Chart for the year of Company Establishment***

The percentage of the year of Company establishment (1 – 5) years, (6 – 10) years, (11 - 15) years, and (16 years and above) were 33%, 56.7%, 9%, and 1.3% respectively. The year of Company establishment for the most of the respondents participated in this survey lies between 6 and 10 years of establishment. However, this paper revealed that the percentage of the year of Company establishment (6 – 10) years is more than that of others years of establishment on the effect of storage condition of cashew nuts in Oke-Ogun, area of Oyo State with the highest percentage of 56.7% (see Table 7, and Figure 10).



**EDITOR-IN-CHIEF**
**Prof. A.I. Mteiye [MALAWI]**

**Table 8: Frequency and Percentage for the year of Experience in the Respondents' workplace**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | 1-5 Years | 216 | 72.0 |
| | 6-10 Years | 53 | 17.7 |
| | 11-15 Years | 31 | 10.3 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**




***Figure 11: Simple Bar Chart for the year of Experience of the Respondents***

The percentage of the year of experience (1 – 5) years, (6 – 10) years and (11 - 15) years were 72%, 17.7% and 10.3% respectively. The year of experience for the most of the respondents participated in this survey lies between 1 and 5 years. However, this research work revealed that the percentage of the year of experience (1 – 5) years is more than that of others years of experience on the effect of storage condition of cashew nuts in Oke-Ogun, area of Oyo State with the highest percentage of 72% (see Table 8, and Figure 11).

**Descriptive Statistics on Research Questions**

**Research Questions One: How long have you been growing cashew nuts?**

**Table 9: Frequency and Percentage on the growing cashew nuts in Oke Ogun area of Oyo State**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | 3 years | 199 | 66.3 |
| | 4 years | 50 | 16.7 |
| | 6 years and above | 51 | 17.0 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**

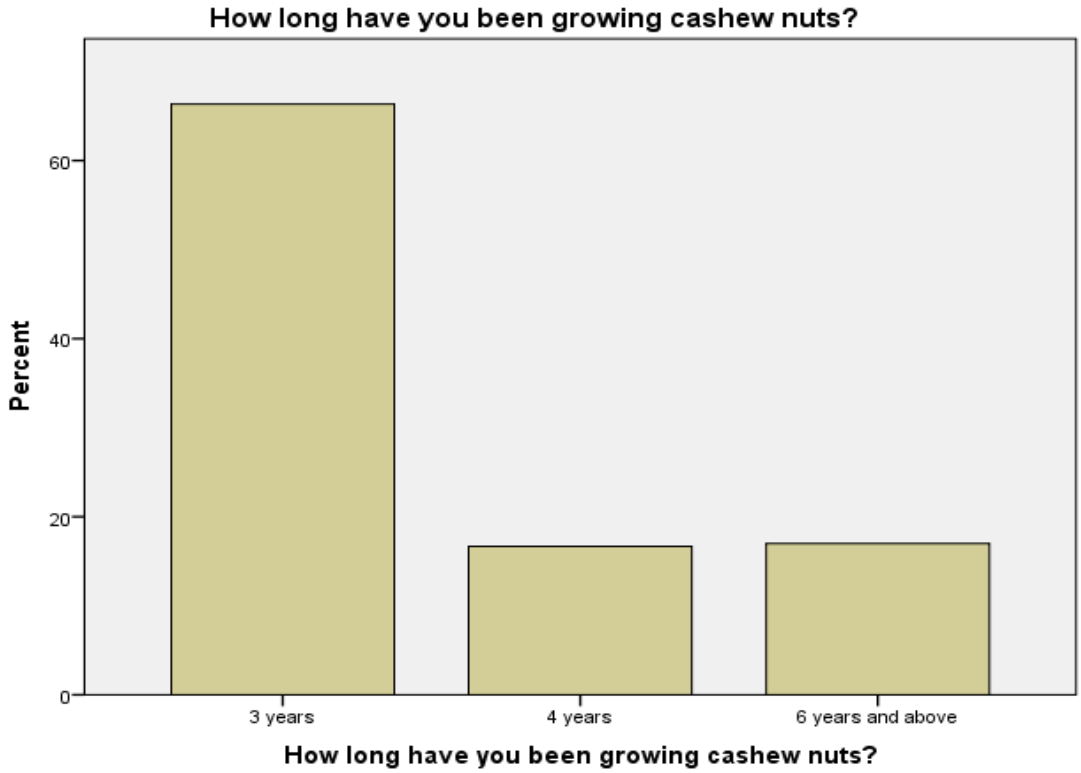


***Figure 12: Simple Bar Chart for the Research Question one***

The percentage of the years of experience of the respondents on the growing of cashew nuts in Oke-Ogun, area of Oyo were 66.3%, 16.7% and 17% for 3 years, 4 years and 6 years & above respectively. The years of experience for most of the respondents who participated in this survey was 3 years. However, this research work revealed that most of the respondents that engaged on growing of cashew nuts in the Oke-Ogun, area of Oyo State had three (3) years' experience with the highest percentage of 66.3% (see Table 9, and Figure 12).

**Research Questions Two: What is your average yield of cashew nuts per year?**

**Table 10: Frequency and Percentage on the average yield of cashew nuts per year in Oke Ogun area**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | 7-11 kg per annum | 157 | 52.3 |
| | 12 kg per annum | 131 | 43.7 |
| | More than 12 kg per annum | 12 | 4.0 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**

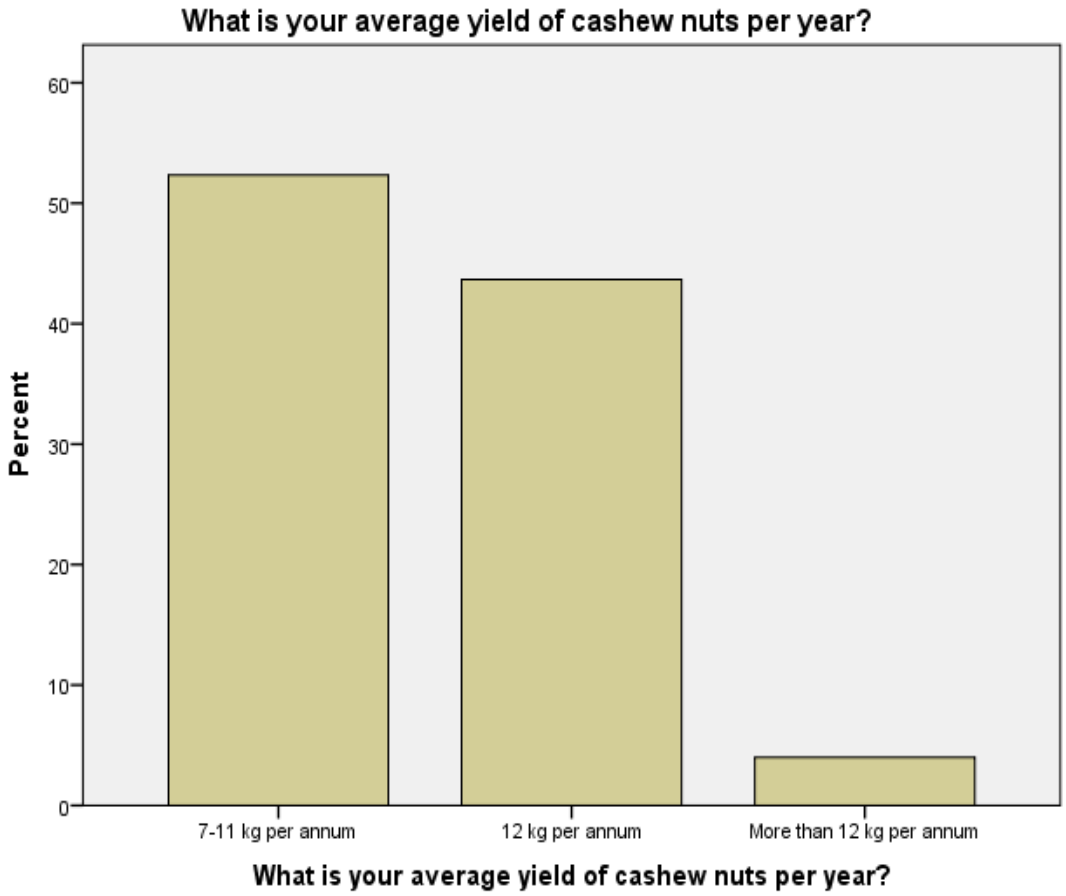


***Figure 13: Simple Bar Chart for the Research Question Two***

The percentage of average yield of cashew nuts for 7 – 11 kg per annum, 12 kg per annum and more than 12 kg per annum were 52.3%, 43.7% and 4% respectively. Therefore, most of the respondents participated in this survey produced between 7 kg and 11 kg average yield of cashew nuts per year in Oke-Ogun, area of Oyo State with the highest percentage of 52.3% (see Table 10, and Figure 13).



**EDITOR-IN-CHIEF**
**Prof. A.I. Mteiye [MALAWI]**

**Research Questions Three: What storage methods do you currently use for your cashew nuts?**

**Table 11: Frequency and Percentage on the storage methods currently use for cashew nuts in Oke Ogun area**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | Container | 163 | 54.3 |
| | Vacuum sealed | 113 | 37.7 |
| | Sealed jar | 24 | 8.0 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**

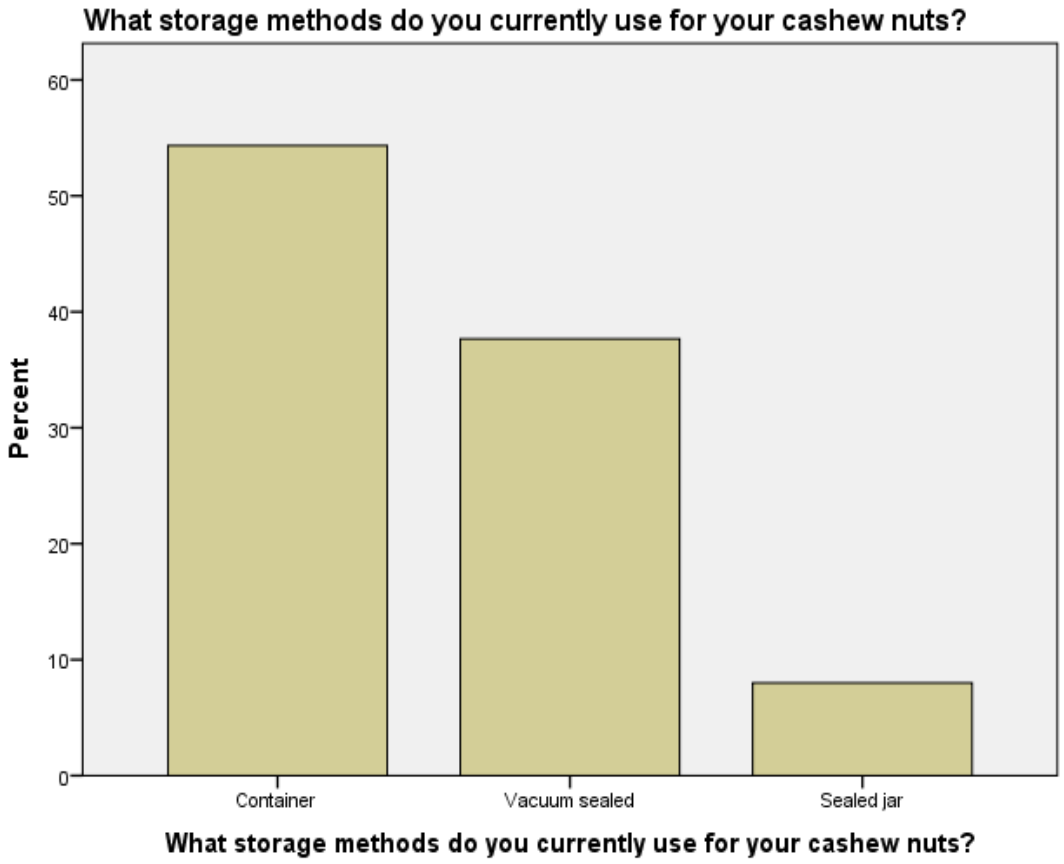


*Figure 14: Simple Bar Chart for the Research Question Three*

The percentages of the people in Oke-Ogun area of Oyo State currently used Container, Vacuum sealed and sealed jar as a mechanism used to store cashew nuts were 54.3%, 37.7% and 8% respectively. Therefore, this paper revealed that most of the people in Oke-Ogun area of Oyo State preferred using Container to store their cashew nuts with about 54.3% (see Table 11, and Figure 14 above).

**Research Questions Four: What type of containers do you use for storing cashew nuts?**

**Table 12: Frequency and Percentage on the Type of Containers use for storing cashew nuts in Oke Ogun area**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | Refrigerator | 4 | 1.3 |
| | Vacuum sealed | 84 | 28.0 |
| | Sealed jar | 212 | 70.7 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**




*Figure 15: Simple Bar Chart for the Research Question Four*

This research revealed that there are three type of containers that people in Oke Ogun area of Oyo State use for storing cashew nuts, which include Refrigerator container, Vacuum sealed container and sealed jar container. Out of 300 respondents participated in this survey, 4 (1.3%) used Refrigerator container, 84 (28%) used Vacuum sealed container and 212 (70.7%) used sealed jar container. Therefore, most of the people in Oke-Ogun area of Oyo State preferred using sealed jar container to store their cashew nuts with highest percentage of 70.7% (see Table 12, and Figure 15 above).

**Research Questions Five: What is the average temperature and humidity in your storage area?**

**Table 13: Frequency and Percentage on the average temperature and humidity use for storing cashew nuts in Oke Ogun area**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | 26.9 $^{OC}$ | 58 | 19.3 |
| | 24 $^{OC}$ | 69 | 23.0 |
| | 30 $^{OC}$ | 64 | 21.3 |
| | 24.9 $^{OC}$ | 73 | 24.3 |
| | 27 $^{OC}$ | 36 | 12.0 |
| | Total | 300 | 100.0 |

**Source: 2023 Field Survey**

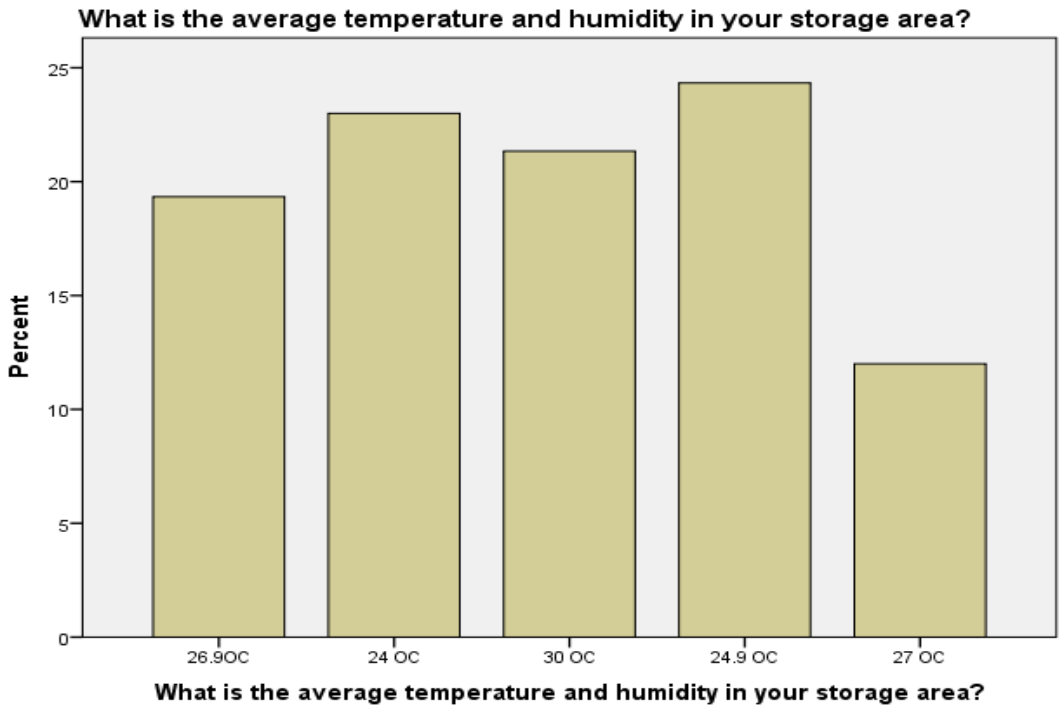


***Figure 16: Simple Bar Chart for the Research Question Five***

The percentages of the people currently used 26.9$^{oc}$, 24 $^{oc}$, 30 $^{oc}$, 24.9 $^{oc}$ and 27 $^{oc}$ as the average temperature and humidity for storing cashew nuts in Oke Ogun area of Oyo State were 19.3%, 23%, 21.3%, 24.3% and 12% respectively. Therefore, this research revealed that most of the people in Oke-Ogun area of Oyo State preferred using 24.9 $^{oc}$ and 24 $^{oc}$ as the average temperature and humidity for storing cashew nuts in Oke Ogun area of Oyo State with the highest percentages of about 24.3% and 23% respectively (see Table 13, and Figure 16 above).

**Research Questions Six: What is the average length of time that you store your cashew nuts?**

**Table 14: Frequency and Percentage of the average length of time use for storing cashew nuts in Oke Ogun area of Oyo State**

| | | Frequency | Percent |
|---|---|---|---|
| **Valid** | 2 years | 255 | 85.0 |
| | 4 years | 37 | 12.3 |
| | 5 years and above | 8 | 2.7 |
| | Total | 300 | 100.0 |




*Figure 17: Simple Bar Chart for the Research Question Six*

This research revealed that out of 300 respondents participated in this survey, 255 (85%), 37 (12.3%) and 8 (28%) used 2 years, 4 years and 5 years and above to store their cashew nuts in Oke Ogun area of Oyo State. Therefore, most of the people in Oke-Ogun area preferred using 2 years to store their cashew nuts with highest percentage of 85% (see Table 14 and Figure 17 above).



**EDITOR-IN-CHIEF**
**Prof. A.I. Mteiye [MALAWI]**

**Test of the Hypotheses on the effect of Storage Condition of Cashew Nuts in Oke-Ogun, Area of Oyo State**

**Research Questions Seven: Are you facing any challenges with the storage of cashew nuts?**

**Hypotheses One:**

$H_{o1}$: People in Oke Ogun area of Oyo State are not facing any challenges with the storage of cashew nuts.

$H_{A1}$: People in Oke Ogun area of Oyo State are really facing challenges with the storage of cashew nuts.

**Table 15: Contingency table for the Hypothesis One**

| | | Are you facing any challenges with the storage of cashew nuts? | | Total |
|---|---|---|---|---|
| | | Yes | No | |
| **Year of experience in your workplace** | 1-5 Years | 183 | 33 | 216 |
| | 6-10 Years | 37 | 16 | 53 |
| | 11-15 Years | 23 | 8 | 31 |
| **Total** | | 243 | 57 | 300 |

**Source: SPSS output 1(a) Are you facing any challenges with the storage of cashew nuts?**

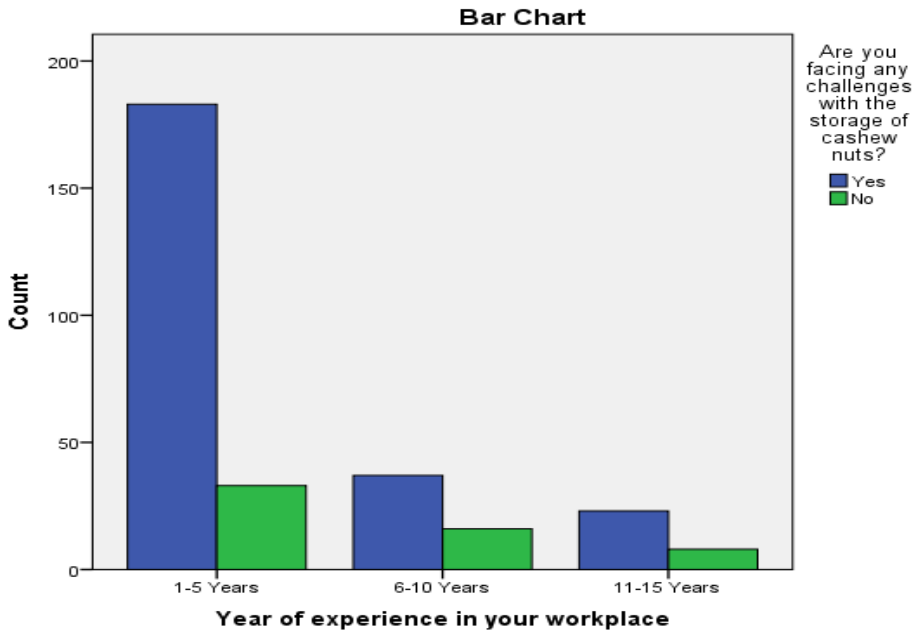


*Figure 18: Multiple Bar Chart for the responses on hypothesis one of the survey*

**Table 16: Pearson's Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| **Pearson Chi-Square** | 7.189[a] | 2 | .027 |
| **Likelihood Ratio** | 6.731 | 2 | .035 |
| **Linear-by-Linear Association** | 5.020 | 1 | .025 |
| **N of Valid Cases** | 300 | | |
| **a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.89.** | | | |

**Source: SPSS output 1(b) Pearson's Chi-Square Tests**

**Decision Rule:**

Reject $H_{o1}$ if $P - value > \alpha\%\ (Alpha\ \% = level\ of\ significance)$. Otherwise do not reject $H_{o1}$.

**Conclusion:**

The Pearson's Chi-Square test was conducted to examine whether people in Oke Ogun area of Oyo State are really facing any challenges with the storage of cashew nuts or not. The SPSS results/output (1b) above revealed that (Pearson's Chi-Square value = 7.189, degrees of freedom (df) = 2 and p-value = 0.027). Since the p-value is less than 0.05 (5%) level of significance, then we strongly reject the null hypothesis $(H_{o1})$ and conclude that people in Oke Ogun area of Oyo State are really facing challenges with the storage of their cashew nuts at 5% level of significance.

**Research Questions Eight: Have you experienced any pest or diseases problems with your cashew nuts?**

**Hypotheses Two:**

$H_{o2}$: People in Oke Ogun area of Oyo State does not experienced any pests or diseases problems with their cashew nuts.

$H_{A2}$: People in Oke Ogun area of Oyo State do normally experienced pests or diseases problems with their cashew nuts.

**Table 17: Contingency table for the Hypothesis Two**

| | | Have you experienced any pest or diseases problems with your cashew nuts? | | Total |
|---|---|---|---|---|
| | | Yes | No | |
| **Year of company establishment** | 1-5 Years | 65 | 34 | 99 |
| | 6-10 Years | 146 | 24 | 170 |
| | 11-15 Years | 21 | 6 | 27 |
| | 16 Years and above | 0 | 4 | 4 |
| **Total** | | 232 | 68 | 300 |

**Source: SPSS output 2(a) Have you experienced any pest or diseases problems with your cashew nuts?**



**EDITOR-IN-CHIEF**
**Prof. A.I. Mteiye [MALAWI]**

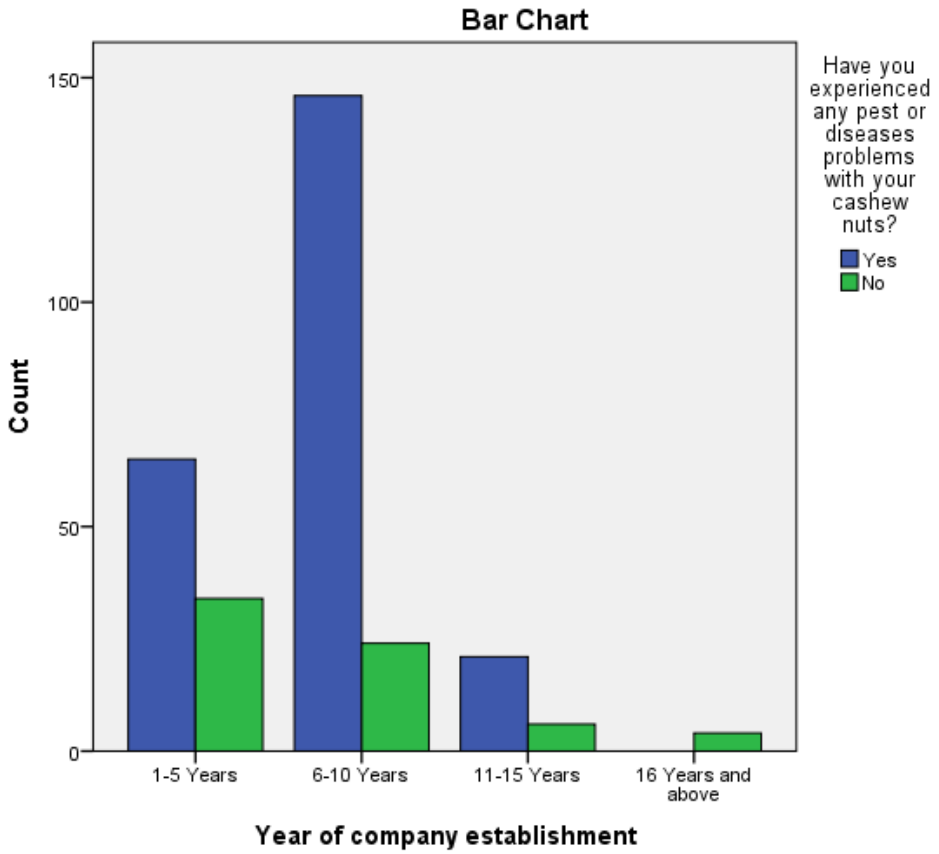


*Figure 19: Multiple Bar Chart for the responses on hypothesis two of the survey*

**Table 18: Pearson's Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| **Pearson Chi-Square** | 28.439[a] | 3 | .000 |
| **Likelihood Ratio** | 26.744 | 3 | .000 |
| **Linear-by-Linear Association** | 1.337 | 1 | .248 |
| **N of Valid Cases** | 300 | | |
| **a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is .91.** | | | |

**Source: SPSS output 2(b) Pearson's Chi-Square Tests**

**Decision Rule:**

Reject $H_{o2}$ if $P - value > \alpha\%\ (Alpha\ \% = level\ of\ significance)$. Otherwise do not reject $H_{o2}$.

**Conclusion:**

The Pearson's Chi-Square test was conducted to examine whether people in Oke Ogun area of Oyo State do normally experienced pests/diseases problems with their cashew



EDITOR-IN-CHIEF
Prof. A.I. Mteiye [MALAWI]

nuts or not. The SPSS results/output (2b) above revealed that (Pearson's Chi-Square value = 28.439, degrees of freedom (df) = 3 and p-value = 0.000). Since the p-value is less than 0.05 (5%) level of significance, then we strongly reject the null hypothesis $(H_{o2})$ and conclude that people in Oke Ogun area of Oyo State do normally experienced pests/diseases problems with their cashew nuts at 5% level of significance.

**Research Questions Nine: Is there any specific regulations or standards that you must follow when growing and storing cashew nuts?**

**Hypotheses Three:**

$H_{o3}$: There is no specific regulations or standards that people in Oke-Ogun area of Oyo State must follow when growing and storing their cashew nuts.

$H_{A3}$: There is a specific regulations or standards that people in Oke-Ogun area of Oyo State must follow when growing and storing their cashew nuts.

**Table 19: Contingency table for the Hypothesis Three**

| | | Is there any specific regulations or standards that you must follow when growing and storing cashew nuts? | | Total |
|---|---|---|---|---|
| | | Yes | No | |
| **Educational Status** | University | 37 | 4 | 41 |
| | NCE | 72 | 4 | 76 |
| | Polytechnic | 58 | 8 | 66 |
| | Secondary | 87 | 0 | 87 |
| | Primary | 30 | 0 | 30 |
| **Total** | | 284 | 16 | 300 |

**Source: SPSS output 3(a) Is there any specific regulations or standards that you must follow when growing and storing cashew nuts?**

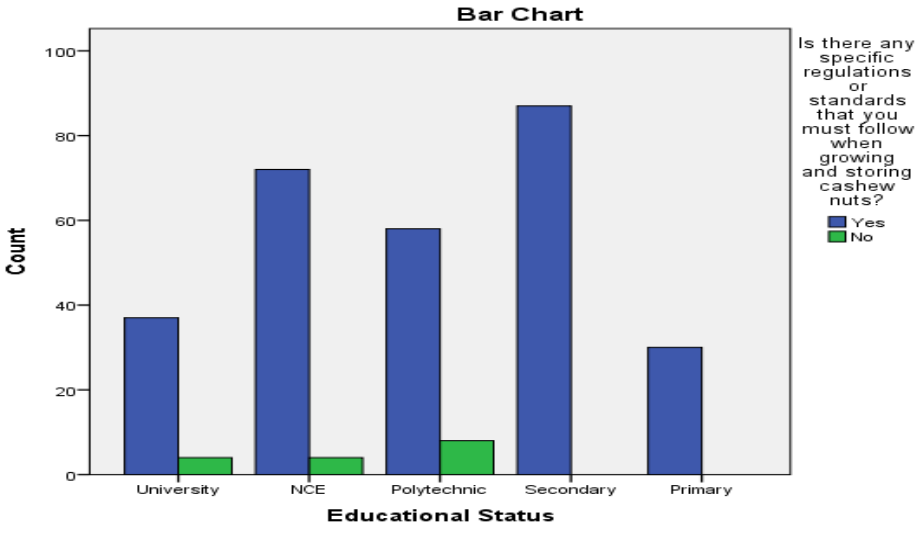


*Figure 20: Multiple Bar Chart for the responses on hypothesis three of the survey*

**Table 20: Pearson's Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| **Pearson Chi-Square** | 14.204[a] | 4 | .007 |
| **Likelihood Ratio** | 18.621 | 4 | .001 |
| **Linear-by-Linear Association** | 5.758 | 1 | .016 |
| **N of Valid Cases** | 300 | | |
| **a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is 1.60.** | | | |

**Source: SPSS output 3(b)** Pearson's Chi-Square Tests

**Decision Rule:**

Reject $H_{o3}$ if $P - value > \alpha\%\ (Alpha\ \% = level\ of\ significance)$. Otherwise do not reject $H_{o3}$.

**Conclusion:**

The Pearson's Chi-Square test was conducted to examine whether there is a specific regulations or standards that people in Oke-Ogun area of Oyo State must follow when growing and storing their cashew nuts or not. The SPSS results/output (2b) above revealed that (Pearson's Chi-Square value = 14.204, degrees of freedom (df) = 4 and p-value = 0.007). Since the p-value is less than 0.05 (5%) level of significance, then we strongly reject the null hypothesis $(H_{o3})$ and conclude that there is a specific regulations or standards that people in Oke-Ogun area of Oyo State must follow when growing and storing their cashew nuts at 5% level of significance.

**General Conclusion**

The findings from the questionnaire surveys and in-person interviews regarding the impact of cashew nut storage in Oke-ogun Saki. The Oke-Ogun area of Oyo State is known for its cashew nut storage problems. The Pearson's Chi-Square test was used to investigate this issue, and the results showed that there are specific guidelines or standards that residents in this area must adhere to when cultivating and storing cashew nuts. Additionally, residents in this area typically experience pest or disease problems related to their cashew nuts.

**Recommendations**

This research work hereby recommend that cashew nut should be stored in the following ways:

1. Due to the high fat content, cashew nuts become rancid fast especially at room temperature. It is important to store them in air-tight containers in a cool, dry place such as cupboard.

2. Cashew nuts should be given more attention by the Government to encourage further researches and investigation into reducing allergens to minimize the reaction when consumed.
3. Also strict hygienic measures should be implemented during storage, drying and packing so as to minimize contamination, this will enhance international trade efforts and improved public health

## References

Adebayo, L. O. & Diyaolu, S. A. (2013). Mycology and spoilage of retail cashew nut. Afr J Biotechnol 2(10):369–373

Adeigbe O. O., Olasupo, F. O., Adewale, B. D. & Muyiwa, A. A. (2015). A review on cashew research and production in Nigeria in the last four decades. Academic Journals, 10(5), 196 – 209.

Agbongiarhuoyi A. E., Uwagboe E. O., Agbeniyi S. O., Famuyiwa B. S. & Shittu T. R. (2020): Analysis of Farmers' Cashew Nuts Marketing Channels and Information Frequency: Implications for Cashew sustainability in Nigeria . World Rural Observations, 12(3): 23- 30.

Dadze, P, Sreelatha T & Ganesh, A. (2014). Bio oil from pyrolysis of cashew nut shell characterization and related properties. Biomass and Bioenergy. 27(3):265–275

ENADEP (2009). Enugu State Agricultural Development Programme Annual Report.

Enwelu, I. A., Ugwu, S. T., Ayogu, C. J., Ogbonna, O. I. (2014). Gender roles and challenges of small scale cashew nut processing enterprise in Enugu North, Nigeria. Journal of Educational and Social Research 2014; 4(7): 74-78.

FAOSTAT (2022). Food and Agricultural Organization Statistical Report on World Cashew Production.

Gbenga, A. (2019). Ogbomoso takes front seat in cashew cultivation. The Guardian; Conscience nurtured by truth .https://guardian.ng/features/ogbomoso-takes- front-seat-in-cashew-cultivation/27 October 2019.

Nagaraja, K. V. (2012). Quality of cashew kernels in relation to export. Cashew 12(3):143–148.

Nigerian Export Promotion Council (2018). Cashew, Accessed 5th August, 2018. Available online: https://nepc.gov.ng/importer/nigeriaproduct/cashe w/

Ogah, O. M., Ogebe, F. O. & Ukpur, S. (2020). The Economics of Processing Cashew Products in Benue State, Nigeria. International Journal of Environment, Agriculture and Biotechnology (IJEAB). 5(1): 120 – 125.

Ojedokun, A. O., Ogunleye, K. Y. & Adelowo, I. (2020). Profitability of Cashew Nut Marketing in Oyo State, Nigeria. International Journal of Research and Scientific Innovation (IJRSI), 7(5): 1 – 5.

Oladejo, J. A. (2015). Profitability and structural analysis of cashew nut market in Oyo State, Nigeria. International Journal of Agricultural Policy and Research, 3 (3); 114-221.

Oluyole, K. A., Yahaya, A. T., Uwagboe, E. O., Mokwunye, I. U., Agbeniyi, S. O., Orisajo, S. B., Otunoye, A. H., Ndagi, I., Shittu, T. R. & Aderolu, I. A. (2015). Constraints in Cashew Production among Cashew Farmers in Southwestern Nigeria. International Journal of Science and Nature, 6 (3): 329-333.

Pinto, M. P., Narayanan, M. M., Kini, G. M., Nair, C. B., Subba Rao, P. V., Pullela, P. .K., Ramamoorthy, S. & Barrow, C. J. (2014). Distilled technical cashew nut shell liquid as an effective biofuel and additive to stabilize triglyceride biofuels in diesel. Renewable Energy. 71:81–88.

Rahaman, A. (2020). Descriptive and Inferential Statistics: An Introduction. (Second edition). Omo-Ade Nigeria Enterprises, Ibadan. ISBN: 978-978-968-667-4, Tp. 283-286.

Sabna, P. S., Muneer, A. M. & Potty, V. P. (2011). Shelf life of cashew kernels stored under different antioxidants. Int J Agric Food Sci Technol 2: 29–3.

Salunkhe, D. K. & Desai, B. B. (2014). Post harvest biotechnology of oil seeds. C.R.C press Inc., Boca Raton, p 264.

Samihah Z. N., Majid F. A. A., Jaafar A. B., Mahdzir A., & Musa M. N., (2016). Potential health benefits of deep sea water: *A Review. Evidence-Based Complementary and Alternative Medicine.Vol 2019. Pp:1-18.*



**EDITOR-IN-CHIEF**
**Prof. A.I. Mteiye [MALAWI]**