EXTRACTION AND CHARACTERIZATION OF MILK FROM TIGER NUT (*Cyperus esculentus*)

BY

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NIGER STATE

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

FEBRUARY, 2010

DECLARATION

I hereby declare that this project work 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 Information derived from personal communications, published and unpublished work were duly referenced in the text.

26/02/10

Ojo, Titus Oluwafemi

Date

2004/18446EA

CERTIFICATION

This is to certify that "Extraction and Characterization of Milk from Tiger Nut (*Cyperus esculentus)*" by Ojo Titus Oluwafemi, 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.

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DEDICATION

This project is dedicated to my grand mother, Mrs. E.A. Agboola who at all times supports with prayers, my father Mr. I. O. Ojo, for his financial supports and majorly to my mother Mrs. E. O. Ojo, for her motherly support and at making this a reality, and to my siblings, Dan, Esther and Christopher, for always being there for me. Finally, I will like to dedicate this project to a late friend of mine, Istifanus Tokan, may his gentle soul rest in perfect peace.

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ABSTRACT

Milk was extracted from tiger nut using the centrifugation (A), soxhlet apparatus extraction (B), and crude-simple filtration (C) methods of extraction. The samples A, B and C extracted were analyzed for the lipid content, crude protein, ash content, carbohydrate and moisture content, using the laboratory standard procedures for food analysis of Association of Official Analytical Chemists (AOAC) in obtaining proximate compositions. The result revealed a lipid content of 27.926%, 21.22% and 20.513% for the milk samples A, B and C respectively. The crude protein was highest for milk sample A followed by samples B and C. The ash content was little for the three samples, A, B, and C, having 0.278%, 0.326% and 0.683% respectively. The carbohydrate content was highest in the milk sample C with 76.236%, followed by that of sample B, 73.895% and sample A, 62.878%, and also having moisture content with sample C having 88.147%, sample B having 79.172% and sample C having 77.296%. It was concluded that centrifugation method of extraction is preferable over that of crude (simple filtration) after considering the time factor and quantity of samples extracted. It was recommended that the government should set up and establish programs that will encourage in-depth research on different methods of extracting the milk from tiger nut in-order to meet up with its rising demands.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 GENERAL BACKGROUND

Milk from plant sources, though undervalued in the past, is now a key ingredient in the diet of African countries. Recently, researchers have shown strong interest in these milk sources due to their high nutritional values and economic potentials. It is worthy repeating that milk sources from plants are seen as a radiating hope as well as an ally in the fight against hidden hunger. The agricultural crop of interest in this study is found in the tropical environments including Nigeria for various purposes.

Milk is one of the main products in most family diet system in Africa, yet the contribution of dairying to general economics is often overlooked (Kerven, 1986). In Africa, milk will not only meet 30% of the family caloric requirements but, also has a vital exchange value, while bartering dairy products enables pastoralists to grow less crop and concentrate on herd management. The cash generated through dairy sales is partly used to purchase food grains.

It is noteworthy, that the dairy sub sector in Africa is thus relegated to the category of subsistence system of production due to minor and peripheral status accorded the sector by various government policies. Allied with the above, are poor nutrition and genetic constitution of the African breeds of ruminants. The above problems lead to insufficient milk available to the people with average per capita daily consumption 15L of milk. This dramatic decrease in consumption of milk and milk products stimulated in part the processing of milk from different seeds and nuts.

These agricultural crops, especially of the plant crops are frequently used for various activities with the importance of discovering and producing different product profitable to man. These crops for the past years have been underutilized in many parts of the world where they are being grown or produced, most especially in the developing countries. One of these underutilized crops is the Tiger Nut (*Cyperus esculentus)*, which was found to be a good substitute for cereal grains. This nut which is cultivated throughout the world are found in America, Northern part of Nigeria and other West African Countries like Guinea, Ivory Coast, Cameroon, Senegal, and other parts of the world.

Discovering the qualities embedded in tiger nut, it is being used for different activities such as oil extraction (Bio-fuel), making of beverage drink, of feed ingredient for animals and has been discovered in the southern USA to be ranked the top 10 most important waterfowl foods and recognized for its growing use as fish bait. This crop is also used for making cookies, flavouring agents for ice creams, additives to biscuits making and other bakery products, and most especially for the vegetarian community, is the production of the *Chufa de Horchata* (tiger nut milk) promoted by the European countries, USA and Israel.

Grain milk looks very similar to cow's milk. It has lower protein content and higher carbohydrate content than cow's milk. Just as cow's milk is often fortified, grain milks may have calcium and some vitamins (especially B12) added to them. Grain milk is low in saturated fat and contains no lactose, which is beneficial for those who are lactose intolerant. Grain milk also lacks milk protein, making it suitable for vegans and people with milk allergies.

The tiger nut otherwise known as *Ofio* in south western part of the Nigeria, *Aya* amongst the *Hausas*, *Imumu* in Ilorin and *Aki-Hausa* amongst the *Igbos* is generally cultivated worldwide and used as close substitute for milk for patients intolerable to lactose, as a nutritional supplement.

The consumption of this product is healthier because they are free from toxic waste which is gotten from pesticides and herbicides which at long run will affect the organisms. This organic milk is also classified as a medicinal drink, due to being highly energetic and diuretic (causing increased urine output), rich in minerals, predominantly phosphorus and potassium, and vitamins E and C. Tiger nut is also said to be a good source of crude fibre which is said to reduce the rate of diseases since it is not easily and totally digestible by the acid and enzymes in the alimentary canal of animals as well as human beings.

Knowing well the financial, medicinal and nutritional benefits embedded in tiger nut, our rural communities are posed with the problems of processing the tiger nut milk. The little quantity of the milk processed daily is being done using the local method of extraction. This method is tedious, time and energy consuming and the quantity of milk produced cannot meet with the demands of the rural communities. In order to help meet up with the demands of this nutritional thirst for the rural communities, other modes of extraction with the characteristics of the milk extracted will be studied.

1.2 Statement of Problem

Shortages as well as inadequacies in the nutritional value of commonly eaten meals like rice, beans, yam and cereals, coupled with the urge to look for a relatively cheaper food sources have led to alternative sources of protein especially in the rural areas of developing countries.

There have also being shortage in the quantity of the tiger nut milk produced in relative to its demands in the rural communities in order to cover up the nutritional lack present in these areas. This has been as a result of using the ancient method of extraction which is mainly the use of muslin cloth (sieve), straining out the milk out from the milled tiger nut. This is also partly due to not having the knowledge of the other modes of extraction of milk from the nut.

1.3 Objectives of Study

The objectives of this study are:

1. To extract milk from tiger nut using three basic methods / modes of extraction.
2. To determine the characteristics of the tiger nut milk after going through different modes of extraction considered, that is centrifugation, the use of soxhlet apparatus and the crude method of extraction.

1.4 Justification of Study

Over the years, the demands for protein by humans supplied from the dairy sectors of agriculture have being unsatisfying and inadequate. This has brought about the extraction of the tiger nut milk as alternative sources of protein in order to meet up with the daily requirements in human nutritional diet.

The tiger nut milk has excellent nutritional, medicinal, dietary qualities that are of good benefits to man as that of the olive oil. The milk also contains oleic acid which regulates the cholesterol level in the body. Even though too low in proteins and in fats, and too high in carbohydrates, to be considered equal to milk, *Chufas de Horchata* can be useful in somehow replacing milk in the diet of people intolerant to lactose (Wikipedia, 2007). With these viable qualities, it gives it a high relevance in considering the possible modes of extraction so as to reduce the drudgery present in the old practice, and also save time and having a higher quantity in production.

1.5 Scope of Study

The study involves the extraction of the milk from the tiger nut samples, considering three different modes of extraction and comparing their individual outputs. The modes of extraction considered in this project are centrifugation, the use of soxhlet apparatus and the crude method. Also the characteristics of each of the products gotten from these different modes of extractions will be studied.

The limitation of this study is that the extractions of the tiger nut milk were carried out with the locally manufactured machines with which there could be errors of manufacture, thereby affecting the final results gotten.

Also the test were carried out using samples that were commercially available in the market and poses the probability of reduced nutrients in the characteristics of the tiger nut milk.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Historical Background of Tiger Nut

Tiger nut Sedge (*Cyperus esculentus*), as a tuber crop is ranked among the oldest cultivated plants in Ancient Egypt. Although noting that Chufa was no doubt an important food element in ancient Egypt during dynastic times, its cultivation in ancient times seems to have remained (totally or almost totally) an Egyptian specialty. They were used to make cakes in ancient Egypt. Presently, they are cultivated mainly, at least for extended and common commercial purposes, in Spain, where they were introduced by Arabs, almost exclusively in Valencia region In Spain, it usually refers to orxata de xufes (horchata de chufas), made from tiger nuts, water and sugar. Originally from Valencia, the idea of making horchata from tiger nuts comes from the period of Muslim presence in Valencia (from the 8th to 13th century).. They are found extensively in California and were grown by the Paiute in Owens Valley. Tiger nuts are also grown in Ghana, Burkina Faso and Mali. (Zohary and Hopf, 2000)

Tiger nut Sedge (*Cyperus esculentus*) is a species of sedge native to warm temperate or subtropical regions of the Northern Hemisphere. It is an annual or perennial plant, growing to 90 cm tall, with solitary stems growing from a tuber. The stems are triangular in section, and bear slender leaves 3-10 mm wide. The flowers of the plant are distinctive, with a cluster of flat oval seeds surrounded by four hanging leaf-like bracts positioned 90 degrees from each other. The plant foliage is very tough and fibrous, and is often mistaken for a grass.

There are several small varieties that grow wild as weeds in North America. A Chinese species known as *"Zhang fu"* (*Cyperus rotundus*) is used as a carminative and energy and hormone regulating herb in Traditional Chinese Medicine. Currently, the North American cyperus grass is merely regarded as another obnoxious weed. However, historically its small tuberous rhizomes were used both as food and medicine by the Native Americans. Even today, the Egyptians cultivate native specie of the genera *Cyperus* in moist soils or sandy shores for their edible tubers. These are called "tiger nuts" and are first dried, and soaked in water. Reportedly, the taste is similar to hazelnuts. It was specie, the famous papyrus (*Cyperus papyrus*) that the Egyptians used to make paper, sails, cloth, mats, and ropes or plaited into sandals. A specie of the genera *Cyperus* native to the Peruvian Amazon jungle has had widespread use by tribal women as a natural contraceptive and this is attributed to a certain mould that grows on the root of the Amazonian species that has oxytoxic (abortive) properties similar to Ergot, a fungus that grows on rye (Ojos Negros Research Group, 2008).

According to Food and Agricultural Organization (FAO, 1987), Tiger nut has a proximate composition of 19.8% moisture content, 5.3% crude protein, 10.0% crude fibre, 24.2% lipid, 38.9% nitrogen free extractives and 1.8% ash. These attributes make Tiger nut highly nutritive as well as responsible for its growing use as feed supplements and fishing baits especially in European countries.

Tiger nuts are fruits from a perennial which, like the potato plant, sends out underground runners. It is shunned as a weed in the majority of warm countries because of its creeping, rapidly expanding roots. It was the Arabs who brought this Cyprus grass plant from Africa to Southern Europe. It is now cultivated on only a small scale in North Africa and Spain, where it is esteemed for its nutritional content, as well as its nutty almond-like taste. These rhizomes are acorn-sized and chestnut brown to blackish-brown, with a wrinkled skin.

2.2 Uses of Tiger Nut

Grain milk looks very similar to cow's milk. It has lower protein content and higher carbohydrate content than cow's milk. Just as cow's milk is often fortified, grain milks may have calcium and some vitamins (especially B12) added to them. Grain milk is low in saturated fat and contains no lactose, which is beneficial for those who are lactose intolerant. Grain milk also lacks milk protein, making it suitable for vegans and people with milk allergies. Flavoured grain milk can come in plain, vanilla, chocolate or a variety of other flavours. Like unflavoured grain milk, it is often available with added nutrients. There are also grain milk cream and desserts available (Wikipedia, 2007).

Despites the multifunctional ability and use of tiger nut, with the fact that it contains a wide variety of nutrients which makes it easy for it to be incorporated into animal feeds, eaten as snacks in terms of refreshment especially after meals, used as baits amongst other vital functions, Tiger nut is still being looked upon as a weed in some parts of the world and this is due to the fact that it is either still underutilized or not utilized in such regions.

The tubers (raw, cooked or dried and ground into a powder) are also used in confectionery. Tiger nut has a delicious nut-like flavour but characterized with a rather chewy and tough skin. They taste best when dried. They can be cooked in barley water to give them a sweet flavour and then be used as a dessert nut. A refreshing beverage is made by mixing the ground tubers with water, cinnamon, sugar, vanilla and ice. The ground tuber can also be made into plant milk with water, wheat and sugar. Also, some edible oil is obtained from the tuber. It is considered to be superior oil when compared to olive oil. The roasted tubers are a coffee substitute. The base of the plant can be used in salads. This probably means the base of the leaf stems (Ken, 2006).

Tiger nut is also useful in medical field as they are regarded as a digestive tonic, having a heating and drying effect on the digestive system and alleviating flatulence. They also promote urine production and menstruation. The tubers are said to be aphrodisiac, carminative, diuretic, stimulant and tonic. In Ayurvedic medicine, they are used in the treatment of Flatulence, indigestion, colic, diarrhoea, dysentery, debility and excessive thirst (Ken, 2006).

The tuber is also used in cooking and in making soap (in a process known as saponification) due to its 30% content of non-drying oil. When properly extracted without contaminations, it has a good quality of not solidify at room temperature and stores well without going rancid. The leaves of the tuber are not also left out, for it can be used for weaving hats and matting etc.

In the United States, the primary use of *chufa* as a crop is to attract and feed game, particularly wild turkeys. It was noticed that turkeys love *chufa* tubers, and as natural scratchers once they discover a plot of *chufa*, they will return again and again, all winter long, or until spring arrives and other food is readily available (Ojos Negros Research Group, 2008).

Chufa tubers also have an important role in pig farming in the United States. They are planted so that pigs could be turned into the fields to fatten and improve the taste of pork. In the United States, *chufa* tubers have been used as hog feed, pastured in the field in states such as Florida, Georgia, and Alabama. Tubers of *chufa* have also been identified as valuable food for waterfowl and cranes. Ducks dive for them when wetland fields are flooded. *Chufa* is also used in seed mixes for wetland restoration, mitigation, and erosion control. *Chufa* is potentially a commercial source of high-oleic acid vegetable oil and high-carbohydrate tuber cakes. Some authors believe that tuber oil could be exploited in the same way as olive oil (Ojos Negros Research Group, 2008).

Products from the *chufa* tubers include aqueous solutions (as a base for non-alcoholic beverages), milky solutions (as refreshing beverages or partial milk substitutes), as well as cookies and ice-cream made with *chufa*. The caramel from malted tubers of *Cyperus esculentus* may be used to add flavour, or colour to certain baked products, non-alcoholic malt beverages and dark beers, and in the production of condiments. The starches obtained from *chufa* and rice showed similar properties; the solutions of the starch exhibited a good paste stability, clarity, and adhesive strength. The starch can be used in many starch-based foods as well as in the cosmetic industry, and for laundry, glazing and stiffening. The waste residue after oil extraction could be further modified producing syrups, flours, or livestock feeds (Ojos Negros Research Group, 2008).

Recent studies have shown that *Chufa* tubers have a relatively high total antioxidant capacity, because they contain considerable amounts of water-soluble flavorous glycosides. Consumption of antioxidants could protect the immune system of malnourished populations. The intake of antioxidant-containing foods may delay the progression of HIV infection to AIDS (Ojos Negros Research Group, 2008).

For many years, the *chufa* tubers have been considered to have adequate properties to fight respiratory infections, and some stomach illnesses. To this date, the *"Horchata de Chufas"* is considered an effective remedy for diarrhoea, according to popular tradition in Valencia, Spain (Ojos Negros Research Group, 2008).

According to researches, it has been noticed that the need for vegetable protein is being on the increase, due to the increase in population of those who are milk-sugar intolerance that is inability to digest milk- sugar (lactose) and also the need of beverages with low and healthy cholesterol. The saturated fats in cow's milk are unhealthy and increase the body's cholesterol. The protein in cow's milk has no benefits for the body's cholesterol. The protein present in *Horchata de Chufas* can decrease cholesterol levels. The FDA (Food and Drug Administration of US) confirms that the protein in *Horchata de Chufas*, as part of a diet low in saturated fat and cholesterol may significantly reduce the risk of coronary heart (Yalc¸ın Cos¸kuner *et al*, 2002).

Improvement in the methods and food processing of vegetable beverages has been on the increase, knowing fully well its uses and importance to man's health.

2.3 Nutritional Content of Tiger Nut Milk

Tiger nut milk has long been recognised for their health benefits as they are high in fibre, proteins and natural sugars. They have a high content of soluble glucose and oleic acid. Along with a high energy content (starch, fats sugars and proteins), they are rich in minerals such as phosphorous and potassium and in vitamins E and C.

It is believed that they help to prevent heart attacks, thrombosis and cancer especially of the colon. They are thought to be beneficial to diabetics and those seeking to reduce cholesterol or lose weight. They fibre content combined with a delicious taste make s them ideal for healthy drinking (Dianne, 2006-2007).

Table 2.1: Proximate Composition and Digestible Crude Protein Contents of Tiger Nut Milk

Minerals	Content (%)
Dry matter	7.73[a]
Crude protein	8.01
Digestible crude protein	4.02
Total ash	0.47
Fat	26.18[a]
pH	6.12
Titrable acidity	0.16
Calcium	8.75[a]
Phosphorus	10.57[a]
Total energy (Kcal. 100^{-1}g)	388.30[a]

Source: Belewu *et al.* (2007)

Table 2.2: Principal Fatty Acid Composition (%) in the Milk Source of Tiger Nut.

Fatty Acids	Tiger Nut
Myristic acid	0.08[a]
Oleic acid	68.38[a]
Linoleic acid	11.70[a]
Lauric acid	Trace
Palmitic acid	13.9[a]
Capric acid	-

Source: Belewu *et al.* (2007)

2.4 Relationship between Tiger Nut Milk and Other Plant Milks

Tiger nut is a root crop, has the ability to produce milk and becoming widely know and embraced for its nutritional values and health benefits. Some agricultural crops also possess the ability of producing milk or vegetable beverages, making it possess similar properties like that of tiger nut. These examples are;

2.4.1 Soya Bean Milk

This is extracted from a leguminous plant, soya beans (*Glycine max).* This is also known as Soybean, soy and soya bean, common name for an annual leguminous plant and its seeds belonging to the subfamily Papilionoideae, family Fabaceae (formerly Leguminosae). The soybean probably originated in eastern China and is widely cultivated as a farm crop. The soybean, an ancient food crop in China, Japan, and Korea, was introduced into the United States in the early 1800s and was grown as a minor forage crop for many years. The two basic products of the soybean are protein meal and oil. In the United States, more than 90 percent of the oil is consumed as margarine, shortening, mayonnaise, salad oils, and other edible products; the rest is used in industrial products such as paint, varnish, linoleum, and rubber fabrics. Soybean meal is the major source of the protein supplement used in livestock feeds, which utilize 98 percent of the total meal produced. In the protein-short areas of the world and elsewhere, soybean meal is finding increasing use in human food products (Microsoft Encarta, 2009).

Soybeans seed has a close protein content and fairly close amino – acids with cow milk. The beans can be utilized in the liquid, powdery and curd forms for human consumption. The oil could be converted to margarine and salad oil. The meal is used as animal feed. Soybean was used to fortify maize custard while soft cheese and yoghurt could be prepared from soybeans. Recently Belewu *et al* (2005) documented the combination of soymilk (50%) and coconut milk (50%) in the preparation of soy-coconut yogurt (Belewu *et al.*, 2007).

Nutritional values of plain soy milk possess an excellent source of high quality proteins, isoflavones and B – vitamins. Soy milk is free of the milk sugar (lactose) and is a good choice for people who are lactose intolerant. Also, it is a good alternative to those who are allergic to proteins of cow's milk. Soy milk contains only vegetables proteins. Vegetable proteins have the advantage that they cause less loss of calcium through the kidneys. It is known that a diet rich in animal (and dairy protein) creates a higher risk for osteoporosis. Soy milk contains no lactose. About 75 percent of the world population cannot tolerate lactose. Some ethnic groups are more affected than others. For example 75 percent of Africans and 90 percent of Asians have lactose intolerance. As an additional benefit, soy milk contains the prebiotic sugars stachyose and raffinose. These prebiotic sugars boost immunity and help decrease toxic substances in the body (Anonymous, 2009).

The majority of soy protein is a relatively heat-stable storage protein. This heat stability enables soy food products requiring high temperature cooking, such as tofu, soymilk and textured vegetable protein (soy flour) to be made. Soybeans are considered by many agencies to be a source of complete protein. A complete protein is one that contains significant amounts of all the essential amino acids that must be provided to the human body because of the body's inability to synthesize them. For this reason, soy is a good source of protein, amongst many others, for vegetarians and vegans or for people who cannot afford meat. According to the US Food and Drug Administration, Soy protein products can be good substitutes for animal products because, unlike some other beans, soy offers a 'complete' protein profile, Soy protein products can replace animal-based foods—which also have complete proteins but tend to contain more fat, especially saturated fat—without requiring major adjustments elsewhere in the diet (Wikipedia, 2007).

Soy milk reduces cholesterol. The saturated fats in cow's milk are unhealthy and increase your cholesterol. The protein in cow's milk has no benefits for the cholesterol. Soy protein can decrease cholesterol levels. The FDA (Food and Drug Administration of US) confirms that soy protein, as part of a diet low in saturated fat and cholesterol may significantly reduce the risk of coronary heart. Soy milk does not cause insulin dependent diabetes, although no general consensus exists among scientists, some studies have shown an association between drinking cow's milk in early life and the development of insulin dependent diabetes. This association does not exist with soy milk (Anonymous, 2009).

2.4.2 Coconut Milk

This is plant milk which is extracted from the fruit of a tree of the palm family widely distributed in the tropical regions and commonly known as coconut.

The coconut palm belongs to the family Arecaceae (formerly Palmae). It is classified as *Cocos nucifera* (Microsoft Encarta, 2009).

Coconut milk is a sweet, milky white cooking base derived from the meat of a mature coconut. The colour and rich taste of the milk can be attributed to the high oil content and sugars.

Coconut (*Cocos nucifera*) milk is being used by confectionaries, bakeries, biscuits and ice cream industries worldwide to enhance flavor and taste of various products. Coconut juice was founded to be rich in calcium (800mg) while the protein and fat contents were 50g and 65g respectively. The energy content was 61.0 kilocalories and the total available carbohydrate was 300g. The milk was reported to be high in minerals and vitamin content, while total saturated fat was 10% of the total energy. Percentage energy distribution from protein, total fat and carbohydrate was 10:30:60 (Belewu *et al.*, 2007).

Coconut milk is considered very healthy in Ayurveda. Some people believe that coconut milk can be used as a laxative. It is also used for healing mouth ulcers. In a study with rats two coconut based preparations (a crude warm water extract of coconut milk and coconut water dispersion) were studied for their protective effects on drug-induced gastric ulceration. Both substances offered protection against ulceration, with coconut milk producing a 54% reduction versus 39% for coconut water (Wikipedia, 2007).

2.5 Separations in Food Processing

Separation of one or more components from a complex mixture is a requirement for many operations in the food and biotechnology industries. The components in question range from particulate materials down to small molecules. The separations usually aim to achieve removal of specific components, in order to increase the added value of the products, which may be the residue, the extracted components or both. All separations rely on exploiting differences in physical or chemical properties of the mixture of components. Some of the more common properties involved in separation processes are particle or molecular size and shape, density, solubility and electrostatic charge. In some operations more than one of these properties is involved. However, most of the processes involved are of a physical nature (Mohsenin, 1980, 1984; Lewis, 1990).

Separations are vital to all areas of the food processing industry. Separations usually aim to remove specific components in order to increase the added value of the products, which may be the extracted component, the residue or both. Purposes include cleaning, sorting and grading operations, extraction and purification of fractions such as sugar solutions or vegetable oils and drinks, recovery of valuable components such as enzymes or flavour compounds, or removal of undesirable components such as microorganisms, agricultural residues.

Separation rate is dependent on the magnitude of the driving force and may be governed by a number of physical principles involving concepts of mass transfer and heat transfer. Rates of chemical reaction and physical processes are virtually always temperature-dependent, such that separation rate will increase with temperature. However, high temperature give rise to degradation reactions in foods, producing changes in colour, flavour and texture, loss of nutritional quality, protein degradation, etc. Thus a balance must be struck between rate of separation and quality of the product (James, 2006).

Separations may be classified according to the nature of the materials being separated.

2.5.1 Solid – Liquid Extraction

Liquid – solid separation applies to operations where discrete solids are removed from the liquid. Many plant materials contain valuable liquid components such as oils or juices in the cellular structure. These may be separated from the pulped raw material by the use of presses, in a process known as expression. Batch type hydraulic systems or continuous roller, screw or belt systems are available for different applications such as fruit juice, wine and cane sugar production, or extraction of oil from seeds. Expression of fruit juices may be aided by the use of enzymes to improve efficiency of expression and to control the pectin level (Schwartzberg, 1983).

An alternative system to recover components from within a solid matrix is extraction, which relies on the use of differential solubilities for extraction of soluble solids such as sugar from sugar beet, coffee from roasted ground beans, juices from fruit and vegetables and from materials during the manufacture of instant tea. The most common extraction material is hot or superheated water. However, organic solvents are used, e.g. hexane for oil extraction and methylene chloride to extract caffeine from tea and coffee. The use of supercritical fluids such as carbon dioxide can also be used for the extraction of volatile materials such as in the decaffeination of coffee (Perry and Green, 1984). A combination of expression and extraction is used to remove 99% of the oil from oilseeds (James, 2006).

Water removal from solids plays an important role in food processing. Liquid foods include aqueous or oil based materials, and frequently contains solids either in true solution or dispersed as colloids or emulsions.

Discrete solids may be removed from liquids using a number of principles. Conventional filtration systems separate suspended particles of solids from liquids on the basis of particle size. The liquid component is passed through a porous membrane or septum which retains the solid material either as a filter cake on the upstream surface, or within its structure, or both. Filter media may be rigid, such as wire mesh or porous ceramics, or flexible, such as woven textiles, and are available in a variety of geometric shapes and pore sizes. In practice, the flow of filtrate may be brought about by gravity, the application of pressure greater than atmospheric upstream of the filter (pressure filtration), applying a vacuum downstream (vacuum filtration) or by means of centrifugal force (centrifugal filtration). The theory and equipment for industrial filtration are fully described by Brennan *et al.* (1990). Applications can be divided into those where a slurry containing large amounts of insoluble solids is separated into a solid cake and a liquid, either of which may be the desired product; alternatively clarification is the removal of small quantities (<2%) of suspended solid from a valuable liquid.

Filtration finds applications throughout the food and biotechnology industries. Sugar juices from cane or beet are filtered to remove high levels of insoluble solids, and are frequently clarified at a later stage. Filtration is employed at various stages during the refining of edible oils. In the brewing industry filtration of mash, yeast recovery after fermentation and clarification of beer are carried out. Filtration is used during the manufacture of numerous other foods, e.g. vinegar, starch and sugar syrups, fruit juices, wine canning brines. In biotechnology, filtration is carried out to clarify and recover cells from fermentation broths.

More recently, membranes with much smaller pores have been introduced. Microfiltration involves the removal of very fine particles or the separation of microorganisms and sterilization of fluids. Ultrafiltration membranes permit the passage of water and components of low molecular weight in a fluid but reject macromolecules such as protein or starch (Grandison and Lewis, 1996).

2.5.1.1 Centrifugation

Solids may be separated from liquids on the basis of particle size and density using settlement, or using centrifugation. Settlement is a slow process because it relies on the influence of gravity, but is widely used in water and effluent treatment processes. In centrifugal classification a suspension of insoluble solids (not more than about 1%) is subjected to cyclic motion in a bowl, which subjects the particles to a centrifugal force, many times in excess of the gravitational force. The denser solid is retained on the inner surface of the bowl while the liquid is tapped off at the centre. An alternative is to use a filtering centrifuge in which the bowl wall is perforated so the liquid is forced out through the wall. The size of the perforations determines what portion of solids is retained in the bowl. Various designs of centrifuge are available for numerous applications such as removal of solids from dairy fluids, oils, juices, beverages, fermentation broths, or dewatering of sugar crystals and com starches. Such separations may be carried out on a batch-wise basis, although automatic and continuous centrifuges are available (Brennan *et al.,* 1990).

A common centrifuge is a mechanical device using the principle of centrifugal force to separate substances of different densities, and a container that is spun rapidly. The only limit to the centrifugal force is the strength of the metal of which the device is made. Centrifugal forces may be thousands of times as great as the force of gravity.

Centrifuges may be used for rapid separation of substances that would normally separate slowly under the influence of gravity (Microsoft Encarta, 2009).

2.5.1.2 Extraction Using Soxhlet Apparatus

The operation of the soxhlet apparatus is mainly on the use of appropriate solvent to extract out the needed material. This apparatus was designed by Franzvon Soxhlet in

1939, first with automated extraction apparatus and later in the intervening years several modification of this apparatus (Soxtherm, Soxtec,Butt, Goldfisch, Bailey-Walker, etc.) have been developed.

Solvent extracts are prepared by treating a solid or liquid with a solvent that will dissolve the desired components selectively. For example, vanilla flavoring is produced by using a solvent (usually alcohol) to dissolve and separate the compounds that produce the vanilla flavor and aroma from vanilla seedpods. This process is known as solvent extraction and is widely used in the commercial production of plant and animal by-products.

In soxhlet apparatus extraction, the solvents used must meet several requirements. They must dissolve the maximum amount of the desired component and a minimum amount of undesirable materials. The solution must be easy to separate from the undissolved substance. In the extraction of solids, this separation is usually not difficult, but in liquid to liquid extraction, a solvent must be chosen that will separate quickly and completely from the liquid being extracted. The final requirement is that the solvent be easy to separate from the extracted material, usually by distillation, without affecting the quality of the product (Microsoft Encarta, 2009).

The use of soxhlet apparatus is one of the oldest methods of separation known and certainly dates back to prehistory. The science of solvent extraction has evolved accordingly over a long period of time and much progress has been made in the understanding of solvation and the properties of the liquid mixtures used in extraction processes. The associated literature on phase behavior is certainly extensive and, although representation of highly non-ideal mixtures is still problematic, many theoretical models have been successfully developed (Fredenslund, 1975; Hildebrand and Scott, 1950; Prausnitz *et al.*, 1986). Extensive databanks of pure component properties have grown to support such models in order to predict solvent performance in process applications. Today, even with the introduction of new separation technologies, solvent extraction remains one of the most widespread techniques operating on an industrial scale. Hannay and Hogarth's (1879) early observations of the dissolution of solutes in supercritical fluid (SCF) media introduced the possibility of a new solvent medium. However, it is only in recent (since 1960) that commercial process applications of supercritical fluid extraction have been extensively examined (Grandison and Lewis, 1996).

2.5.1.3 Crude Method of Extraction of Tiger Nut Milk (Filtration)

Filtration is a mechanical or physical operation which is used for the separation of solids from fluids (liquids or gases) by interposing a medium through which only the fluid can pass. Oversize solids in the fluid are retained, but the separation is not complete; solids will be contaminated with some fluid and filtrate will contain fine particles (depending on the pore size and filter thickness). It is also used to separate particles and fluid in a suspension, where the fluid can be a liquid, a gas or a supercritical_fluid. Depending on the application, either one or both of the components may be isolated.

Filtration, as a physical operation is very important in chemistry for the separation of materials of different chemical composition. A solvent is chosen which dissolves one component, while not dissolving the other. By dissolving the mixture in the chosen solvent, one component will go into the solution and pass through the filter, while the other will be retained. This is one of the most important techniques used by chemists to purify compounds.

This method of extraction has been practiced for ages, and it is predominantly practiced by those in pastoral communities. In quest of wanting to satisfy the nutritional thirst of these communities, more energy and time has been given to this method but with no avail. It is a vigorous practice which relies mainly on man's energy.

The matured, dried tiger nut plant is uprooted and the tiger nut harvested from the farm. The harvested nuts are now cleaned and washed with water so as to prevent it from contaminants and sand particles, after which they are spread under the heat of the sunlight, where they will be dehydrated. This drying process is only carried out if there is an intention for storage or to be taken directly as a snack .The washed tiger nuts are now soaked for several hours so as to make it easier to grind by pounding. After the tiger nuts are seen to have soaked by swelling, they are drained and later triturated by pounding it with the help of our locally available mortar and pestle. This stage is known to be one of the tedious stages because it demands for more energy of impact created within the mortar and the pestle. The pounded or triturated nuts are now mixed with water, making it easy to extract the tiger nut milk content out from the solid grounded nuts. The milk is now separated from the inert (insoluble substance) by straining it through the tiny mesh of a sieve or a muslin cloth. A particular amount of water is added to the inert so as to extract more of the milk left in the insoluble substance.

Generally, the extraction of the tiger nut milk is still done in a small scale due to the local method embraced by most people of the rural communities and by so doing, cannot meet up to the demands of the tiger nut in the communities.

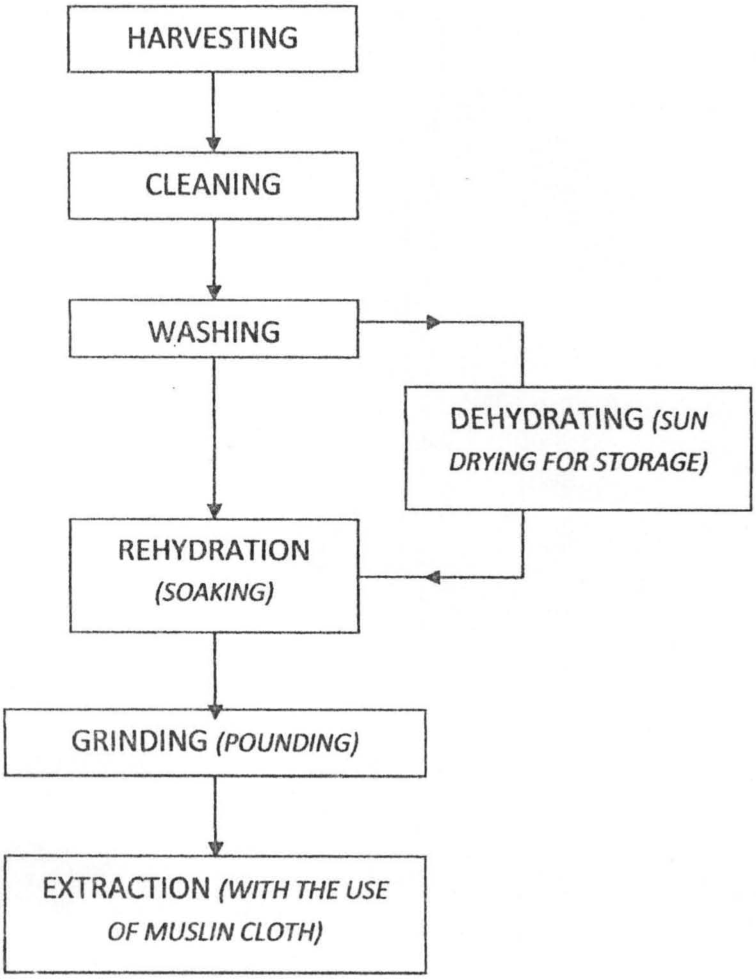

Fig 1: Flow Chart of a Crude Method of Extraction.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 MATERIALS AND APPARATUS

The project involves the use of three different methods of extraction in extracting the tiger nut milk from tiger nut. The proximate composition of the individual results from the different extraction was also analyzed.

3.1.1 Materials

The materials used in the process of carrying out the practical are grouped below:

Samples

The major material/sample used is the dried variety of tiger nut obtained from Minna market.

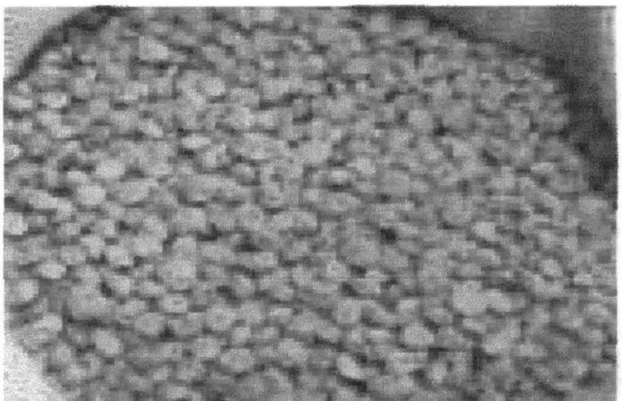

Plate 1: Dried Sample a Yellow Variety Tiger Nut.

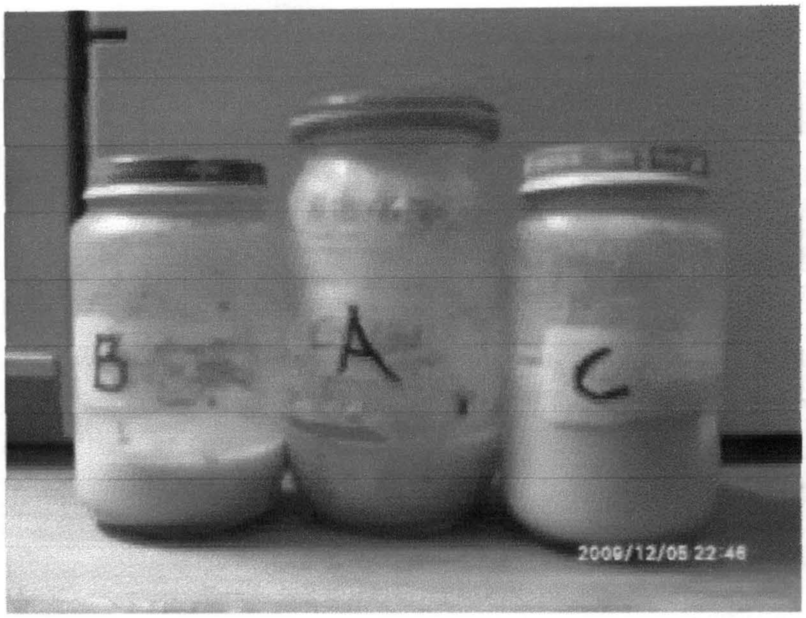

Plate 2: Tiger Nut Milk Extract Samples

Apparatuses Used in Extraction of Tiger Nut Milk

The following apparatus were used in the extraction of the milk content out from the tiger nut sample:

1. Soxhlet apparatus
2. Centrifuge
3. Thomas Willey Milling machine
4. Test tubes
5. Distilled water
6. Blender (miller)
7. Two layers of Muslin cloths (cheese cloth)

Apparatus used in the Proximate Composition Analysis

The following apparatus were used in the determination of the proximate compositions of tiger nut milk.

1. Markham's apparatus
2. Petri dish
3. Desiccators
4. Crucibles
5. Weighting balance (Analytical balance machine i.e. Adventuer OHAUS) by MELLER
6. Filter paper
7. Electronic air oven
8. Fume cupboard
9. Electronic hotplate
10. Kjeldahl digestion block
11. Soxhlet apparatus
12. Silica dishes
13. Beaker
14. Pipette
15. Thimbles
16. Spatula
17. Muffle furnace
18. Buncher funnel
19. Water distiller

Reagents Used During Proximate Composition Analysis

The following reagents were used during the proximate composition analysis of the individual tiger nut milk extracted.

1. Sodium Hydroxide (NaOH) solution
2. Tetraoxosulphate (IV) acid (H_2SO_4)
3. Methyl orange indicator
4. Petroleum ether
5. Hydrochloric acid (HCl)
6. Boric acid (H_3BO_3)
7. Phenol
8. Sodium tetraoxosulphate (VI) acid (Na_2SO_4)
9. Bromocresol green
10. Methyl red indicator
11. Ethanol
12. Distilled water

3.2 Extraction Methods

The following methods were carried out during the study.

3.2.1 Preparatory Processes before Tiger Nut Milk Extraction

Three methods of extractions were considered in the extraction of the tiger nut milk.

The tiger nut sample was first properly sorted, washed and rinsed finally with distilled water. The sample was later soaked with hot water of about 80°C for about one hour. The water was later drained out and replaced with another hot water at the same temperature, so as to speed up the water absorption of the dried tiger nut sample and also to soften it for better trituration.

3.2.1.1 Centrifugation Method of Extraction

About 6L (litres) of distilled water was added to 1Kg (Kilogram) of washed, prepared tiger nut sample and triturated/milled several times using the blender (miller). It was later divided into several large test tubes and placed into the centrifuge machine, to centrifuge for few minutes in order to separate the milk from the insoluble residue. The centrifuge was left to operate at about 18000 rpm (revolutions per minutes) for 5 minutes.

This method assisted in increasing the rate of gravitational force of the denser particles by incorporating centrifugal force from the centrifuge, which can be calculated using the Stoke principle.

The clear white colloidal sample, which is the milk was later decanted and separated into a clean bowl / container labelled A.

3.2.1.2 Soxhlet Apparatus Extraction

Some quantity of washed and prepared tiger nut sample was milled using the Thomas Willey Milling machine. Some quantity of the milled tiger nut sample was filled into a thimble and placed into the soxhlet chamber of the soxhlet apparatus. The round bottom flask was filled with the solvent of about 4 times the volume of the soxhlet chamber. A serious challenge was encountered in using the appropriate solvent, and after considering the product needed, water as a universal solvent, was used as the solvent.

All the apparatus were set up appropriately with the condenser inclusive. The round bottom flask of the apparatus was placed directly on a heat source, electric hot plate and left to siphon in a number of times for about 5-6 hours into the reflux soxhlet chamber. The condenser was detached and thimble removed, also the round bottom flask which holds the milk content. The milk content is received in a clean container and labelled B.

3.2.1.3 Crude Method of Extraction (Simple Filtration)

About 6L (litres) of distilled water was added to 1Kg (Kilogram) of washed, prepared tiger nut sample and triturated/milled several times using the blender (miller). The blended sample was poured into a two layered muslin cloth, to separate the milk from the insoluble residue. This was placed in a clean container labelled C, pressed and squeezed together, as a result squeezing out and separating the milk from its insoluble residue into the clean container.

3.3 Procedures for the Determination of the Proximate Composition

The following methods were carried out in determination of the proximate composition of the tiger nut milk samples, which were outlined in Association of Official Analytical Chemists (AOAC, 1980).

3.3.1 Determination of the Moisture Content (MC)

The determination of the moisture content is one of the most important and widely used measurements in samples that absorb and retain water. Chemical analysis are usually made on dry matter basis, moisture content determination looks very simple in concept, but in practice the accurate determination is complicated by number of factors which vary considerably from one sample to another.

The procedure outline in AOAC (1980) was used for the determination of the moisture content, a clean well labelled oven dried dish was weighed W_1, add tiger nut milk samples into the dish and weigh W_2. Heat the dish and tiger nut milk samples in the thermosetting oven at 105°C for 24 hours, the dish is then transferred to a desiccator and allowed to cool for one hour and weigh W_3. The moisture content was then obtained using the formula given below.

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

Where W_1 = mass of the oven dried dish.

W_2 = mass of the oven dried dish and Tiger Nut milk samples.

W_3 = mass of the oven dried dish and dried Tiger Nut milk samples

3.3.2 Determination of the Ash Content

The ash of biological materials is an analytical term for the inorganic residue that remains after the organic matter has been burnt off. The ash is not the same as the inorganic matter present in the original material since there may be losses volatilization or chemical interaction between the constituents.

The procedure outline in AOAC (1980) was used for the determination of ash content, a crucible is placed in the muffle furnace and heated at 350°C for 15 minutes, it is then removed and cooled in a desiccator for about an hour and it mass, W_1 obtained. 3-5g of the milk samples was then added and the crucible weighed again for the mass W_2. The crucible was heated in the furnace slowly increasing the temperature from 200-600°C, removed and allowed to cool in a desiccator before being weighed for the mass W_3. The ash content is then computed using the formula below.

$$\%\,\text{Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where W_1= mass of the empty crucible

W_2= mass of the crucible and Tiger Nut milk sample

W_3= mass of the crucible and residue (Ash)

3.3.3 Determination of the Crude Fibre (CF) Content

Crude fibre is that portion of the milk content that is not ash or dissolves in boiling solution of 1.25% H_2SO_4, 1.25% NaOH or Tri-chloro-acetic acid (T.C.A.). Crude fibre was originally thought to be indigestible portion of any main food. It is however known that fibre consists of cellulose that can be digested to a considerable extent by both ruminants and non-ruminants.

The procedure outline here was used for the determination of crude fibre; A mass of tiger nut milk sample, W_1 was placed in a 500ml conical flask, 50ml Tri-chloro-acetic acid (T.C.A.) was added and allowed to boil within a minute before being boiled lightly for 30 minutes over a steam bath, it is then filtered through a filter paper using Bunche funnel, rinsed thoroughly with hot distilled water. The residue is then left to drain and separated into a crucible with the help a spatula, kept in a crucible oven dried at 105°C cooled in a desiccator and its weight W_2 obtained, it is then heated in a muffle furnace at 300°C for 30 minutes, kept in a desiccator and allowed to cool to room temperature and weighed again W_3. The crude fibre is then obtained from the formula

$$\%\ Crude\ Fibre\ (CF) = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}.$$

Where W_1= mass of Tiger Nut milk sample used

W_2= mass of crucible and residue

W_3= mass of crucible and ash

3.3.4 Determination of the Lipid Content /Ether Extract (EE) Content

Lipids refer to the fats and oil contained in plants and animals, fats are contained in animals while oils are found in both plants and animals. Examples of fats include lard, animal sources of oil include cod liver oil, sebaceous fluid (in little quantity) while plant sources of oil include palm oil, groundnut oil, cotton seed oil etc.

Fats are mixtures of various glyceride of fatty acids which are soluble in certain organic solvents. Extraction is carried out, using a Soxhlet apparatus with ether or petroleum ether. The usual procedure is to continuously extract the fat content with 40/60°C petroleum ether in a convenient extractor (Soxhlet extractor). The ether extraction method is based on the principle that non-polar components of the sample are easily extracted into organic solvents. Direct extraction gives the proportion of free fat but gives no clue to the particular fatty acids.

The procedure outline in AOAC (1980) was used for the determination of lipid content, a dried fat free thimble was weighed W_1, add dried milk samples and weigh again W_2. A fat free 500 ml round bottom flask is then weighed W_3. The flask is then filled to two-thirds of its volume with petroleum ether. A soxhlet extractor with a reflux condenser was fitted together, heat source was adjusted so that the solvent boiled gently and was left to siphon for a period of 5-6 hours, condenser was detached and thimble was removed. The flask containing fat residue was dried in an air oven at 100°C for 25 minutes and was allowed to cooled in a desiccator weighed W_4, the thimble was placed in a beaker and put in an oven at 50°C which dried with constant weight with sample. It was cooled in a desiccator and weighed W_5. The lipid content of the tiger nut milk sample was then calculated from either of the two formulae below.

$$\%\ \text{Lipid content} = \frac{W_4 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

$$\%\ \text{Lipid content} = \frac{W_2 - W_5}{W_2 - W_1} \times \frac{100}{1}$$

Where W_1= mass of the empty thimble

W_2= mass of the thimble and dried tiger nut milk sample

W_3= mass of fat free empty flask

W_4= mass of flask containing the oil residue

W_5= mass of the thimble and tiger nut milk sample after oil extraction.

3.3.5 Determination of the Nitrogen Free Extracts (NFE) Content

The procedure outline in AOAC (1980) was used for the determination of Nitrogen content in any sample; it involves complete digestion of samples in hot concentrated acid, and in the presence of an appropriate catalyst. The catalyst is to convert all nitrogen in the nitrogenous materials in the sample to ammonium ion.

The Kjeldahl digestion is usually performed by heating the sample with H_2SO_4 containing substances which promote oxidation of organic mater by increasing the boiling point of the acid (K_2SO_4 or Na_2SO_4) and Selenium (Se) or Copper (Cu) which increase the state of oxidation of organic matter. These reagents here are referred to as a digestion catalyst, digestion for certain period usually for about an hour, is necessary until a clear solution is obtained so as to obtain an accurate results. The determination of nitrogen free extracts consists of three stages as shown below.

Stage 1 (Digestion)

Add 20 ml of concentrated H_2SO_4 acid and a Kjeldhal digestion tablet to 2g of the tiger nut milk sample. Heat on heater starting with low heat for 15 minutes, increase to medium heat for 30 minutes and finally at high heat until digested (light green or grey white), continue heating for few minutes to ascertain complete digestion. It is then left to cool. Wash residues if any and filter, also making the digest up to 50 ml (V_1).

Stage 2 (Distillation)

5 ml of 2% boric acid is added into a 100 ml conical flask, this is because boric acid traps ammonia from the digest. 3 drops of indicator is added (the indicator is 0.198g of bromocresol green and 0.132g of methyl red in 200 ml of alcohol). The receiving flask was placed so that the tip of the condenser tube was below the surface of the boric acid. 10ml of 40% NaOH was added and distilled about 50ml into the receiving flask (V_2).

Stage 3 (Titration and Calculation)

Titrate the distillate with standard mineral acid (0.1M HCl or 0.025M H_2SO_4), also titrated with the acid was a blank.

Sample titre: T_1

Blank titre: T_2

Control titre: $T_1 - T_2 = T$

Molarity of acid: M

Digestion:

$$H_2SO_4 + 2NH_3 \xrightarrow{catalyst} (NH_4)_2 H_2SO_4$$

$$(NH_4)_2 H_2SO_4 + 2NaOH \rightarrow 2Na_2SO_4 + NH_3 + 2H_2O$$

$$NH_3 + H_3BO_3 \rightarrow NH_4^+ + H_2BO_3^-$$

Titration:

$$NH_4^+ + H_2BO_3^- \xrightarrow{Bromocreso\lg reen+methylred} NH_4Cl + H_3BO_3$$

If 1 mole of HCl requires 1 mole of NH_3

Therefore, Molarity of HCl is the same as the Molarity of NH_3

$$\text{Molarity of } NH_3 = \frac{M \times T}{1000}$$

$$\text{Mass of } NH_3 = \frac{M \times T}{1000} \times 17$$

$$\text{Mass of nitrogen content} = \frac{M \times T}{1000} \times 17 \times \frac{14}{17} = M \times T \times 0.014g$$

$$\%\ \text{Nitrogen content} = \frac{M \times T \times 0.014}{W} \times \frac{V_1}{V_2} \times 100$$

3.3.6 Determination of the Crude Protein (CP) Content

The procedure outline in AOAC (1980) was used for the determination of crude protein, the amount of crude protein in liquid food like milk, juice and other stuff can be obtained by multiplying the nitrogen content of the food by 6.38. The factor 6.38 owes it origin to the assumption that all liquid food protein contains 16% and that all nitrogen in a feed is present as protein, though these assumptions are not entirely valid. The protein contained in the plant milk may vary in terms of its soaking period or quantity of water absorption. This it is mathematically obtained from the expression below.

$$\%\ \text{Crude Protein (CP)} = \text{NFE} \times \text{Factor}$$

Where NFE = Nitrogen free extract

3.3.7 Determination of the Carbohydrate Content

Carbohydrates are generally referred to energy giving portion of food materials; the end product of digestion of carbohydrates is glucose which is stored in plants as starch and in animals as glycogen. According to the procedure outline in AOAC (1980) for the determination of the carbohydrates content, the percentage carbohydrate content is mathematically obtained from the expression below

$$\% \text{ Carbohydrate} = 100\% - (\% \text{ Protein} + \% \text{ Lipid} + \% \text{ Ash} + \% \text{ Crude Fibre})$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

The results obtained from the tests carried out on the tiger nut milk samples are presented in the table below.

Table 4.1: Proximate Compositions of Milk Extracted from Tiger Nut using Different Extraction Methods

	Samples		
Composition %	**A**	**B**	**C**
Moisture content	77.296	79.172	88.147
Ash content	0.278	0.326	0.683
Lipid content	27.926	21.220	20.513
Nitrogen free extract	1.394	0.715	0.402
Crude Protein	8.894	4.559	2.567
Carbohydrate	62.878	73.895	76.236

4.2 Discussion

From the above results, the tiger nut milk samples have shown to possess great characteristics that indeed show that it is a plant beverage that has great potentials in terms of its usefulness for the benefit of mankind. A comparison shows that the composition varies with the different extraction methods. It is seen from Fig 4.1

below, that there is a little difference in each of the proximate composition between the three samples.

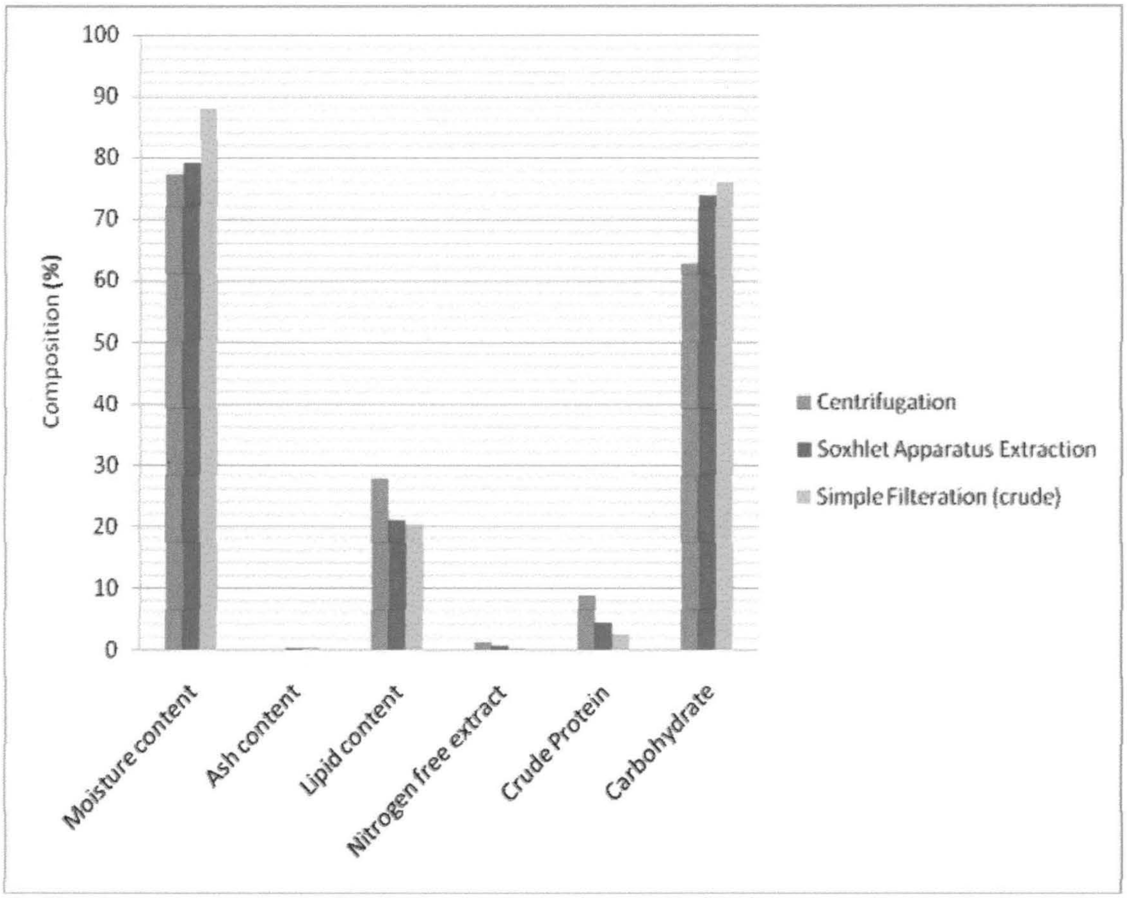

Fig 4.1: Proximate Compositions of Milk Samples Extracted from Tiger Nut using Different Methods of Extraction

The moisture content of the sample from the simple filtration extraction method is noted to be higher than that of the samples extracted using soxhlet apparatus extraction method and centrifugation method being the least with moisture content. This is as a result of the force applied on the muslin cloth used to extract the milk out from the residue. By doing this more water is extracted with the milk and this is represented in the figure below (Fig. 4.2)

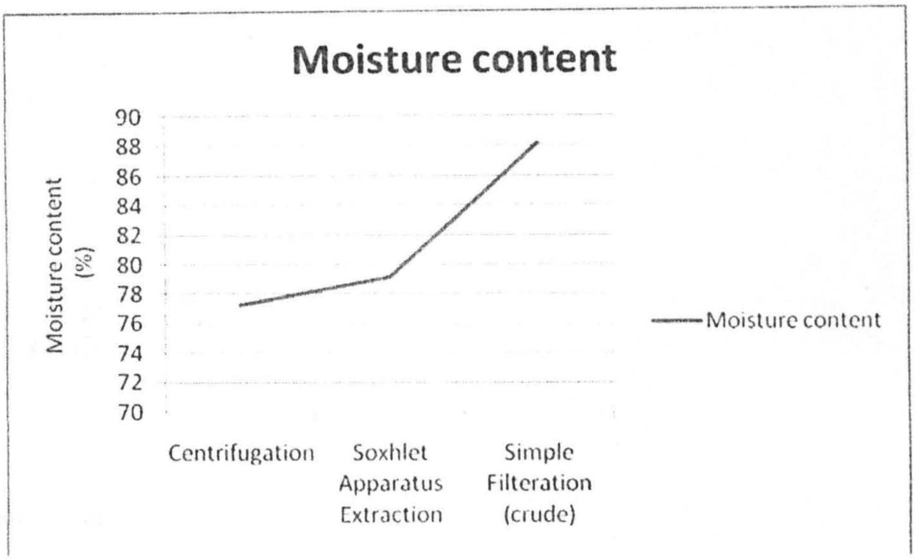

Fig 4.2: Graphical Representation of Moisture Content of Milk Extracted from Tiger Nut Using Different Extraction Methods

The ash content which is analytically known to be the term for the inorganic residue in the milk that remains after the organic matter has been burnt off, also differs a little according to the different mode of extraction. The ash content comparison of the milk represented graphically below (Fig. 4.3), shows that the sample extracted from simple filtration is more, compared with that using soxhlet apparatus and centrifugation making the least. The sample from simple filtration has more ash content as a result of having more of the content squeezed out from the tiger nut which makes it preferable for needed minerals and nutrients.

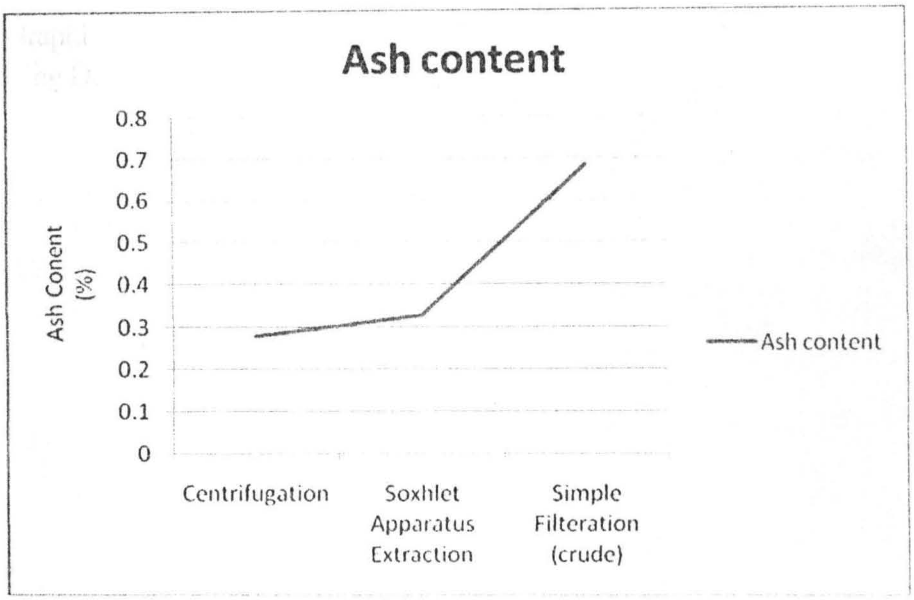

Fig 4.3: Graphical Representation of Ash Content of Milk Extracted from Tiger Nut Using Different Extraction Methods

The lipid content of the sample extracted using the simple filtration method has the least compared to that of soxhlet apparatus and centrifugation method been the highest. This comprarison is graphically represented below (Fig 4.4)

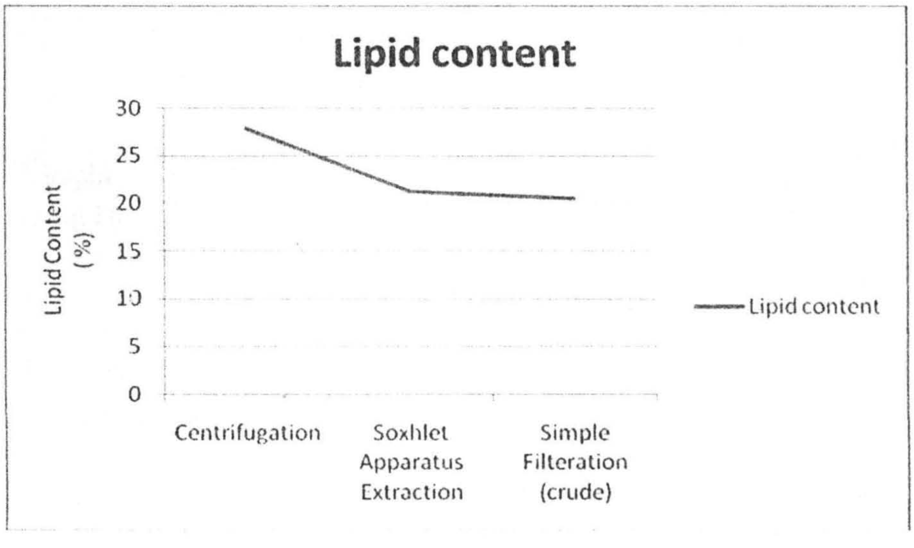

Fig 4.4: Graphical Representation of Lipid Content of Milk Extracted from Tiger Nut Using Different Extraction Methods

The term crude protein includes all nitrogenous compounds in a feed, and that contained in the samples extracted from the three different methods of extraction varies, with the sample extracted using centrifugation being the highest, followed by that using soxhlet apparatus and that extracted using simple filtration (crude) being the least. The crude protein content equivalent of a feed was calculated by multiplying the nitrogen content with a factor. Therefore the high crude protein obtained in the sample extracted using centrifugation method was as a result of high nitrogen quantity in the seed, resulting from the soaking time factor of the tiger nut. This is graphically represented below (Fig 4.5).

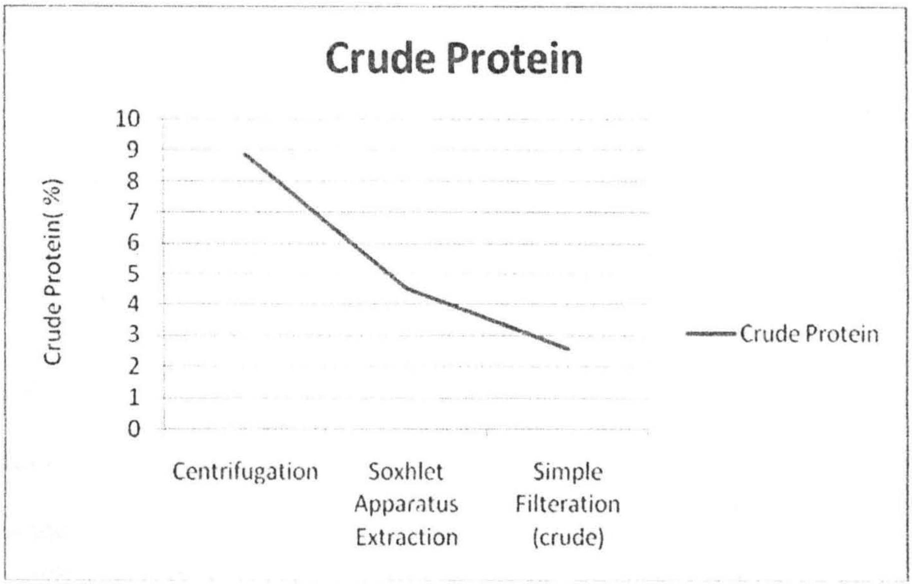

Fig 4.5: Graphical Representation of Crude Protein of Milk Extracted from Tiger Nut Using Different Extraction Methods

Carbohydrates are naturally occurring organic compounds containing carbon, hydrogen and oxygen, and this is seen to be close in the samples extracted from the three methods, having that extracted from centrifugation to be the least, followed by the sample extracted using soxhlet apparatus, and that using simple filtration (crude) as the highest.

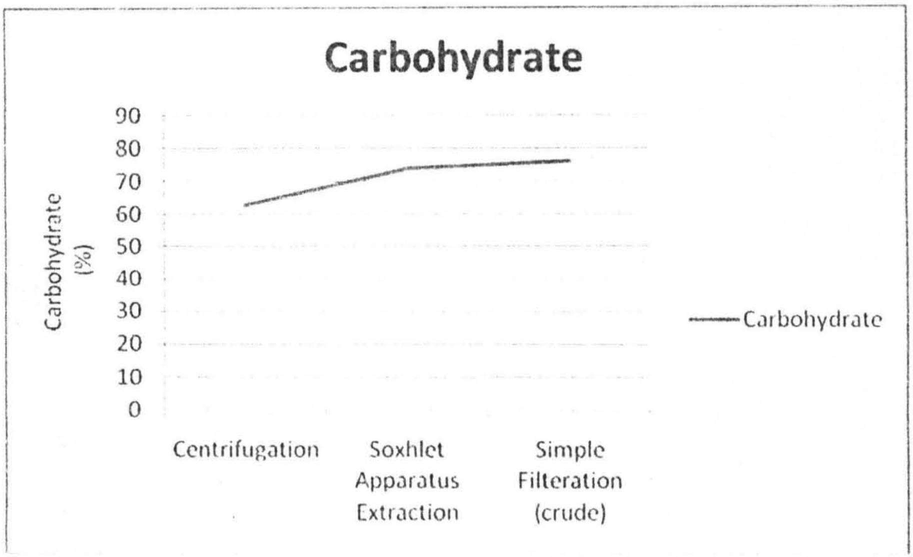

Fig 4.6: Graphical Representation of Carbohydrate content of Milk Extracted from Tiger Nut Using Different Extraction Methods

Also considering the time taken coupled with the quantity extracted from using the extraction methods, the centrifugation method is still on the advantage due less human energy dissipated and can be fairly compared in composition with that from simple filtration method (crude). On the other hand the simple filtration method is still beneficial when considering the nutritional composition and that extracted using soxhlet apparatus is of the average in the nutritional composition, more of time taken and least in quantity extracted.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The increase in statistics of those who are intolerable to the digestion of lactose in milk from animal source and low production of milk, are faced with the easy availability of a better substitute from plants, with which tiger nut milk is of a better advantage. According to this, different methods of extraction were considered, compared with the commonly used crude method (simple filtration).

From the result of the proximate compositions of the three extraction methods considered in chapter four, sample extracted using centrifugation as a mode of extraction have fairly the same composition with that extracted using the crude method (simple filtration) and soxhlet apparatus, only that time spent and drudgery was reduced using centrifugation as a method of extraction.

5.2 Recommendations

From the study, the following recommendations could be made:

1. The department should setup facilities and equipments with which tests on proximate composition of biomaterials can be carried out
2. The government should create the awareness and encourage the production of milk from plant source e.g. tiger nut, so as to overcome the high price of

imported milk, poor milk production in the country, to solve the problem of protein-calorie malnutrition and to help those intolerable to lactose digestion.

3. Finally government should organize, set up and establish programs that will encourage in-depth research on different and better methods of extracting tiger nut milk.

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