DETERMINATION OF THE NUTRITIONAL QUALITY OF TIGER NUT MILK.

BY

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DECLARATION

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 Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

18/02/2010.

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CERTIFICATION

This project titled "Determination of Nutritional Quality of Tiger Nut Milk" by Adeeso Lukman Adetayo meets the regulation governing the award of Bachelor of Engineering (B. ENG.) of Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation

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This project is dedicated to my family who throughout these years have nurtured me in the way of truth.

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ABSTRACT

Tiger nut is a good source of Vitamins and Minerals, which can be eaten as raw nut or milled so as to extract the milk and other useful nutrients in it. In this work, Laboratory standard procedures for food analysis of Association of Official Analytical Chemists (AOAC) were followed to obtain proximate composition of tiger nut milk (both Yellow and brown variety) commercially available in Minna, Niger State. Yellow samples had moisture content of 81.88%, ash content of 3.00%, crude protein of 2.54%, lipid content of 38.00%, and carbohydrate of 56.46%. Brown samples had the following features: moisture content of 83.09%, ash content of 2.50%, crude protein of 2.54%, lipid content of 20.5%, and carbohydrate content of 74.46%.

Sensory properties such as Colour/Appearance, Aroma, taste, mouth feel, texture, consistency, and general acceptability was carried out. The following results were obtained; 90% of the panelists accepted the mouth feel of Brown sample as against 80% of the Yellow sample, where as for the texture both samples were equally accepted; as regards the aroma 90% accepted the Brown sample while 80% maintained that of the Yellow sample, 80% went for the taste of the Brown sample while 70% accepted the taste of the Yellow sample, the consistency of 80% was accepted for Brown sample while 90% accepted the consistency of the Yellow sample, for the appearance the acceptability of the Brown samples was 10% lesser than the Yellow sample and General acceptability for Brown sample was 90% while for Yellow sample was 70%.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of study

Agricultural products have over the years been underexploited in the regions of which they are produced especially in the developing countries. One of these agricultural products with high emerging level of use is the Tiger nut (*Cyperus esculentus*) which is used in making cookies, locally made beverages (*Kunnu, Horchata*), used as bio-fuel (oil) as well as consumed as snacks (especially when dried).This multifunctional use of Tiger nut makes it a necessity to determine the proximate and physicochemical properties of this extremely valuable agricultural product so that more extensive study can be conducted in order to determine and locate more areas of which the Tiger nut is relevant.

Tiger nut was found to be a good substitute for cereal grains (Abodunrin and Belewu, 2008). The 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. Tiger nut otherwise known as *Ofio* in south western part of the Nigeria, *Aya* amongst the *Hausa*s and *Aki-Hausa* amongst the *Igbo*s, is used as close substitute for milk in patients intolerable to lactose; as a nutritional supplement as well as being recognized for its growing use as fish baits.

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 (digestive tract) of animals as well as human beings.

1.2 Tiger Nut

Tigernut (*Cyperus esculentus L.)* belongs to the division–*Magnoliophyta*, class*liliopsida,* order – *cyperales and* family–*cyperaceae* (family). It was found to be a cosmopolitan perennial crop of the same genus as the papyrus plant. Other names of the plant are earth almond as well as yellow nut grass (The Columbia Electronic Encyclopedia, 2004). The nut has been cultivated since early times (chiefly in south Europe & West Africa) for its small tuberous rhizomes which are eaten raw or roasted, used as hog feed or pressed for its juice to make a beverage. Non-drying oil (usually called chufa) is equally obtained from the rhizome. In West Africa, the plant is gathered from the wild while it is a troublesome weed in planted field in the United States (The Columbia Electronic Encyclopedia, 2004). The nut was found to be rich in myristic acid, oleic acid and linoleic acid (Eteshola and Oraedu, 1996).

1.2.1 Health Benefits of Tiger nuts

Sanful, (2009) reported that Tiger nut helps in preventing heart attacks, thrombosis; activates blood circulation and also helps in preventing cancer, due to high content of soluble glucose. It was also found to assist in reducing the risk of colon cancer (Sanful, 2009.) Very high fiber content combined with a delicious taste makes tiger nut ideal for healthy eating, since crude fibre is said to reduce the rate of diseases as it is not easily and totally digestible by the acid and enzymes in the alimentary canal (digestive tract) of animals as well as human beings (Sanful,2009).The nut is rich in energy content (starch, fat, sugars & protein), Minerals (phosphorus, potassium) and Vitamins E and C (Abodunrin and Belewu, 2008 in Sanful,2009). Tiger nut reduces the risk of colon cancer and it is suitable for diabetic persons and also helps in losing weight (Beniwal, 2004). Tiger nut was equally reported to have high content of oleic acid with positive effect on cholesterol level due to high content of vitamin E. The nut was found to be ideal for children, older persons and sportsmen (Martinez, 2003). The inclusion of 33.33% of tiger nut in the diet of cockerel starters was reported by Bamgbose *et al.* (2003).

1.3 Tiger Nut Milk

It exists in the market as a milk variety of plant origin put forward as alternatives to liquid milk of animal origin for food. It has also been asserted that these products provide a nutritional value comparable to that of milk of animal origin but without providing cholesterol and that they avoid the appearance of problems associated with intolerance of lactose and some proteins of cow milk. Most milk of plant origin are made of soya beans and involves several disadvantages such as anti nutritional factors, a reduction of their nutritive value as a result of heat treatment at high temperatures and/or repeated heat treatment, unpleasant flavours e.t.c. It is these disadvantages that give tiger nut milk an edge over other milks from plant source. Although tiger nut has a protein concentration lower than that of cow milk and therefore is not a complete nutritional substitute for milk, it has a widely accepted flavour (Guamis, 2003).

1.4 General Properties of Milk

Milk is a complex dispersion of globules and protein in an aqueous solution of lactose, mineral, and other minor constituents. Milk's physical characteristics are affected by several factors including the composition and processing of milk. Measurements of milk's physical properties are used in processing, to determine the concentration of milk's components, and to evaluate the quality of milk products. (Chandan, 1997).

1.5 Constituents of Milk

The major constituents of milk are 87.4% water and 12.6% milk solid (3.7% fat, 8.9% milk solids-non-fat). The milk solids-non-fat contains 3.4% protein, 4.8% lactose and 0.7% minerals.

1.5.1 Energy

Milk's energy (calorie) content varies widely and depends mostly on its fat content. For example, whole milk (3.2% milk fat) provides 150 kcal/cup, 2% reduced fat milk provides 121 kcal/cup, 1% low fat milk provides 104 kcal/cup, and non fat (fat free or skimmed milk) provides 90 kcal/cup. The addition of non fat milk solids, sugar and other energy yielding components also influences milk's calorie content. Milk is a nutrient-dense food providing a high concentration of nutrients in relation to energy content. (http://www.ars.usda.gov/main/main.htm).

1.5.2 Protein

About 80% of the total protein in milk is casein and 20% is whey protein. Milk also contains small amount of various enzymes (e.g., lipoprotein lipase, alkaline phosphatase, lactoperoxidase) and traces of non protein nitrogenous compound (e.g., ammonia, urea, cretin, and uric acid). (Jensen, 1995). Milk is an excellent source of high-quality protein, providing varying amounts of all of the essential amino acids that humans cannot synthesize and in proportions resembling amino acid requirements. Only the sulphur amino acids (methioninee plus cystine) in milk proteins are slightly limiting as compared with the adult's estimated requirement of essential amino acids. Cow milk protein, which is rich in lysine, complements many plant proteins, which normally are limited in this amino acid. Also, because of its high quality, cow milk protein is used as a standard reference protein to evaluate the nutritive value of food proteins. (Takada, 1997).

1.5.2.1 Beneficial Effects of Proteins

Individual milk proteins have a wide range of beneficial health and functional effect. For example, antibacterial properties of peptide derived from bovine lactoferrin have been demonstrated (Dionysius, 1997). Also, limited evidence from in vitro and experimental animal studies indicates that milk proteins may protect against cancer. As reviewed by Parodi 2001, whey protein in particular appears to be antocarcinogenic, possibly as a result of their ability to enhance immunity. In addition, whey protein concentrates and isolates are used as ingredients in a number of formulated food products.

1.5.3 Carbohydrates

The primary carbohydrate in milk is lactose, a natural disaccharide consisting of one galactose unit. Lactose accounts for about 54% of the total solids-not-fat content of whole milk and about 30% of its calories (about 9% of the calories is of 2% reduced fat milk). The lactose content of milk varies by species. Cow milk contains about 4.8% lactose (12 to 12% lactose/cup), where as human milk has 7% lactose (15 to 18g lactose/cup) (Filer, 1997). The higher concentration of lactose in human milk explains why lactose is used to enrich breast milk substitutes or infant formula. The lower lactose content of cheeses is due to the removal lactose rich whey and the conversion of lactose to lactic acid by select microorganism in cheese making. Minor quantities of glucose, galactose, and oligosaccharides are also present in milk. Glucose and galactose are the products of lactose hydrolysis by the enzyme lactase. Galactose may have a unique role in the rapid development of the infant brain (Miller,1999).

1.6 Milk Composition

Milk fat, the most complex of lipids, exist in microscopic globules in an oil-in-water emulsion in milk. Milk's lipids are mainly triacylglycerols (triglycerides) or esters of fatty acids with glycerol (97-98%), 0.2 to 0.1% phospholipids, 0.2 to 0.4% free sterols (cholesterol, waxes, and squalene, an intermediate of cholesterol), traces of free fatty acids, and varying amounts of the fat-soluble vitamins A, D, E, and K.

1.7 Statement of the Problem

High price of imported milk and milk products coupled with poor milk production in Nigeria in particular and Africa in general seem to have made consumers more ready to accept milk produced from plant sources hence the need to embark on this study.

1.8 Objectives of the Study

The objectives of this study are:

1. To determine the proximate compositions of Tiger Nut milk.
2. To carry out sensory evaluation of tiger nut milk.

1.9 Justification of the Study

Over the years, Tiger nut has been one of the agricultural products underutilized especially in the developing countries like Nigeria, where it abounds in large quantities. The prevalence of obesity and the high level of diet related health conditions have generated a lot of concern about our dietary intake and its effect on our health. The need to make more informed choices regarding food preferences among the people cannot be overemphasized. In the light of these problems, the tiger nut has been recognized as one of the best nutritional crops that can be used to augment the diet (Afenu, 2008). The tiger nut crop is one of the cash crops, which is not given due recognition and patronage possibly because many people do not know its nutritional benefits. They also have excellent nutritional qualities with a fat composition similar to olive plant and have a rich mineral content, especially phosphorus and potassium. Tiger nuts are also gluten and cholesterol-free, and have very low sodium content.

1.10 Scope of the Study

The quality parameters to be determined in this study are limited to the following; Crude protein, Carbohydrates, Lipid content, Ash and Moisture Content, while the sensory properties of the Tiger nut milk to be determined are Colour/Appearance, Aroma, taste, mouth feel ,texture, consistency, and general acceptability.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Historical Background and Evolution of Tiger Nut

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 (Innvista, 2008).

Tiger nut is not really a nut but a small tuber first discovered some 4000 years ago. It has many other names like Zulu nut, yellow nut grass, Earth almond, edible rush and rush nut (Dianne, 2007).It is found worldwide in warm and temperate zones, occurring in Europe and Africa. It was introduced into the New World from the Old World. In the Western Hemisphere, it grows from southern Canada to northern Argentina. The plant is known in most of the United States, except Wyoming and Montana. It occurs elsewhere in the world in regions with temperate to tropical climates (Ojos Negros Research Group, 2008).

According to (Zohary and Hopf, 2000), Tiger nut 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. At present, they are cultivated mainly, at least for extended and common commercial purposes, in Spain, where they were introduced by Arabs, almost exclusively in the Valencia region. Tiger nuts are also grown in Ghana.

Tiger nut (*Cyperus esculentus L.*), an edible perennial grass-like plant native to the old world, is a lesser known vegetable that produces sweet nut like tubers known as 'earth almonds' (Tiger nut also called *chufa* is translated as 'ground almond' in Spanish). Tiger nut is also known by various names such as Tiger nut, Earth nut, groundnut, rush nut and edible galingale (Yalc *et al*, 2002).

Nowadays, Tiger nut is cultivated in Northern Nigeria and Ghana, where it is made into a sweet meal, and Togo, where it is used uncooked as a side dish. These countries and others such as Ivory Coast, export 2300 tonnes of Tiger nut tubers every year to Spain. Tiger nut is also a representative crop of the Spanish Mediterranean region, where tubers are used to make a beverage called *Horchata* or *Horchata de Chufas*. The milky-looking aqueous extract of Tiger nut has a pleasant and characteristic flavour of vanilla and almonds (Ojos Negros Research Group, 2008).

Tiger nut is potentially a commercial source of high-oleic acid vegetable oil and high-carbohydrate tuber cakes. Some authors believe that the tuber oil could be exploited in the same way as olive oil. Chinese researchers have measured the physical and fuel properties of oil extracted from the Tiger nut, and concluded that the physical properties are similar to those of other vegetable oils. They have suggested that this oil may also be used as bio-diesel fuel (Ojos Negros Research Group, 2008).

2.2. Description of Tiger Nut Plant

Cyperus esculentus (Tiger nut Sedge, *Chufa* Sedge, Yellow Nutsedge, Earth almond) are species of sedge native to warm temperate to subtropical regions of the Northern Hemisphere. It is an annual or perennial plant, growing to 0.9m 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° from each other. The plant foliage is very tough and fibrous, and is often mistaken for a grass (Wikipedia, 2007).

According to (Ojos Negros Research Group, 2008), Tiger nut (yellow nut sedge) is a tough erect fibrous-rooted perennial, 0.3048-1m high, reproducing by seeds and by many deep, very slender rhizomes, which form weak runners above the ground, and small tubers or nutlets at the tips of underground stems. The tubers are dark, unevenly globed shaped, 9.5-19.1mm long, and edible, tasting somewhat like almonds. Near the base of the triangular yellow-green stem, a cluster of three-ranked, grass-like leaves arises which are often longer than the stems, and 3.2-8.5mm broad.

Tiger nut is considered one of the world's worst weeds. Well adapted to irrigated agriculture, tiger nut is particularly problematic in row crops because it competes with crops for water, light, and nutrients, thereby reducing crop yield. It has also been known to spoil the quality of some crops. In some areas, tiger nut tubers have been known to grow into potato tubers causing them to be graded as culls. They may also pass through shelled lima beans, requiring costly hand sorting. In addition, there has been some suggestion that this specie may produce chemicals that are toxic to crops (Ojos Negros Research Group, 2008).

2.3 Characteristics of Tiger Nut Plant

Tiger nut grows from perennial tuber-bearing rootstocks; the tubers are approximately 10.2-20.4mm long. The leaves are narrow and grass-like, growing in three vertical rows on the stem. Most of the leaves are clustered at the base of the stem. The small flowers are yellowish or yellowish-brown, and arranged in narrow spikelets on umbel-like inflorescences (group of flowers originating from a single point). Located immediately below the inflorescence are 76.2-22.86mm long leaf-like structures (bracts). The flowers have three stamens and a three-cleft style. The yellowish-brown seeds are about 1.6mm long and three-angled (Ojos Negros Research Group, 2008).

2.4 Cultivation of Tiger Nut Plant

Tiger nut is planted in late spring to midsummer by dropping the dried tubers 6-12 inches apart in rows spaced 0.6096-1m apart. The planting rate is 17.1-45.2kg per hectare. The grown tuber germinates into a plant producing several tubers bunched together directly beneath it, the plant and a few stragglers some distance away. Although bunched together, each nut is attached to a thin underground stem that connects the single tuber to the growing shoot. Tiger nuts are easy to grow and require almost the same care as corn. Experience in Northwest Florida suggests that tiger nut plots should not be less than 0.4047 hectare, and preferably 0.8-2 hectares (Ojos Negros Research Group, 2008).

Planting time must allow 90-100 days frost-free growing time. In Northwest Florida, tiger nut is planted from April to early August. Earlier plantings seem to higher yield but require more cultivation or herbicide protection. Later plantings tend to last longer into the next winter, which is desirable. Tiger nuts grow best in sandy-loam soils but will grow in the hardest clay. The influence of soil texture on the amount and quality of tubers has also been studied. The most appropriate soil texture for tiger nut cultivation is sandy-loam (Ojos Negros Research Group, 2008). Tiger nut harvest requires the soil to be dry, which can produce a lot of dust.

2.5 Uses of Tiger Nut

Despite its multifunctional ability use, with the fact that it contains a wide variety of nutrients which make 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.

Currently, tiger nut 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 *Cyperus* in moist soils or sandy shores for their edible tubers. These are called "tiger nuts" and are first fried, and then soaked in water. Reportedly, the taste is similar to hazelnuts. It was another specie, (*C. papyrus*) that the Egyptians used to make paper, sails, cloth, mats, ropes, or plaited into sandals.

Tiger nut is a source of revenue (in terms of foreign exchange) for exporting countries. For example, in Maradi State, in eastern Niger, *C. esculentus* is cultivated for export to Nigeria. Revenues from this weed exceed those from the typical cash crops such as cowpea and groundnut. The tubers of *C. esculentus* may be consumed raw, roasted, or ground (Ojos Negros Research Group, 2008).

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 tubers contain up to 30% of non-drying oil, it is used in cooking and in making soap (in a process known as saponification). It does not solidify at room temperature and stores well without going rancid. The leaves can be used for weaving hats and matting etc.

According to (Ojos Negros Research Group, 2008), in the United States, the primary use of Tiger nut as a crop is to attract and feed game, particularly wild turkeys. Turkeys love tiger nut tubers; as natural scratchers, once discovering a plot of Tiger nut, they will return again and again, all winter long, or until spring arrives and other food is readily available. Tiger nut tubers have been planted so that pigs could be turned into the fields to fatten and improve the taste of pork. In the United States, tiger nut tubers have been used as hog feed, pastured in the field in states such as Florida, Georgia, and Alabama. Tubers of tiger nut have also been identified as valuable food for waterfowl and cranes. Ducks dive for them when wetland fields are flooded. Tiger nut is also used in seed mixes for wetland restoration, mitigation, and erosion control. It 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 tiger nut 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 tiger nut. 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 tiger nut 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 Tiger nut 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 tiger nut 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).

2.6 Relationship Between Tiger Nut and Other Root Crops

Tiger nut is a root crop. Thus, crops to be considered to be similar should also possess similar properties to the tiger nut examples of which are;

•Groundnut (*Arachis hypogea*): This is a leguminous root crop grown in the desert and semi desert regions of the world. It produces grains in pods beneath the surface of the earth and its root is characterized by root nodules which house nitrogen fixing bacteria which help to augment for nitrogen requirement by fixing and converting atmospheric nitrogen into nitrates essential for the growth of plants. The groundnut, also referred to as peanut, is cultivated in loose sandy loamy soils and this is to aid its harvesting.

•Bambara nut (*Vigna subterranea*): The Bambara groundnut (or Bambara nut) is a member of the family *Fabaceae*. According to some authors, it is also known as *Voandzeia subterranea*, but others place it in *Vigna*. The plant originated in West Africa. The bambara groundnut ripens its pods underground, much as the peanut (also called groundnut). They can be eaten fresh or boiled after drying. Bambara groundnuts are also known as *Jugo beans* or in Swahili, *Njugumawe* (Wikipedia, 2008). They are grown in Western Africa as a protein source. They also contain sufficient quantities of carbohydrates and fats. After drying and roasting the nut, it can be used to make flour, soup, porridge, and milk

2.7 Nutritional Contents of Tiger Nut

According to (Dianne, 2007), tiger nuts have long been recognized for their health benefits as they are high in fibre, proteins and natural sugars. They have a high moisture 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 phosphorus and potassium as well as vitamins E and C. Typically, 100g of tiger nut contains 386 kcal (1635kJ) as 7% proteins, 26% fats (oils), 31% starch, 21% glucose. They contain 26% fibre of which 14% are non-soluble and 12% are soluble (Dianne, 2007). The mineral contents of tiger nut are shown in Table 2.1

Table 2.1: Mineral Contents of the Tiger Nut

Mineral	Content (mg)
Sodium (Na)	34
Calcium (Ca)	94
Iron (Fe)	4
Zinc (Zn)	3.5
Phosphorus (P)	211
Potassium (K)	424
Magnesium (Mg)	93
Copper (Cu)	0.97
Manganese (Mn)	0.25

Source: Dianne, 2007.

2.8 Proximate Composition of Tiger Nut

Proximate composition refers to the precise content of food materials in terms of the nutritional value of agricultural products which are of great importance in determining the class of which the agricultural products fall into, as well as finding a suitable substitute for the products in times of shortages and price inflation (usually noticeable in developing countries). The proximate composition of Tiger nut to be discussed includes: Crude protein, Lipid content, Ash, Moisture content and Carbohydrates.

2.8.1 Crude Protein

The term crude protein includes all nitrogenous compounds in a feed. The crude protein content or equivalent of a feed is calculated by first determining its nitrogen content and then multiplying the result by 6.25. On average, the nitrogen content of natural protein is approximately 16 percent ($100 \div 16 = 6.25$).

This is the approximate amount of protein in foods that is calculated from the determined nitrogen content by multiplying by a factor (as 6.25 for many foods and 5.7 for wheat) derived from the average percentage of nitrogen in the food proteins and that may contain an appreciable error if the nitrogen is derived from non-protein material or from a protein of unusual composition (Merriam-Webster's Medical Dictionary, 2008). According to (Online Medical Dictionary.htm, 1997), Crude proteins are incomplete proteins which lack essential amino acids.

2.8.2 Lipid Content

Lipid is the next predominant nutrient to water and carbohydrate in diet. Some of the dietary sources of these nutrients are readily identified as visible fats and oils. Lipids may be classified as fat and oil in solid and liquid state respectively at room temperature. The primary one is a *triglyceride*; a *triglyceride* contains 3 fatty acids that are esterified to the 3 hydroxyl alcoholic-glycerol. It produces energy much greater than carbohydrates (say about 2.5 times the amount produced by the carbohydrates) which are energy giving food. Fatty acid has a general formula: R-COOH. R-group contains carbon and hydrogen in it, if the carbon atoms are bonded together with a single bond **C-C,** the compound is saturated, if the carbon atoms are bonded together with double bonds **C=C,** the compound is unsaturated. The fatty acids that are unsaturated can react with Oxygen to reproduce undesirable flavour.

2.8.3 Ash

These are inorganic compounds which appear in food analysis i.e. they are substances left behind when the carbon, hydrogen, nitrogen and organic compounds have all burnt off. An adult may have over 1kg of calcium in his body, whereas of chromium, he has only 5-10mg and of copper 150mg (N.R.C, 1996). It is obtained after *Ashing* (exposing the product in a furnace at high temperature first at 350°C then increasing it to 550°C).

2.8.4 Moisture Content

This is referred to as the percentage of water in agricultural products and is usually mathematically obtained as the ratio of the loss in weight to the actual weight all multiplied by 100% after the agricultural product has been heated at a temperature of 105°C for a period of 24hrs.

According to Ihekoronye and Ngoddy, (1985), the state of water activity in food is described by the relationship between moisture of the product and the relative humidity of the air surrounding it. The ratio of these two parameters is called "water activity" (a_w). The relative humidity which corresponds to each specific moisture content of the product is called "equilibrium relative humidity".

2.8.5 Carbohydrates

Carbohydrates are naturally occurring organic compounds containing carbon, hydrogen and oxygen, with the hydrogen and oxygen present in the ratio 2:1, as in water. The general molecular formula for carbohydrates is $C_xH_{2y}O_y$ (where x and y are positive integers). Carbohydrates can be classified into two as shown below

•Simple sugars: These are sugars that are crystalline in nature; they are water soluble and have a sweet taste. They consist of the monosaccharide and disaccharides sugars. Examples of the monosaccharide sugars include glucose, galactose, mannose and fructose. The disaccharides are obtained by the condensation of two monosaccharide sugars resulting in the elimination of a molecule of water as shown below.

$$2C_6H_{12}O_6 \xleftrightarrow{\text{Condensation}} C_{12}H_{22}O_{11} + H_2O$$

Monosaccharide disaccharides water

Examples of disaccharides include sucrose (cane sugar), lactose (milk sugar) and maltose (malt sugar).

•Complex sugars: These are a group of complex carbohydrates composed of very long chains of monosaccharides linked together by condensation, i.e. elimination of one molecule of water for every bond formed between two monosaccharide molecules. Examples include starch and cellulose (Ababio, 2001).

2.9 Sensory Evaluation of foods

Sensory evaluation are those sensational properties of Tiger nut milk that could be affected as a result of not picking the foreign and bad nuts before preparation and thus, reduce the quality of milk produced. The sensory properties of Tiger nut to be considered are:

- Colour/Appearance
- Aroma
- Taste
- Mouth feel
- Texture
- Consistency
- General acceptability

Colour/ Appearance

The appearance of the milk refers to the level of colour/visual appeal of the products obtained after sieving the milk extract and separating the milk from the shaft.

Aroma

The Aroma of the milk is that subtle impression of quality, a smell, especially a pleasant that tends to generally increase or reduce tiger nut acceptability.

Taste

The taste of milk is a small quantity of the Tiger nut milk drunk, or sampled to assess its on the sensory receptors on the surface of the tongue or in the mouth.

Mouth feel

The taste of the milk expresses the level of astringency produced as a result of the method used in milk extraction.

Texture

The milk texture is the feel and appearance of the surface especially how smooth or rough it is.

Consistency

The consistency is an attribute of the milk to flow without forming logging insoluble particles in the inner side of the container. It refers to the property of the milk to exhibit smoothness and good flow properties.

General Acceptability

This is deduced from the results of the samples available.

2.10 Hedonic Scale

This is a general representation scale used by the consumer for assessing acceptability of beverages base on the product's sensory properties. Below is common Hedonic scale that can be used for any beverage.

Table 2.2: Hedonic scoring for assessment of consumer acceptability of Tiger nut beverages

Scale	Mouth feel	Texture	Aroma	Taste	Consistency	General Acceptability	Appearance
1.	Excellent	Very Smooth	Excellent	Excellent	Excellent	Excellent	Excellent
2.	Very Good	Smooth	Very Good	Very Good	Very Good	Very Good	Very Good
3.	Good	Neutral	Good	Good	Good	Good	Good
4.	Fair	Lumpy	Fair	Fair	Fair	Fair	Fair
5.	Poor	Very Lumpy	Poor	Poor	Poor	Poor	Poor

Source : Sanful, 2009.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

Fresh samples of Tiger nuts, yellow and brown species were bought from the Minna Ultra-Modern market, Niger state, Nigeria.

3.1.1 Reagents

The reagents used for this analysis are:

•Potassium sulfate (K_2SO_4)

•Copper sulfate ($CuSO_4$)

•Concentrated sulfuric acid (H_2SO_4) ,s.g 1.84

•Sodium hydroxide (NaOH)

•Methyl red indicator solution

•Petroleum ether (C_6H_6)

•60-62% Perchloric acid ($HClO_4$)

•Concentrated nitric acid (HNO_3)

•Boric acid

3.1.2 Apparatus

- •Crucible
- •Desiccators
- •Muffle furnace
- •Volumetric flasks
- •Beakers
- •Measuring cylinder
- •Conical flask
- •Spatula
- •Filter paper
- •Muslin cloth
- •Condenser
- •Soxhlet Extraction Apparatus
- •Round bottom flask
- •Extraction thimble
- •Heating mantle
- •Kjeldahl flask
- •Burettes
- •Pipette
- •Petri dish
- •Filter paper
- • Water bath
- •Oven
- •Macro kjeldahl Nitrogen Digestion and Distillation Apparatus

3.2 METHODS

3.2.1 Preparation of Samples

The samples were sorted out, soaked for about 30 minutes and thoroughly washed so as to wash off adhering particles. The samples were milled with a milling machine. 100grams of the yellow and brown of the milled tiger nuts were weighed out separately into 500ml beakers respectively.

The two samples were now labeled yellow and brown respectively. 200ml of distilled water was measured with a1000ml measuring cylinder and was added to the samples labeled yellow and brown each. Each of the samples was mixed thoroughly with distilled water and then filtered with the aid of a muslin cloth. The filtrates were kept in plastic bottles and refrigerated.

The samples were analyzed for Crude protein, Lipid content, Ash, Moisture content and Carbohydrates using the official methods of the Association of Official Analytical Chemists (A.O.A.C., 1980).

Sorting of Tiger nuts

↓

Soaking of Tiger nuts

↓

Thorough washing of Tiger nut

↓

Draining and blending of Tiger nuts

↓

Filtering of tiger nut milk

↓

Sterilizing and Cooling of the Plastic bottles

↓

Refrigerating/ Drinking

Figure 3.1: Flow chart for the preparation of tiger nut milk

3.2.2 Moisture Content Determination

The determination of moisture content is one of the most important and widely used measurements in samples that absorb or retain water.

Procedure

A Petri dish was washed and oven dried, it was kept in a desiccator to cool. It was weighed and the weight was recorded as W_1. The yellow tiger nuts sample were added to it and the weight was taken and recorded as W_2. It was placed in an oven at a temperature of 105°C for 24 hours (AOAC, 1980). The dish was kept in a desiccator and allowed to cool. The weight was taken as W_3.This process was repeated twice. The procedure was also carried out for the brown sample in triplicates respectively. The moisture content was calculated as;

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

Where,

W_1= weight of petri dish

W_2= weight of petri dish and sample before drying

W_3=weight of petri dish and sample after drying

3.2.3 Ash.

This is the residue of incineration at 550-600°C. This analysis was carried out using standard analytical method A.O.A.C, (1980).

Procedure

The crucible was washed and dried in the oven at a temperature of 100°C for six hours; it was removed from the oven and kept in a desiccator to cool. It was weighed and the weight was recorded as W_1. 2g of the yellow sample was weighed into the crucible. The crucible was reweighed and the new weight was recorded as W_2. The crucible was kept in a muffle furnance at a temperature of 600°C for 2 hours. It was removed from the muffle furnance and kept in the desiccators to cool. It was then weighed and the weight was recorded as W_3. This process was repeated twice. The procedure was also carried out for brown sample in triplicates respectively.

%Ash was calculated from the weights gotten from the procedure as follows;

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

Where,

W_1= weight of crucible

W_2= weight of crucible and sample before ash

W_3=weight of crucible and sample after ash

3.2.4 Lipid Content.

Lipids are diverse group of fatty substances (glyceride) which are insoluble in water and soluble in non polar organic solvents. Extraction is carried out with soxhlet apparatus with petroleum ether. The usual method is continuous heating at 40-60°C. The ether extraction method is based on the principle that non polar components of the sample are easily dissolved in ether. Direct extraction gives the proportion of free fat but gives no clue to the particular fatty acids. A.O.A.C, (1980) was used to carry out this analysis.

Procedure

Glass wares were washed with distilled water and dried in an oven. The thimble was washed and kept in an oven to dry and its weight was taken as W_1. 2g of moisture free yellow sample of tiger nut was added; the weight of thimble plus sample was taken and recorded as W_2. A fat free 500ml round bottom flask was then weighed and the weight was recorded as W_3. The flask was then filled with two third of its volume with petroleum ether. A soxhlet extractor with a reflux condenser was fitted together; heat was applied using a heating mantle at a temperature of 60°C so that the solvent boiled gently, it was left to siphon for a period of 8 hours. The condenser was detached and the thimble was removed. The flask containing lipid residue (fat) was dried on a water bath. It was kept in desiccators to cool, it was weighed and the weight was recorded as W_4. The lipid content of tiger nut was calculated as follows;

$$\%\ Lipid\ Content = \frac{W_4 - W_3}{W_2 - W_1} \times 100$$

Where,

W_1 = weight of empty thimble

W_2 = weight of the thimble and Tiger nut sample

W_3 = weight of fat free empty flask

W_4 = weight of flask containing oil residue

3.2.5 Crude Protein

The central basis used in this procedure is the oxidation of the organic compound using strong sulfuric acid. As the organic material is oxidized the carbon it contains is converted to carbon dioxide and the hydrogen is converted into water. The nitrogen, from the amine groups found in the peptide bonds of the polypeptide chains, is converted to ammonium ion, which dissolves in the oxidizing solution, and can later be converted to ammonia gas. The Kjeldahl method of nitrogen analysis is the worldwide standard for calculating the protein content in a wide variety of materials.

Procedure

Step 1: Digestion

12ml concentrated H_2SO_4 was measured using a 100ml measuring cylinder into a kjeldahl flask. One digestion tablet was added. 1g of sample was weighed and added to the mixture. The mixture was weighed and recorded as W_1. Heat was applied using a kjeldahl digestion block at a low temperature for 15 minutes; the temperature was increased to medium for 30 minutes and was later increased to the highest temperature until a grey white coloration was noticed. Heating continued for 3 more minutes to complete digestion. The digest was left to cool and filtered. The filtrate was made up to 50ml (V_1) and transferred into a round bottom flask. A blank digestion was carried out using the method above.

Step 2: Distillation

The distillation apparatus was set up. A few pumic stone was added to the filtrate from step.15ml of boric acid was added into a 100ml Erlenmeyer flask, 3 drops of indicator was added. It was carefully placed below the condenser with the receiver tube dipped in the acid. 10ml of 40% NaOH was poured carefully into the flask. The flask was quickly connected to the distillation system so as to avoid the loss of nitrogen. The volume of the distillate was measured as V_2. A blank distillation was carried out using this method.

Step 3: Titration

The distillate was titrated with 0.1N H_2SO_4 until there was a noticeable colour change from greenish yellow to pink. The blank distillate was also titrated with the acid.

These steps were repeated in triplicates for the yellow and brown tiger nut samples.

$$NH_4^+ + H_2BO_3^- \xrightarrow{\text{indicator}} NH_4Cl + H_3BO_3$$

If 1 mole of HCl requires 1mole of NH_3,

Therefore, molarity of HCl is the same as the molarity of NH_3.

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

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

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

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

Where,

M = molarity of acid

T = titre value

V_1 = Volume of filtrate after digestion

V_2 = Volume of distillate

Crude protein is obtained by multiplying the % Nitrogen by 6.25 for food samples. The factor 6.25 owes it origin to the assumption that all food protein contains 16% nitrogen and that all the nitrogen in feed are present as protein.

Therefore,

$$\%Crude\ Protein = NFE \times Factor$$

Where NFE = Nitrogen Free Extract.

3.2.6 Carbohydrate

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

$$\%Carbohydrate = 100\% - (\%Protein + \%Lipid + \%Ash + \%Fibre)$$

Since milk generally has no fibre content (Anderson *et al;* 2007)

Therefore;

$$\%Carbohydrate\ for\ Milk = 100\% - (\%Protein + \%Lipid + \%Ash)$$

3.3 Sensory Evaluation of the Tiger nut milk

Ten panelists comprising both male and female students were used in the sensory evaluation study. The panelists were presented with the two samples, the yellow and brown tiger nut milk. Panelists were asked to compare the two samples on the bases of mouth feel, texture, taste, aroma, consistency, appearance and general acceptability, using the hedonic descriptive scale. Assessors were instructed in the basic taste panel procedures, to make their own individual judgments after a moderate amount of consideration. The panelists were instructed to take a sip of water and pause for a few seconds before tasting each sample and to re-taste if they were not sure of their decisions. From the data obtained, the mean values and standard error for each was calculated. The significant differences between the samples were tested using the t-test.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 Results

Table 4.1 below shows the results obtained from the tests carried out on the Tiger nut samples.

Table 4.1 Proximate Analysis of Tiger nut Milk Samples.

Composition%	Yellow			Brown		
	1	2	3	1	2	3
Moisture content	81.38	79.78	82.17	83.36	81.73	84.18
Ash content	2.95	3.01	3.04	2.53	2.51	2.46
Crude Protein	2.55	2.57	2.50	2.55	2.54	2.53
Lipid content	37.38	38.12	38.50	20.16	20.57	20.77
Carbohydrate	56.65	55.53	57.20	73.24	75.44	74.70

Table 4.2: Average Proximate Analysis of Tiger nut Milk samples.

Composition%	Yellow (average)	Brown (average)
Moisture content	81.11±1.22	83.09±1.25
Ash content	3.00±0.05	2.50±0.04
Crude protein	2.54±0.04	2.54 ±0.04
Lipid content	38.00±0.57	20.50±0.31
Carbohydrate	56.46±0.85	74.46±1.12

Table 4.3 Percentage score on comparative sensory evaluation of Tiger nut milk.

	Mouth Feel	Texture	Aroma	Taste	Consistency	Appearance	General Acceptability
Brown Sample	90	80	90	80	80	80	90
Yellow Sample	80	80	80	70	90	90	70

4.2 Discussion

From the presented results Table 4.2, the Tiger nut milk samples have indeed shown that it is milk that has great potentials in terms of its usefulness for the benefit of mankind. A comparison shows that the Brown sample has a higher value of carbohydrate (74.46%) than the Yellow sample (54.46) and this makes it more acceptable. These values are higher than the carbohydrate contents of some milk and thus justify its use as a closer and better substitute for people in need of energy (sport men and women) and the development of the infant brain by the galactose content of tiger nut milk.

The Yellow sample has a higher percentage of lipid content (38.00%) and this signifies that it produces more oil on compression when compared to the Brown sample. Hence, it is economical to use the Yellow sample for the purpose of oil extraction since it will save cost, time and energy. Lipid content which is mostly concentrates of the energy producing nutrient, so our bodies need only very small amounts to build the membranes that surround our cells and in helping the blood to clot. Once digested and absorbed, lipids help the bodies absorb certain Vitamin. Also lipid stored in the body cushions vital organs and protects us from extreme cold and heat.

From Table 4.2, a close comparison shows that both samples have equal amount of protein (2.54%) and thus are both recommended because protein which is composed of long chain of amino acids play an essential roles in the cells of all living creatures- they serve as building blocks of cells, control chemical reaction and transport materials to and from cells.

Yellow sample has a higher ash content of (3.00%) which serves as a better source of minerals like calcium, phosphorous etc. for strong bones and teeth in human beings.

The Brown sample has higher moisture content of (83.09) than the Yellow sample (81.11%), but are both accepted because the recommended moisture in milk ranges from 80-90% (FAO, 1968). This makes tiger nut milk succulent and refreshing and can be incorporated between meals.

The proximate composition of Tiger nuts milk when compared to the nutritional value from (FAO, 1968), shows that it has nutritional values that meet up with standard milk requirements, but due to ignorance of these facts, the awareness on tiger nut milk's potential as a source of milk is still poor.

The mouth feel of the Tiger nut milk is an important factor for consumers, of the 10 panelists as shown in Table 4.3 above, who participated in the sensory evaluation 90% indicated their acceptance of the mouth feel of the Brown milk sample while 80% accepted the mouth feel of the Yellow milk sample.

The texture quality is also an important factor to consumers. 80% accepted the texture of Brown and Yellow Samples.

The aroma of the milk sample is important to the consumer. 80% of the panelists accepted the aroma of the Yellow milk sample as against 90% of the Brown sample.

The taste of the milk is also an important factor for the consumers, of the 10 panelists, 80% accepted the taste of the Brown milk sample while 70% accepted the taste of the Yellow sample.

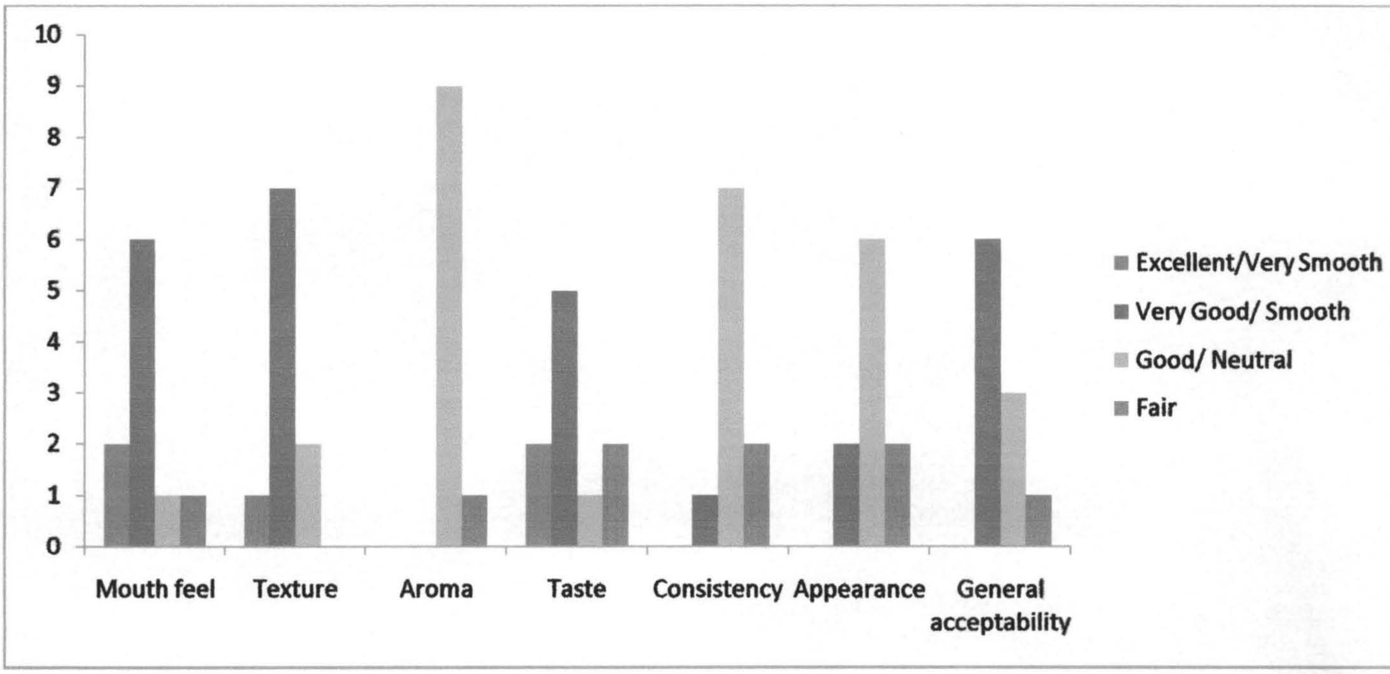
The appearance is important to consumers. 90% of the panelists accepted the appearance of the Yellow milk sample as against 80% of the panelists that accept the appearance of the Brown milk sample.

The consistency of the milk, that is how light or heavy the milk is, is an important factor for the consumer. 90% of the panelists accepted the consistency of the Yellow sample as against 80% of the Panelists.

The general acceptability of the milk sample is very important to the consumers. 90% of the panelists found the Brown milk sample very acceptable while 80% of the panelists found the Yellow sample very acceptable. There seem to be a slight preference for the Brown milk sample.

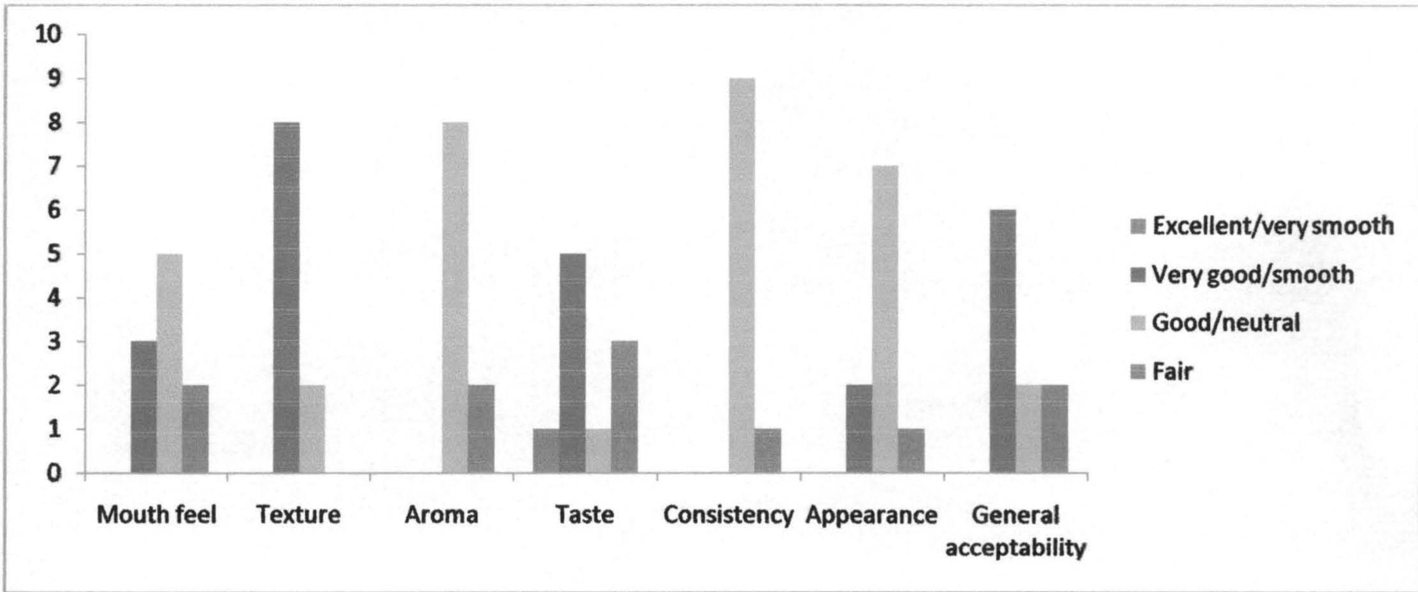
The results showed that although the texture, aroma, appearance, consistency were important for the Panelists, mouth feel and taste were more important for overall acceptance of the milk samples. The mouth feel of the Brown milk sample was more acceptable than the mouth feel of the Yellow sample. Also the taste of the Brown milk sample was more acceptable to the panelists than that of the yellow sample.

Figure 4.1 Graphical representation of comparative sensory evaluation of Brown Tiger nut milk sample.



From figure 4.1 above, the vertical axis represent the 10 panelists while the horizontal axis represents the sensory properties of Brown Tiger nut milk sample used. 2 panelists described the mouth feel as excellent, 6 panelists said it is very good and 1 each went for good and fair. 1 of the panelists accepted the texture of the brown sample to be very smooth, seven described the texture as smooth and 2 went for neutral. 9 of the panelists described the aroma as good and 1 described it fair. 2 of the panelists accepted the taste as excellent, 5 described the taste as very good, 1 panelist described the taste as good and 2 panelists said the taste is fair. 1 of the panelist accepted the consistency as very good, 7 describe the consistency as good and 2 said the consistency is fair. 2 of the panelists described the appearance of the Brown sample as very good, 6 said the appearance is good and 2 described the appearance as fair. 6 of the panelists accepted the Brown sample as very good, 3 described it acceptability as good and 1 described it acceptability as fair.

Figure 4.2 Graphical representation of comparative sensory evaluation of Yellow Tiger nut milk sample.



From figure 4.2 above, the vertical axis represent the 10 panelists while the horizontal axis represents the sensory properties of Yellow Tiger nut milk sample used. 3 panelists described the mouth feel as very good, 5 panelists said it is very good and 2 panelists went for fair. 8 of the panelists accepted the texture of the Yellow sample to be very smooth and 2 described the texture as neutral. 8 of the panelists described the aroma as good and 2 described the aroma as fair. 1 of the panelists accepted the taste as excellent, 5 described the taste as very good, 1 panelist described the taste as good and 3 panelists said the taste is fair. 9 of the panelists accepted the consistency as good and 1 said the consistency is fair. 2 of the panelists described the appearance of the Yellow sample as very good, 7 said the appearance is good and 1 panelist described the appearance as fair. 6 of the panelists accepted the Brown sample as very good, 2 described its acceptability as good and 2 described it acceptability as fair.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The aim of this study was to access and analyse the quality parameters of Tiger nut milk and also to carry out Sensory evaluation of Tiger milk.

From the analysis, the results showed that despite the nutritional quality of Tiger nut milk, it is still underutilised and it is due to ignorance of these facts that it is yet to be exploited as a source of milk. Also high price of imported milk and milk product coupled with poor milk production in Nigeria in particular and Africa in general seem to have make consumers more ready to accept milk produced from plant sources hence, it is suggested that milk from Tiger nut should be encouraged so as to solve the problem of protein calorie malnutrition in Africa and also to meet up with high demand of milk in Nigeria of today.

5.2 RECOMMENDATIONS

The use of Tiger nut milk as source of milk should be given serious consideration.

Furthermore, since there is gradual increase in the demand of milk of quantity of some quality parameters like phosphorus and potassium (minerals), protein, lipids, ash and carbohydrate, care should be taken during extraction so as to conserve enough of these parameter for storage. Some of the recommendations suggested for better results include:

- Further work should be carried out on extending/ determining the shelf life the Tiger nut milk produced.

- Analysis should be carried out on the shaft removed during milk extraction so as to further remove fibre content of Tiger nut.
- Finally, means should be device to further preserve Tiger nut milk product.

REFERENCES

Ababio, O. Y. (2001): New School Chemistry for Senior Secondary Schools, Third Edition, AFRICANA-FEP Publishers Limited, Onitsha, Nigeria, pp. 504 – 520

Abodunrin O.A and A. Belewu, 2008. Preparation of Kuunu from Unexploited Rich Food Source: Tiger nut (cyperus esculuntus). Pak.J.Nutr.,7: 109-111.

Ade- Omowaye, B. I. O., B.A Akinwande, I. F. Bolarinwa and A. O. Adebiyi, 2008. Evaluation of tiger nut(Cyperus esculentus)-wheat composite flour and bread. Afr. J. Food Sci., 2:087-091

Afenu S. 2008. Production of Tiger nut Beverage, HND Dissertation, Cape Coast Polytechnic, Cape Coast, Ghana, 1: 4-36.

AOAC (1980): Official Method of Analysis of the AOAC (13th edition), association of Official Ananlytical Chemists Washinton, DC, USA, pp.858

Bamgbose A.M.,D. Eruvbetine and W. Dada, 2003. Utilization of Tiger nut (Cyperus rotundus L.) in the diets for cockerel starters. Biores. Technol., 89: 245-8.

Beniwal, R.S., 2004. A ramdomised trail of yoghurt for prevention of antibiotic-associated diarrhoea, Digestive Disease and Sci., 48: 2077-2052.

Dianne, M. (2006-2007): Tiger Nuts (National Vegetable Society)

FAO (1968): Food Composition Table for Use in Africa, US Department for education and public health service Washington, D.C (html document)

FAO (1987): *The nutrition and feeding of farmed fish and shrimp; a training manual. 2: Nutrient sources and composition,* No.5/E 1987 p. 137 pg AB468/E p.4

Innvista (2008): Tiger Nuts (html document)

Ken Fern (2006): Notes from observations, tasting etc at Plants for a Future and on field trips

Ihekoronye and Patrick (1985): Integrated Food and Science Technology for the Tropics Macmillian Education Limited, pp. 103-104

Martinez. V., 2003. Scientific analysis of effects of tiger nut on heart disease and related aspects. Pp. 1-2. Tiger nut and Health.

Ojos Negros Research Group (2008): Three_issues_coquillofacts02, (html document).

Rita E. Sanful (2009): The Use of Tiger Nut (Cyperus esculuntus), Cow Milk and Their Composite as substrate for Yoghurt Production. Pp 755-758.

Wikipedia (2007): http://en.wikipedia.org/wiki/Cyperus_esculentus, (html document).

Yalc,ın Cos,kuner , Recai Ercan, Ers,an Karababa and Ahmet Nedim Nazlıcan (2002): Physical and chemical properties of chufa (Cyperus esculentus L) tubers grown in the Çukurova region of Turkey, Wiley InterScience, 2002, pp. 625-631.

Zohary Daniel and Mary Hopf, (2000): Domestication of plants in the Old World, third edition Oxford University Press, p. 198

APPENDIX

Proximate Composition of Tiger Nuts milk

Moisture content

a. Yellow Milk Sample

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$\frac{104.75 - 42.80}{104.74 - 28.37} \times \frac{100}{1} = 81.11\%$$

b. Brown milk sample

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100.$$

$$\frac{111.45 - 42.38}{111.45 - 28.32} \times \frac{100}{1} = 83.09\%$$

Ash (Total Ash)

a. Yellow Milk Sample

$$\frac{W_3 - W_1}{W_2 - W_1} \times 100 .$$

$$\frac{37.97 - 37.91}{39.91.37.91} \times 100 = 3.00\%$$

b. Brown Milk Sample

$$\frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$\frac{38.25-38.20}{-0.20-38.20}\times 100 = 2.50\%.$$

Lipid Content

a. **Yellow Milk Sample**

$$\frac{W_4-W_3}{W_2-W_1}\times 100$$

$$\frac{2.86-2.10}{3.08-1.08}\times 10 = 38\%$$

b. **Brown Milk Sample**

$$\frac{W_4-W_3}{W_2-W_1}\times 100$$

$$\frac{2.87-2.46}{2.85-0.85}\times 10 = 20.50\%$$

Nitrogen Free Extracts (NFE)

a. **Yellow Milk Sample**

$$\frac{TV\times MA\times 0.014\times 10}{W}\times 100$$

$$N=\frac{0.52\times 0.1\times 0.014\times 10}{2}\times\frac{100}{1} = 0.36\%$$

b. **Brown Milk Sample**

$$\frac{TV\times MA\times 0.014\times 10}{W}\times 100$$

$$N=\frac{0.58\times 0.1\times 0.014\times 10}{2}\times\frac{100}{1} = 0.41\%$$

Crude Protein (CP)

a. **Yellow Milk Sample**

Factor × NFE

$6.25 \times 0.36 = 2.28\%$

b. **Brown Milk Sample**

Factor × NFE

$6.25 \times 0.41 = 2.54\%$

Carbohydrates

a. **Yellow Milk Sample**

$$Carbohydrates = 100 - (3.00 + 2.54 + 38.00)$$

$$= 100 - 43.54 = 56.46\%$$

b. **Brown Milk Sample**

$$Carbohydrates = 100 - (2.50 + 2.54 + 20.50)$$

$$= 100 - 25.54 = 74.46\%$$