NUTRITIONAL, PHYSICOCHEMICAL, MICROBIOLOGICAL AND SENSORY CHARACTERISTICS OF YOGHURT PRODUCED WITH IMITATION MILK FOR LACTOSE-INTOLERANT PERSONS.

BY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, COLLEGE OF BASIC AND APPLIED SCIENCES,

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DECLARATION

I hereby declare that this project has been written by me and is a record of my research work. It has not been presented in any previous application for a higher degree of this or any other University. All citations and sources of information are acknowledged utilizing references.

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CERTIFICATION

This is to certify that the content of this project entitled '**Nutritional,Physicochemical, Microbiological, And Sensory Characteristics of Yoghurt Produced with Imitation Milk for Lactose-Intolerant Persons.**' was prepared and submitted by **ESSIEN, EDWIN EMEMABASI** in partial fulfillment of the requirements for the degree of **BACHELOR OF TECHNOLOGY IN FOOD SCIENCE AND TECHNOLOGY.** The original research work was carried out by him under my supervision and is hereby accepted.

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DEDICATION

I dedicate this project to God Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this program and on

His wings only have I soared. I also dedicate this work to my parents; Mr. B. Essien and Dr. Mrs. A. Essien who have encouraged me all the way and whose encouragement has been instrumental to me being able to give it all it takes to finish that which I had started.

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ABSTRACT

Lactose intolerance is a common digestive issue in which the body is unable to digest lactose, a type of sugar found primarily in milk and dairy products. Lactose intolerance is common around the world, and patients usually avoid milk and dairy products to alleviate symptoms. Yoghurts were produced from imitation milk of plant sources; Almond, Coconut and tigernut while cow milk yoghurt served as the control. This research work aimed at quantifying the nutritional characteristics (proximate composition and mineral profile) of the yoghurts. Physicochemical, microbial and sensory assessments were also carried out on all four samples. The acceptability of these imitation milk yoghurts was judged by two sets of panelists; lactose intolerant people and people who consume milk. The results obtained were statistically analyzed and discussed. The findings showed that sample BYN (Cow milk yoghurt) had the highest ash and carbohydrate contents (2.33±1.00% and 12.19±0.73% respectively). RYN (Coconut milk yoghurt) had the highest fat content (12.37±1.26%) while XYN (tigernut milk yogurt) had the highest protein and lowest fat (1.48±0.33% and 5.18±0.0.72%) contents. PYN (Almond milk yoghurt) had the lowest protein content (0.55±0.02%). The mineral profile of BYN showed to be the highest in Ca (0.25%). All the imitation milk yoghurts were found to have higher amounts of manganese, iron and copper than BYN; with PYN having the highest values for the three minerals (4.89, 13.90 and 2.24 respectively). RYN had the highest Zn content (6.35ppm). The lactose intolerant panelists preferred the sweetened coconut yoghurt (RYS) which had the highest score for acceptability and was significantly different ($p<0.05$) from the rest. The imitation milk yoghurts in this study can be recommended to individuals seeking alternative to cow milk yoghurt or who are deficient in select micronutrients.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The term "milk" exclusively refers to the natural mammary discharge resulting from one or more milkings, with no additives or extractions. Imitation milk is a product that looks and tastes like milk but does not contain any milk fat or other vital dairy constituents, this milk is of plant origin such as soya bean, peanut, rice and coconut. There are numerous similarities between the two, ranging from aesthetics to consumer preferences. Milk is the most widely consumed food on the planet, and it is also a key element in the production of a variety of dairy products. Despite the massive production and consumption of milk and milk-based products, a significant portion of the global population suffers from milk solids allergy and lactose intolerance (Katoch et al., 2021).

A percentage of the global population is allergic to cow's milk, which forces people to change their eating habits or seek out alternatives. This demography of people may find lactose-free beverages made from plant seed blends to be a viable feeding option with increased nutritional and functional qualities (Olagunju and Oyewumi, 2019).

Demand for a more Western-style diet is increasing, placing strain on the world food supply. One of the key reasons contributing to the harmful impact of the modern diet on both global and individual health is the consumption of high quantities of animal-based products, particularly those obtained from cows, such as beef and milk (Poore&Nemecek, 2018). As a result, there is a lot of interest in changing to a more plant-based diet to improve human health, boost food sustainability and reduce pollution, land use, and water use (Willett et al., 2019).

One of the factors contributing to the increased demand for milk and milk products such as yoghurt in Nigeria is the country's growing population and enormous rural-to-urban migration in search of a better quality of living. This has also resulted in a scarcity of indigenous animal milk to meet the growing population's milk needs (Odejobi et al., 2018).

Plant-based milk replacements are also a low-cost alternative for poor people in developing nations who lack access to cow milk (Olagunju and Oyewumi, 2019).Consumer interest in health and wellbeing is quickly increasing around the world (Ali et al., 2015), fueled by increased awareness of chronic diseases and the numerous health claims presently linked with various foods. In reality, most people presently consume imitation milk out of choice rather than necessity owing to an allergy (Mintel Group, 2016). Imitation milk is frequently seen as healthy, potentially as a result of the health claims made about them, especially in terms of vitamins, fiber, or cholesterol. This, combined with the bad associations people have with cow's milk, is driving the market. The risk of contributing to several human ailments, as well as the high-fat content, is some of the negative impressions of cow's milk (Dewhurst et al., 2006).

In 2015, around 130 different Imitation milk variations were offered on the European market, with a total value of 1.5 billion dollars (Mintel Group, 2016). Furthermore, fermented foods and beverages are gaining popularity among consumers, expanding the non-dairy sector even further. On the market, new goods such as fermented yoghurt and cheese replacements are appearing. However, these goods continue to receive insufficient scientific study, and they have not received the attention they deserve in recent decades.

Cow milk is used to make yoghurt, which is a dairy product. It is essentially a milk product obtained through the activities of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* in the fermentation of lactose components in animal milk (Sanful, 2009). Sour cream and cottage cheese are two other fermented milk products. Cow milk is widely available around the world and is therefore the milk of choice for making yoghurt (Usman and Bolade, 2020). Yoghurt is a good source of protein, calcium, vitamins B2 and B12, potassium, and magnesium because it is made from cow's milk (Magee, 2020). It is also thought that the fermented milk product has therapeutic properties and important health benefitson a variety of gastrointestinal functions and illnesses (Adolfsson, 2004). Yoghurt is popular as a dessert drink or snack because of its pleasant aromatic flavor, thick creamy consistency, and reputation as a healthy food. In Nigeria, the majority of commercial yoghurt producers use imported milk powder as a major ingredient, making the industry import-dependent. The dairy industry in Nigeria is underdeveloped because animal rearers continue to practice nomadic animal husbandry, resulting in poor animal nutrition and health. The country's underdeveloped dairy industry is exacerbated by the poor genetic conditions of Nigerian ruminant breeds (Ogbimi and Oyewale, 2000). As a result of all of these obstacles, the country has been unable to produce high-quality livestock and milk. Researchers have attempted to use plant-based milk-like alternatives for the production of yoghurt in composite formulations with cow milk due to the scarcity of cow milk in commercial quantities in Nigeria and many other countries (Usman and Bolade, 2020). This has resulted in the promotion of high-value goods such as tigernut milk, coconut milk, soybean milk, and other plant-based functional yoghurts.

1.2 Statement of the Problem

Due to its nutritional content and versatility in satiating appetite, milk has been one of the most widely consumed foods by humans for millennia. However, due to clinical studies demonstrating that some constituents of milk are associated with deleterious health effects such as cow milk allergy (CMA), lactose intolerance (LI), anemia, and coronary heart disease, its consumption has raised concerns among the health-conscious and risk-prone population.

People who have lactose intolerance, milk allergies, or vegans, or ovo-vegetarians do not consume any animal products. These individuals are either unable to ingest milk or have chosen not to consume milk. This issue has existed for quite some time. For those in the demographic who want to feel like they're drinking milk, substituting milk for plant-based imitation milk is a smart option.

Plant-based milk is free of certain components found in mammalian milk, such as cholesterol, saturated fatty acids, antigens, and lactose, while also providing a good source of minerals, non-allergic proteins, essential fatty acids, and other nutrients, making them an excellent dairy-free alternative. For those looking for dairy-free options, plant-based milk may be a decent option. As a result, customers are more interested in choosing plant-based imitation milk over traditional mammalian milk.

1.3 Aim and Objectives of the Study

This study's overall goal is to produce and assess yoghurt prepared using imitation milk derived from Almond nuts, Coconut, and tigernuts in comparison to yoghurt produced with cow milk. The specific goals are to:

1. Produce yoghurt from plant-based imitation milk.
2. Assess the yoghurt's nutritional quality, physicochemical, and microbial characteristics when it's made with plant-based imitation milk.
3. Evaluate the sensory quality and consumer acceptability of yoghurt made with plant-based imitation milk for lactose-intolerant persons.

1.4 Scope of the Study

This body of work focused on the production of yoghurt from plant-based imitation milk made from Almond nut (*Prunusdulcis*), Coconut (*Cocos nucifera*), and tigernut (*Cyperusesculentus*). The nutritional value of the yoghurts were determined and the acceptability assessed by lactose-intolerant persons .

1.5 Significance of Study

Sixty-eight percent of the global population have lactose malabsorption (Storhaug et al., 2017), which forces people to change their eating habits or seek out alternatives. Alternatives are plant based imitation milk. This milk looks like cow milk but does not contain lactose and depending on the source of the milk the nutrients present are known. Fermentation using probiotic bacteria to make yoghurt would help improve the nutritional value of the imitation milk and also provide alternatives for lactose intolerance persons who might be interested in the sensory attributes of yoghurts.

1.6 Definition of Terms.

1.6.1 Lactose intolerance

Lactose intolerance is a common digestive issue in which the body is unable to digest lactose, a type of sugar found primarily in milk and dairy products.

1.6.2 Plant-based imitation milk

Plant-based Imitation milk can be made to look like milk and used in place of milk. These products have the appearance of whole milk but contain no actual milk ingredients and are generated from plant sources.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Cow Milk Yoghurt

Yoghurt is a fermented milk product that contains digested lactose and certain, live bacterial strains, such as *Streptococcus thermophilus* and *Lactobacillus bulgaricus.* Protein, calcium, potassium, phosphorus, and vitamins B2 and B12 are just a few of the important elements found in it, and it also acts as a vehicle for fortification (Fisberg and Machado, 2015).

Researchers did not offer an explanation for the health advantages linked with yoghurt intake until the twentieth century. Stamen Grigorov, a Bulgarian medical student, discovered Bacillus bulgaricus (now L. bulgaricus) which is a lactic acid bacterium that is being used in yoghurt cultures today in 1905. Based on Grigorov's results, Yllia Metchnikoff of the Pasteur Institute in Paris, a Russian Nobel winner, proposed in 1909 that lactobacilli in yoghurt were linked to lifespan in the Bulgarian peasant population (Fisberg and Machado, 2015). Yoghurt became well-known for its health advantages in the early twentieth century, and it was marketed as a medication in pharmacies.

Yoghurt is usually milk that has been fermented and acidified with live and well-defined bacteria, resulting in a thicker, frequently flavored product with a long shelf life. It is a vehicle for fortification and includes important nutrients (added probiotics, fibers, vitamins, and minerals). Sweeteners, fruits, and flavors may all be used to change the consistency and flavour. Rice, soy, and almonds may all be used to make yoghurt (Olabi et al., 2014).

The symbiosis of two bacteria strains (S. thermophiles and L. bulgaricus) in a sterile environment at a very low temperature (36°C–42°C) for 3–8 hours is what makes yoghurt. According to CODEX 2003, both bacterial strains must be active in the final product (with at least 10^{6}cfug^{-1}bacteria). Changes in carbohydrates, proteins, and lipids occur as a result of the process that pre-pasteurized skimmed milk undergoes before being converted into yoghurt. It produces a product with a more acidic flavour and better look, taste, consistency, and digestion. Lactic acid and a number of other chemicals are produced when milk lactose is employed as the fermentation substrate, adding to theflavour. The development of undesirable microorganisms is delayed as a result of a lower pH, the calcium and phosphorus in milk are converted to their soluble form, and the majority of proteins, which are now calcium free, are better digested by proteolytic enzymes, improving their digestibility and overall bioavailability (Olabi et al., 2014).

Lactobacillus acidophilus and *Bifidobacterium bifidus,* for example, are often added for their possible health advantages. When yoghurt is eaten on a regular basis, pathogen development may be reduced, which is ultimately advantageous to the human stomach (Aznar et al., 2013). Some yoghurts, such as Greek yoghurt, have their protein content increased by concentrating or adding protein to give double the amount found in normal yoghurt. Some products also include calcium and vitamin D, which provide nutritional benefit to those who have a high prevalence of lactose intolerance or a limited consumption of dairy foods.

2.2. Lactose Intolerance

Lactose intolerance is common around the world, and patients usually avoid milk and dairy products to alleviate symptoms. Lactose is a unique carbohydrate found only in mammalian milk, with 7.2 g/100 mL in mature human milk and 4.7 g/100 mL in cow's milk, but it is negligible in the milk of some marine mammals. (Lomer et al., 2007) Lactose requires hydrolysis by the enzyme lactase for effective utilization and, during infancy, provides an excellent source of energy during a period of rapid growth and development. Improved management of lactose intolerance requires a better understanding of lactase and its deficiency, as well as why milk contains a unique carbohydrate (Lomer et al., 2007).

Lactose intolerance refers to either a lactase deficit (hypolactasia) or a lactase deficiency (alactasia). Lactose entering the small intestine is not broken down due to a lack of lactase synthesis (Di Rienzo et al., 2013). Lactose that has not been digested draws water into the intestines by osmosis. In addition, microorganisms in the large intestine ferment it, generating fatty acids and gases like carbon dioxide, hydrogen, and methane. Lactose intolerance symptoms include watery diarrhea, stomach discomfort or cramping, and bloating, which are caused by the fluid and products of fermentation (Di Rienzo et al., 2013). These symptoms usually appear 30 minutes to 2.5 hours after ingesting lactose-containing foods (Casellas et al., 2013).

Milk and dairy products are frequently assumed to be the source of gastrointestinal symptoms, and excessive avoidance can lead to nutritional deficiency, particularly in terms of calcium intake. Many people with lactose intolerance can consume milk and dairy products without experiencing symptoms, and fermented milk products may aid in tolerance improvement. Other people benefit significantly from lactose restriction, but care must be taken to ensure adequate calcium intake. A better understanding of the complexities of lactose intolerance, lactase deficiency, and symptom generation would aid clinicians in more effectively treating patients.

2.2.1 Rampancy of lactose intolerance

Lactose intolerance was first described by Hippocrates around 400 years ago, but clinical symptoms have only been recognized in the last 50 years. Lactase intolerance affects up to 70% of the world's population, but not everyone is lactose intolerant due to a variety of nutritional and genetic factors. Lactose intolerance is more common in people of African descent. White north Europeans, North Americans, and Australians have the lowest rates in adults, ranging from 5% in the UK to 17% in Finland and northern France. Lactase intolerance affects more than half of the population in South America, Africa, and Asia, and it is nearly 100 percent in some Asian countries. Surprisingly, subjects of mixed ethnicity have a lower prevalence of lactase non-persistence, whereas the native ethnic group has a high prevalence. Lactase expression typically declines throughout childhood, although it has also been observed to decrease later in puberty (Lomer et al., 2007).The rate of lactase activity loss also varies by ethnicity, but the physiological explanation for this variation in timing is currently unknown. Lactase activity in Chinese and Japanese people declines by 80–90% within 3–4 years of weaning, while Jews and Asians decline by 60–70% over several years, and lactase activity in white Northern Europeans declines by 18–20 years (Lomer et al., 2007).

2.2.2 Symptoms of lactose intolerance

When lactose is not absorbed in the small intestine, it is called lactose maldigestion. It travels through the gastrointestinal tract to the colon, where it can cause lactose intolerance symptoms in some people. Lactose intolerance is characterized by abdominal pain, bloating, flatus, diarrhoea, borborygmi, and, on rare occasions, nausea, and vomiting. In a few cases, gastrointestinal motility is reduced, and subjects may experience constipation as a result of methane production. When infused with methane, animal models show a significant reduction in the major migratory complexes of the gut, slowing gut transit. Abdominal pain and bloating are typically caused by bacterial microflora colonic fermentation of unabsorbed lactose, which results in the production of short-chain fatty acids (SCFA), hydrogen, methane, and carbon dioxide, increasing gut transit time and intracolonic pressure. Acidification of the colonic contents and an increased osmotic load caused by unabsorbed lactose in the ileum and colon result in increased electrolyte and fluid secretion and a faster transit time, resulting in loose stools and diarrhoea. Excessive crying, flatulence, and watery feces are all signs of lactose intolerance in babies (Vandenplas, 2015).

2.3 Coconut

Cocos nucifera (L.), often known as coconut, coco, coco-da-bahia, or coconut-of-the-beach, is a member of the Arecaceae (palm) family. The plant is native to Southeast Asia (Malaysia, Indonesia, and the Philippines), as well as the islands that lie between the Indian and Pacific Oceans. The coconut palm's fruit is said to have been carried from that location to India and subsequently to East Africa. This plant was brought to West Africa with the discovery of the Cape of Good Hope, and from there it spread to the American continent and other tropical parts of the world (Lima et al., 2015).

The plant is an arborescent monocotyledonous tree with a thick canopy that grows to about 25 meters in height (giant coconut). The coconut system's root is fasciculated. A tuft of leaves covers a solitary apical bud at the tip of the unbranched stem. The pinnate leaves have a petiole, rachis, and leaflets and are feather-shaped. The big adult coconut may produce 12–14 inflorescence spikes each year under ideal conditions, but the adult dwarf coconut can produce 18 spikes in the same time frame. Female flowers cluster in globular clusters on the axillary inflorescence. It's a monoecious plant (male and female reproductive organs on the same plant) (Lima et al., 2015).

The coconut palm grows to be around 30 meters tall and is widely farmed in tropical climes. It is the only living species in the genus *Cocos*, which has roughly 2,600 species in the palm family Arecaceae. The fruit of the coconut palm, which consists of a fibrous husk (mesocarp) encasing a huge seed or inner stone, is known as a coconut. The edible, commercially important white and fleshy section of the seed (the coconut "meat" or endosperm), which surrounds the hollow, fluid-filled core chamber, is also referred to as a coconut. The hollow center is filled to the brim with a cloudy but translucent tasting liquid (liquid endosperm) that is somewhat thicker than water (Lima et al., 2015).

Coconuts originated in India and Southeast Asia, but because they float, they were taken to Pacific Ocean shores and successfully established themselves in every subtropical location they could find. People contributed to the expansion of coconut palms across the Atlantic, and they now flourish in practically every subtropical coastal zone on the planet. Coconut milk is a beverage made from grated coconut meat that can range in thickness from thick and creamy to thin and milk-like. For years, and perhaps millennia in certain countries, such as India, it has been one of the most important ingredients in Southeast Asia, South Asia, the Caribbean, and northern South America. It's a key element in a lot of traditional foods and drinks, and it's also used for ceremonial offerings. Coconut milk has the longest history of use of any plant milk. People simply would not accept cow's milk in many areas where it is a staple, hence coconut milk is referred to as "the milk."

2.3.1 Nutritional Benefits of Coconut

Coconut has a wide range of applications. Coconut which is the liquid endosperm of the coconut, is a delicious natural soft drink. It contains 17.4 calories per 100 grams. Vitamin B is found in coconut water in the form of nicotinic acid B3 (0.64 µg/mL), pantothenic acid B5 (0.52 µg/mL), biotin (0.02 µg/mL), riboflavin B2 (0.01µg/mL), folic acid (0.003 µg/mL), thiamine B1 and pyridoxine B6 (USDA, 2008). Sugars, sugar alcohols, vitamin C, folic acid, free amino acids, phytohormones (auxin, 1, 3-diphenylurea, cytokinin), enzymes (acid phosphatase, catalase, dehydrogenase, diastase, peroxidase, RNA polymerases), and growth stimulating factors are among the nutrients found in coconut water (Yong et al., 2009). The dried kernel of copra, which is primarily utilized for oil extraction, contains 65 to 75 percent oil (NMCE, 2007). Toddy is made from the unopened spathe, which is turned into jaggery, vinegar, and sugar. The kernel (wet meat) is primarily utilized in curries, chutneys, toffees, sweets, and other dishes (NMCE, 2007).

Caprylic acid C-8:0 (8%), capric acid C-10:0 (7%), lauric acid C-12:0 (49%), myristic acid C-14:0 (18%), palmitic acid C-16:0 (8%), stearic acid C-18:0 (2%), oleic acid C-18:1 (6%), and linoleic acid C-18:2 (2%) are the fatty acids found in coconut (Yong et al., 2009). It is high in medium chain saturated fatty acids (MCFAs), which can be absorbed directly from the colon and delivered straight to the liver to be quickly processed for energy production (Enig, 2004). Due to its high mineral content, particularly potassium, coconut water offers cardioprotective properties in myocardial infarction. VCO, according to Nevin and Rajamohan, reduced total cholesterol, triglycerides, phospholipids, low-density lipoprotein (LDL), very-low-density lipoprotein (VLDL), and increased high-density lipoprotein (HDL) cholesterol levels while increasing high-density lipoprotein (HDL) cholesterol levels (Nevin and Rajamohan, 2004). In vitro LDL-oxidation was reported to be prevented by the polyphenol component of virgin coconut oil.

Inorganic ions such as K (290 mg%), Na (42 mg%), Ca (44 mg%), Mg (10 mg%), and P (9.2 mg%) are abundant (Effiong et al., 2010). The concentration of these electrolytes in coconut water produces an osmotic pressure that is similar to that found in blood (Effiong et al., 2010) and has no effect on plasma coagulation. Coconut water's high potassium content is said to help decrease blood pressure (Loki and Rajamohan, 2003).

2.3.2Uses of coconut

The uses of coconut can be divided into two, namely culinary and non-culinary uses

2.3.2.1 Culinary uses (*New World Encyclopedia contributors, 2020)*

- The white, fleshy component of the seed is delicious and can be cooked using fresh or dried.
- Sport fruits, known as macapuno in the Philippines, are also harvested.
- Coconut water, which contains sugar, fiber, proteins, antioxidants, vitamins, and minerals, is poured into the cavity. Coconut water is a highly healthy food source with an isotonic electrolyte balance. It's a popular beverage in the humid tropics, and it's also found in isotonic sports drinks. It can also be used to make nata de coco, a gelatinous treat. Coconut water is sterile until opened, and mature fruits have substantially less liquid than young immature coconuts. Many tropical beverages, such as the Pina Colada,
- The oil and aromatic chemicals in shredded coconut are extracted by processing it with hot water or milk. It has a fat content of about 17% and should not be mistaken with the coconut water explained above. Coconut cream will rise to the top and separate from the milk when refrigerated and allowed to set.
- The fiber leftover from the manufacturing of coconut milk is utilized as livestock feed.

- Palm wine also called "toddy" or tuba in the Philippines is made from the sap obtained by slicing the flower clusters of the coconut. Boiling the sap reduces it, resulting in a delicious syrup or candy.
- Adult plant apical buds, often known as "palm-cabbage" or "heart-of-palm," are tasty. The act of harvesting the bud kills the palm, making it a rare delicacy. Salads made with hearts of palm are known as "millionaire's salad."
- RukuRaa (coconut nectar) is an extract from the young bud, a very uncommon type of nectar collected and used as a morning break drink in the Maldives islands. It is famous for its energetic force, which keeps "raamen" (nectar collectors) healthy and active even at the age of 80 and 90. Sweet honey-like syrup and creamy sugar for sweets are also by-products.
- Coconut sprout, an edible fluff of marshmallow-like consistency formed when the endosperm nourishes the growing embryo, is found in newly germinated coconuts.
- Rice is wrapped in coco leaves for cooking and storage in the Philippines, and these packets are known as puso.

2.3.2.2 Non-culinary uses (*New World Encyclopedia contributors, 2020*)

- Coconut proved to be an ideal intravenous fluid (Campbell-Falck et al., 2000).
- Coir (coconut husk fiber) is used to make ropes, matting, brushes, caulking boats, and stuffing fiber; it is also widely used in horticulture to make potting compost.
- Coconut oil is made from copra, which is the dried meat of the seed.
- Palmwoodis made from the trunk and is becoming more popular as an environmentally friendly alternative to endangered hardwoods. It has a variety of uses, including furniture and specialized architecture (such as the Coconut Palace in Manila).
- The husk and shells can be utilized as a source of charcoal and can be used as fuel.
- Floors are buffed using dried half coconut shells with husks. It's known as "bunot" in the Philippines.
- Dried half-shells are utilized as a musical instrument in the Philippines in a folk dance called maglalatik, which is a traditional dance depicting battles over coconut meat during Spanish rule.
- Dried coconut shells can be cut into shirt buttons. Hawaiian Aloha shirts frequently have coconut buttons.

- Cooking skewers, kindling arrows, and bundles, brooms, and brushes can all be made from the stiff leaflet midribs.
- In theater, half coconut shells are smashed together to produce the sound of a horse's hoofbeats.
- Half coconut shells can be used as an improvised bra, particularly for comic or theatrical effects.
- To keep snorkeling goggles from fogging during use, apply fresh inner coconut husk on the lens.
- The body of musical instruments such as the Chinese yehu and banhu, as well as the Vietnamese àngáo, are made of dried half coconut shells.
- In Pakistan, coconut is also extensively used as a natural cure to treat rat bites.

2.4 Tigernut

tigernut is *Cyperusesculentus*L. in botanical terms. Depending on the tribe or area where the tigernut tuber is grown and used, it goes by different names. The genus name Cyperus comes from the ancient Greek name Cypeirus, while the species name esculentus comes from the Latin term esculentus, which means palatable (Ayeh-Kumi et al., 2014). tigernut is also known as ‘Zulu nut,' ‘Yellow nut sedge,' ‘Chufa,' ‘Flat sedge,' ‘Edible rush nut,' ‘Water grass,' ‘Almond,' ‘Northern nut grass,' and ‘Nut grass,' among other names (Sánchez-Zapata et al., 2012). Hausas, Igbos, and Yorubas, Nigeria's three most populous ethnic groups, refer to tigernut tubers as "Aya," "Ofio," and "Imumu," respectively (Maduka and Ire, 2018). In Southern Nigeria, tigernut tubers are known as ‘Aki Hausa,' which literally means ‘a nut that is mostly grown and sold by the Hausas who control Northern Nigeria' (Bamishaiye and Bamishaiye, 2011). Many states in Northern Nigeria produce a significant part of the tigernut tubers that are sold throughout the nation as snacks (Ukwuru et al., 2011).

Cyperusesculentus grows like a weed, a crop, and in the wild. tigernut is a wild edible plant that has the potential to enhance human nutrition. It makes a major contribution to the economic and cultural well-being of individuals living in rural communities in Sub-Saharan Africa (Bamishaiye and Bamishaiye, 2011). Outside of its native range, it is an invasive species that is easily transported and becomes invasive. *C. esculentus*is regarded as a weed in many countries (Sánchez-Zapata et al., 2012). During the summer, it can be found in wet soils such as rice paddies and peanut farms, as well as well-irrigated lawns and golf courses.

tigernut was an essential food in prehistoric and ancient Egypt, where it was one of the oldest cultivated plants (Allouh et.al 2015). Its roots reaching back to roughly 16,000 BC have been discovered in WadiKubbaniya, north of Aswan. Dry tubers can also be found in graves from the Predynastic period, dating back to roughly 3000 BC. C. was present at the moment. Tubers of the *Cyperus esculentus* were eaten cooked in beer, roasted, or as sweets made from crushed tubers and honey. The tubers were also employed as fumigants to sweeten the smell of dwellings or garments and were administered orally, as an ointment, or as an enema. During the Dynastic period, Chufa remained a vital source of food, and the plant's cultivation was limited to Egypt (Zohary and Hopf, 2000).

2.4.1 Description of tigernut

Cyperus esculentus is an annual or perennial plant with solitary stems that develop from a tuber and grow up to 90 cm (3 feet) tall. Seeds, creeping rhizomes, and tubers are used to propagate the plant (Stoller, 1981). *C. esculentus* may take advantage of soil disturbances produced by human or natural factors because of its clonal nature (Renne and Tracy, 2006). The stems have a triangular shape and thin leaves that are 3–10 millimeters broad. The plant's spikelets are unique, with a cluster of flat, oval seeds encircled by four dangling, leaf-like bracts that are positioned 90 degrees apart. They are 5 to 30 centimetres long, with 8 to 35 florets and a linear to narrowly elliptic shape with pointy ends. The tint ranges from straw to gold-brown in hue. Each plant may generate up to 2420 seeds. The plant's leaves are stiff and fibrous, giving it the appearance of a grass. Small, hard, spherical tubers and basal bulbs connect to a vast and complicated system of fine, fibrous roots and scaly rhizomes. The tubers range in size from 0.3 to 1.9 cm in diameter and come in a variety of hues including yellow, brown, and black. During a single growth season, a single plant may yield hundreds to thousands of tubers. When soil temperatures stay over 6 °C (43 °F), the leaves, roots, rhizomes, and basal bulbs die, but the tubers survive and resprout the next spring. They may resprout after a period of time. Many rhizomes are started when the tubers germinate and end in a basal bulb near the soil surface. The stems and leaves above ground, as well as the fibrous roots below, are initiated by these basal bulbs. C. esculentusis pollinated by the wind and needs cross pollination to reproduce since it is self–incompatible (Stoller, 1981).

2.4.2 Nutritional benefits of tigernut

*C. esculentus*has been reported to be a healthy food because it is said to activate blood circulation and help prevent heart disease and thrombosis (Chukwuma, et al., 2010). It was also discovered to help reduce the risk of colon cancer (Adejuyitan, et al., 2009). This tuber is high in energy (starch, fat, sugar, and protein), minerals (primarily phosphorus and potassium), and vitamins E and C (Belewu and Belewu 2007), making it suitable for diabetics and those looking to lose weight (Borges et al., 2008).

tigernut tuber has an energy value of 400–413.8 kcal/100 g (Sánchez-Zapata et al., 2012). Carbohydrates make up the majority of the tigernut, accounting for 43.3 g/100g. Sanchez-Zapata et al. (2012) found that the starch concentration is comparable to that of cassava and nearly double that of potato (29.9% in wet matter). The dietary fiber level of 8.81 g/100g is much greater than that of other tubers, which varies from 0.66 to 2.55 g/100g, and is comparable to that of nuts. Insoluble dietary fiber accounts for 99.8% of the total. Sucrose concentration is also considerably greater, at 13.03 g/100g, than in other tubers, which range from 0.31 to 4.77 g/100g.

2.4.3 Uses of tigernut

Dried tigernut is smooth, soft, and sweet, with a nuttyflavour. tigernuts can be eaten fresh, roasted, fried, baked, or in the form of tigernut milk or oil. It is also used as fishing bait.

2.5 Almond

Almonds (***Prunus dulcis***) are thought to have originated in Western and Central Asia in the fourth millennium B.C., if not earlier. This was possible for two reasons: the first is that gardeners were able to create tasty almonds from seed, implying that they may have been farmed before the invention of grafting, a technology required for the domestication of most other plants. The second cause for almond cultivation's emergence is completely fortuitous. All almonds used to be highly bitter to humans because they contained lethal quantities of cyanide. This was attributable to the presence of the amygdalin compound. To avoid predation, wild almonds contain amygdalin in their seeds. This is still true today: fifty wild almonds are enough to kill an adult. A spontaneous mutation in the plant occurred at some point—no one knows when—suppressing the production of this deadly toxin. Almonds were tasty and safe to consume all of a sudden. After humans discovered the mutant nuts, domestication took up, and almonds became a popular delicacy in the Middle East (Milinchuk, 2019).

2.5.1 Description of Almond

Prunus, the genus that comprises plums, cherries, peaches, and apricots, also includes the almond plant. Prunus has roughly 430 species that can be found in the northern temperate parts of the world. The Prunus genus belongs to the Rosaceae family, which is one of the largest flowering plant families with about 3,400 species. It also includes flora like apples, berries, hawthorn trees, mountain ash, and many others. The almond tree belongs to the Prunus subgenus Amygdalus, along with the peach. The corrugated seed shell distinguishes it from the other subgenera. Other Prunus species, such as the plum and cherry, have a pleasant fleshy outer covering that is replaced by a leathery coat called the hull, which holds the edible kernel inside a hard shell, generally referred to as a nut in culinary language. Almond, on the other hand, is not a real nut in botanical terms. The reticulated hard stone shell is known as an endocarp, and the fruit, or exocarp, is a drupe with a downy outer covering in botanical terms. The almond tree is a southwest Asian native. Fruit can ripen as far north as the British Isles in the domesticated form. It is a little tree that can reach a height of 4–9 meters. The leaves are lanceolate and serrated at the margins, measuring 6–12 cm long. The blooms, which are white or pale pink and have a diameter of 3–5 cm and five petals, bloom before the leaves in early April (New World Encyclopedia contributors, 2021).

The plant comes in two varieties: one that produces sweet almonds (typically with white flowers) and another that produces bitter almonds (frequently with pink flowers). The former has a set oil and emulsion in its kernel. The oil was used internally in medicine as late as the early twentieth century, with the caveat that it must not be mixed with bitter almond oil. It's still widely used in alternative medicine, especially as a carrier oil in aromatherapy, although it's no longer prescribed by doctors (New World Encyclopedia contributors, 2021).

Bitter almonds are wider and shorter than sweet almonds, and they contain about half of the fixed oil found in sweet almonds. It also includes the enzyme emulsin, which reacts with a soluble glucoside, amygdalin, in the presence of water to produce glucose, cyanide, and bitter almond essential oil or benzaldehyde. Bitter almonds can contain up to 8% hydrogen cyanide (prussic acid).

2.5.2 Nutritional benefit of almond

The almond is a popular healthy food that is high in good fats, protein, minerals, and vitamins. It also contains therapeutic properties that can be used to treat a variety of illnesses. Almond seeds have a variety of pharmacological characteristics, including anti-stress, anti-oxidant, immunological stimulant, cholesterol reducing, and laxative qualities. Almonds, which contain copper, iron, and vitamins, are an effective nutritional therapy for anemia. Hari Jagannadha Rao and Lakshmi (Hari Jagannadha Rao and Lakshmi, 2012) Almonds have been linked to a lower risk of heart disease by lowering total and LDL cholesterol and exerting anti-inflammatory and antioxidant properties. Plant sterols, such as those found in almonds, may interfere with cholesterol and bile acid absorption, and the high amount of unsaturated fat in almonds favors an improved lipid profile, especially when this food replaces other foods high in saturated fat and refined carbohydrates.

Almond seeds are high in protein and minerals including calcium and magnesium. Almond seeds are a good source of iron and can help with anemia. Vitamin E, dietary fiber, B-vitamins, critical minerals, mono-unsaturated fats, and phytosterols, which have cholesterol-lowering qualities, are all abundant in them. They can help with constipation and a variety of skin conditions like eczema and acne. Gastroenteritis, renal aches, diabetes, head lice, facial neuralgia, and gastric ulcers can all be treated with almond seeds. Hari Jagannadha Rao and Lakshmi (Hari Jagannadha Rao and Lakshmi, 2012)

2.5.3 Uses of almond

While the almond is commonly eaten raw or toasted on its own, it is also used in a variety of recipes. Almonds come in a variety of forms, including whole, slivered, and crushed flour. Nibs, or small almond pieces of 2–3 mm in size, are used for special uses such as ornamentation. Other uses are:

- Almond milk (New World Encyclopedia contributors,2021)
- Almond flour(Elana, 2009)
- Almond syrup (Ward 1911)
- Nutritional and culinary uses; Almonds are a nutritional powerhouse." Almonds are a rich source of protein, vitamin B_2 (riboflavin), vitamin E, copper, niacin, calcium, fiber, folic acid, magnesium, and potassium and a good source of iron and zinc (Herbst, 2001)

Medicinal uses; Claimed medicinal benefits of almonds include improved complexion, improved movement of food through the colon, and the prevention of cancer (Davis and Iwahashi 2001)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1. Materials

The raw materials for this project were bought from the local Ibafo market.

The raw materials used in this project were dried tigernut, de-shelled almond nut, coconut, powdered milk (Loya milk) and starter culture (Yogourmet freeze-dried yoghurt starter).

3.2 Equipment, Instruments and Reagents Used

Equipment instrument and reagents utilized for this research work included Attrition mill, Laboratory oven (Uniscope, Memmert), Muslin cloth, Bottles, Pot, Gas cooker, Thermometer, Muffle furnace (Vulcan 3-550.), Laboratory Oven, Porcelain crucibles, Volumetric flasks (2000ml), 50ml polyethylene centrifuge tube, Precision balance (0.0001g accuracy) (Denver) Vortex mixer (Genius 3), Weighing paper, (Fisherbrand), Centrifuge 5810R machine (eppendorf), Atomic Absorption Spectrophotometer(Buck 211), ICP/OES (Perkin Elmer), Nitric acid (HNO_3) Redistilled, min 69% (GFS chemical), Hydrochloric Acid (HCl 37%) (Merck no. 1.00317***), Distilled water, MRS Agar,lactophenol blue, 70% Ethanol, Methylated spirit, Petri-dish, Incubator, Microscope, Autoclave, inoculating needle, cotton wool, Bunsen burner, pipette, Micro-pipette and Colony counter.

3.3 Methods

3.3.1 Production of tigernut milk

For milk production, the tubers with the best performance were sorted out and soaked at room temperature for 12 hours. About 3 cups of the soaked tuber were placed in a grinder and processed for 10 minutes with 1.5 litres of water. The paste was placed in a muslin cloth and squeezed to extract the milk(Sanful, 2009).

3.3.2 Production of almond milk

Three cups of Almond nuts were heated for 1.5 minutes to peel the skin off the nut. The nuts were ground with 1.5 litres of water for 5-10 minutes. The paste obtained was put in a muslin cloth and squeezed to extract the milk.

3.3.3 Production of coconut milk

Three coconuts were used. The husk of a matured coconut is removed, exposing the hard shell, and the shell of the coconut is removed with a de-shelling machine. This can also be done manually by slamming it against a hard surface, shattering the shell open, and using a knife to remove the meat from the shell. The meat next goes through paring, which is the scraping away of the brown skin connected to the coconut meat, resulting in white coconut meat. The paired coconut is rinsed with clean water to eliminate dirt and contaminants that have become stuck to the coconut meat. The coconut meat was chopped to make it smaller for processing in a blender with 1.5 litres of water to make a paste. To extract the milk, a muslin cloth is employed. The paste is placed in the cloth and squeezed to obtain the milk (Ezeonu, 2016).

3.3.4 Production of yoghurt

One liter of the milk got from the extraction was heated to $70^{o}C$ for 5 minutes and then cooled to $45^{o}C$ for the inoculation of 5 g of starter culture. After the addition of the starter culture, the milk was bottled and stored in an incubator for 8 hours for the fermentation process to take place at the end of the 8 hours the bottles were refrigerated to end the fermentation process (Ezeonu, 2016).

3.4 Proximate Analysis

3.4.1 Determination of moisture content

A clean evaporating dish was washed, dried in an oven, and cooled to room temperature in a desiccator. As A g, the cooled dish was weighed. As B g, 5 g of the sample was weighed. The dish and its contents were placed in an oven set to$105^{o}C$ for three hours to dry. Using tongs, the dish was placed in a desiccator, allowed to cool, and then weighed. The sample was re-dried in an oven for one hour, and the process was repeated until the difference between successive drying at one-hour intervals was less than two milligrams. C g was the final weight recorded (AOAC, 2012).

Calculation:

$$\%moisture\ content \frac{B-C}{B-A} \times 100$$

Where; A = weight of empty dish in grams

B = weight of dish + sample before drying

C = weight of dish + sample after drying

(B-C) = lost in the weight of the sample after drying

3.4.2 Determination of ash content

Weigh a quantity of 2 g of the sample into a crucible. Dry at 105°C; burn at low red heat, ash in a muffle furnace at dull red heat (550°C-600°C for 15 minutes) until free of carbon, remove from muffle furnace, cool briefly, place in desiccators until cold, and weigh (AOAC, 2012).

Calculations;

$$\%ash = \frac{B-C}{B-A} \times 100$$

Where; A = weight of empty crucible in grams

B = weight of dish + sample before ashing

C = weight of dish + sample after ashing

(B-C) = lost in the weight of the sample after ashing

3.4.3 Determination of protein content

The macro Kjeldahl technique was used to determine the crude proteins. 2 g of the material was placed in a Kjeldahl digestion flask along with two KJELTAB® tablets. In the fume cupboard, 25 mL of strong sulphuric acid was added to the digestion flask, and the digestion was carried out for 1 hour until a clear and light blue colour was visible. In a 100 mL volumetric flask, the digest was cooled and diluted to the desired concentration with distilled water. Carry out the distillation procedure in an auto distillation unit (dilute with 70 mL of distilled water and alkalize with 50 mL of 40% w/v NaOH) (nitrogen-free). The mixture was automatically distilled into 30 mL of a 4% w/v boric acid solution (with methyl red and bromocresol green indicators) (mix indicator 0.198 g bromocresol green plus 0.132 g Methyl red in 200 mL alcohol) and the distillation was continued until the boric acid solution turned from pink to yellowish-green and a total volume of about 150 mL was reached. The solution in the conical flask was titrated against 0.1 N hydrochloric acid after distillation until the endpoint was achieved. The identical process was used to take a blank, but only with distilled water.

The % Nitrogen (%N) and % crude protein (%CP) is determined using the equation below:

$$\%N = \frac{(Vs - Vb) \times C \times 14.007}{W}$$

$$\%CP = \%N \times CF$$

Where Vs is the volume (mL) of standard acid used to titrate the sample to the endpoint, Vb is the volume (mL) of standard acid used to titrate the blank to the endpoint, C is the molar concentration (mol dm-3) of HCl used in four decimal places, W is the weight (g) of sample used, and CF is the sample conversion factor (6.25) or (6.38) for dairy. The conversion factors are determined by the material being analyzed (AOAC 2012).

3.4.4 Determination of fat content

The Rose-Gottleib method was used to determine the fat content. 10 g of milk was measured into the separating funnel, then 1ml of ammonia and 10ml of ethanol (95%) was added and carefully mixed.

The funnel was cocked and shaken violently for 1 minute after adding 25 ml peroxide-free diethyl ether. 25 ml petroleum ether was added, and the mixture was violently shaken for 30 seconds. Weighed and dried a 500ml beaker The separating funnel was kept out for at least half an hour until the layers were separated. The fat-containing aqueous layer was put into the dry beaker. Two batches of 5 ml mixed ether were added to the tube and then transferred to the separating funnel. The extraction was done twice more using 15 ml ether and 15 ml petroleum ether, as well as the subsequent procedures. Following extraction, the aqueous solution in the beaker is dried in a 102℃ oven until all of the solvent has evaporated out. After that, the oil-filled beaker is weighed (AOAC 2012).

The %fat in the sample is calculated with the equation below:

$$\%fat = \frac{weight\ of\ oil\ (g)}{weight\ of\ milk\ (g)} \times 100$$

$$weight\ \ of\ milk = weight\ of\ beaker\ with\ oil\ -\ weight\ of\ clean\ dry\ beaker$$

3.4.5 Determination of carbohydrate content

By deducting the amount of moisture, protein, fat, and ash from 100, the total carbohydrate content was determined (AOAC, 2012).

3.5. Determination of Mineral Content

3.5.1 Preparation of Aqua Regia

A 2 liters volumetric flask was filled with 1.2 liters distilled water. 400 ml concentrated Hydrochloric acid was carefully added then and 133 ml of 69% nitric acid and diluted to 2 liters.

3.5.2 Ash Procedure

0.50 - 0.5 ml of the sample was measured into a clean porcelain crucible. Record weight to the nearest (+0.001g), the actual weight of the sample was recorded. Each batch of 80 samples should contain five internal control samples and one external reference sample and two blanks. The crucible was placed in a cool muffle furnace and ramp temperature to 500 degrees Celsius over a period of 2 hours. Allow remaining at 500 degrees for an additional 2 hours. The samples were allowed to cool down in the oven. The ashed sample was first poured into your already numbered or labeled 50 ml centrifuge tubes. The crucible was washed with 5 ml of distilled water into a centrifuge tube and then rinsed again with 5ml of aqua regia this was done two or more times to make a total volume of 20 ml. The sample was then properly mixed in a vortex mixer then centrifuged for 10 minutes at 3000 rpm. The supernatant was decanted into clean vials for macro and micronutrient determination and the mineral component was analyzed using atomic absorption spectrophotometer or inductively coupled plasma.

3.6 Determination of pH

A technique of AOAC was utilized to determine the pH (hydrogen ion concentration) in the goods, and a digital pH meter was employed. The sample solution was placed in the beaker, and the electrode was immediately put into the solution. The electrode was cleaned with distilled water and dried with tissue paper once the first reading was done. Similarly, all additional samples in the series were determined in the same way (AOAC 2012).

3.7Determination of Total Acidity

10 g of each sample was weighed into a conical flask, 30 ml of warm water was added into the flask. 1 ml of phenolphtaleinwas added into the flask as the indicator. The solution in the flask was mixed well and titrated against 0.1 N NaOH. The volume of NaOH used to reach the endpoint was noted and using the equation below the %titratable acid was calculated (AOAC 2012).

$$\%titatable\ acid = \frac{volume\ of\ NaOH\ used\ in\ titrating\ \times\ normality\ of\ NaOH \times 9}{weight\ of\ sample\ (g)} \times 100$$

3.8 Determination of total solid

To get the total solid for each sample, the value of the moisture content was subtracted from 100 (AOAC 2012).

3.9 Microbial Analysis

3.9.1 Serial dilution

The serial dilution was done in McCockneybottles, the bottles were washed and dried in the oven at $121^{o}C$for 30 minutes. 9 ml of distilled water was pipetted into the bottles. The bottles were then sterilized in the autoclave at $121^{o}C$ at 15 psi for 15 minutes. Then the bottles were left to cool, 1 ml of the sample was pipetted into the bottle to form the stock. 1ml of the stock was then pipetted out and into another 9 ml of distilled water to give 10^{-1} the process was continued till$10^{-6}$was reached. This is no longer referred to as sample but inoculant.

3.9.2 Preparation of media

For the determination of the presence of lactic acid bacteria the medium used was de Man Rogosa Sharpe (MRS) Agar. For the determination of fungi the medium used was Potato Dextrose Agar (PDA). 32.016 g and 18.72 g of MRS and PDA respectively were weighed into 480 ml of distilled in a 500 ml Durham bottle separately for MRS and PDA. The mixture was homogenized by shaking gently and then placing it in a water bath. Once fully homogenized the agar was brought out to cool but not solidify.

3.9.3 Isolation of bacteria

Sterile Petri-dishes were labeled by sample with each dilution factor. 0.1 ml was pipetted out using a micropipette unto the petri-dish without fully opening the dish. The method of inoculation the bacteria used was the pour plate method. The cooled MRS Agar was then poured aseptically into all petri-dish then shook gently. The dishes were left so the agar solidifies and the dishes were turned upside down before incubating them at $37^{o}C$for 24 hours. After which the colonies that appeared were counted using a colony counter. The result was then recorded (Afolabi et al., 2012).

3.9.4 Total fungi and mold count and identification

Sterile Petri-dishes were labeled by sample with each dilution factor. 0.1 ml was pipetted out using a micropipette unto the petri-dish without fully opening the dish. The method of inoculation of the fungi and mold used was the pour plate method. The cooled PDA Agar was then poured aseptically into all petri-dish then shook gently. The dishes were left so the agar solidifies before incubating them at $37^{o}C$for 2-5 day. After which the fungi growth were counted then the type of fungi was identified with the use of a microscope and a reference material (Afolabi et al., 2012).

3.10 Sensory Evaluation

All samples of yoghurt were evaluated by 10 lactose intolerant panelists (based on the results from a questionnaire filled by them (Appendix 1)) and 10 lactose tolerating panelists. The panelists were Mountain Top University students who were asked to rate the appearance, texture, smell, taste, mouthfeel, aftertaste, and over acceptability on a 9-point hedonic scale, with 1being the most disliked and 9 being the most liked (Omola, 2014). A special testing area was used for this evaluation so that distractions could be minimized and conditions could be controlled; the testing room should be quiet, comfortable, with a consistent level of lighting and good ventilation; each panelist was given water to drink; the samples were given codes before being tested, and an evaluation sheet was prepared for the panelists.

3.11 Statistical Analysis

The IBM SPSS statistical package (version 26) was used for the statistical analysis of results. Results obtained were subjected to analysis of variance (ANOVA) to determine differences within the samples and the Duncan Multiple Range test (Duncan, 1955) was used to determine the difference within the variation at a 95% confidence level ($p \leq 0.05$). All determinations reported in this study were carried out in triplicates.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Proximate Composition of Yoghurt Samples

According to table 4.1, the moisture content of all samples ranges from (78.35% – 80.35%); the highest being coconut milk yoghurt and the lowest being cow milk yoghurt. This could be as a result of the procedures used during the production of the milk. The moisture content of the imitation milk sample and was significantly different at ($p \leq 0.05$) from that of cow milk yoghurt. Coconut milk yoghurt was also found to have the highest fat content (12.37%), coconut a good source of oil (Bawalan and Chapman, 2006). The %fat for all samples ranged from (5.18% – 12.37%) with the lowest being tigernut yoghurt. All samples were significantly different from each other. The fat content of almond and coconut milk yoghurts were higher than that of cow milk yoghurt, this result can be backed up with the findings of (Belewu et al., 2010) who also found that the fat content in both tigernut and coconut milk yoghurts to be higher than cow milk yoghurt.

The ash content of the cow milk yoghurt was significantly different at ($p \leq 0.05$) from all other samples. Cow milk yoghurt had the highest ash content among all the samples assessed which agrees with the results of work done by Ezeonu et al., (2016) who compared the proximate characteristics of coconut, tigernut and cow milk yoghurt. tigernut milk yoghurt had the lowest ash content (0.34%). The ash content for all samples were not significantly different from each other. The high value ash of cow milk yoghurt could be caused by the micronutrients fortification of the milk powder utilized for the production of the yoghurt. Although according to Ezeonu et al., (2016); cow milk yoghurt had a higher ash content than both coconut milk and tigernut milk yoghurt which implies that there is a higher mineral content in cow milk yoghurt than in both coconut milk and tigernut milk yoghurt as the higher the ash content, the higher the mineral presence in the food (Pomeranz et al., 1994).

Protein is an important part of every diet because Protein aids in the formation and repair of cells and tissues in the body. Skin, muscle, bone, organs, hair, and nails are all made up of protein (Brazier Y. 2020) and one of the reasons people take milk is because of its protein content. Almond is also found to be a good source of protein. After the analysis of all the samples, the protein content of all the samples ranged from (0.55% - 1.48%). tigernut yoghurt had the highest percentage of protein (1.48%); higher than that in cow milk yoghurt. Oladipo et al., (2014) reported that tigernut milk yoghurt had

Table 4.1: Proximate Composition of the Yoghurt Sample

Sample	Moisture Content %	Fat %	Crude Ash %	Crude Protein %	Carbohydrate %
Tiger-nut	79.68±0.63[a]	5.18±0.0.72[c]	0.31±0.08[b]	1.48±0.33[a]	4.41±0.65[c]
Almond	79.86±0.33[a]	8.12±0.48[b]	0.34±0.03[b]	0.55±0.02[b]	9.33±0.69[b]
Coconut	80.50±0.12[a]	12.37±1.26[a]	0.51±0.07[b]	1.30±0.10[a]	5.33±1.18[c]
Milk	78.35±0.75[b]	5.93±0.83[c]	2.33±1.00[a]	1.21±0.20[a]	12.19±0.73[a]

Mean values with different superscripts in the same column are significantly different at ($p \leq 0.05$)

XYN- tigernut milk yoghurt

PYN- Almond milk yoghurt

RYN- Coconut milk yoghurt

BYN-Cow milk yoghurt

higher protein content than cow milk yoghurt. Almond milk yoghurt had the least with 0.55% although cow milk, tigernut milk, and coconut milk yoghurts were not significantly different from each other. The carbohydrate content ranged from 4.41% -12.19%. The highest carbohydrate value was recorded in the cow milk yoghurt and the lowest was recorded in the tigernut milk yoghurt. This could be because of the high lactose in cow milk. Both almond milk yoghurt and coconut milk yoghurt recorded 9.33% and 5.33% respectively. The fiber content for all samples was zero.

4.2 Mineral Profile of Yoghurt Samples

Nine micro-nutrients namely: Phosphorus (P), Calcium (Ca), Magnesium (Mg), Potassium (k), Sodium (Na), Manganese (Mn), Iron (Fe), Copper (Cu), and Zinc (Zn) were assessed in all the samples (Table 4.2).

Cow milk yoghurt had the highest amount of phosphorus (0.12%) and tigernut milk yoghurt recorded the lowest (0.01%). Coconut milk and Almond milk yoghurt recorded 0.09% and 0.04% respectively. Ezeonu et al., (2016) also found that the phosphorus level in cow milk yoghurt was higher than coconut milk and tigernut milk yoghurts. Phosphorus, according to Bonvissuto (2020) is essential to the body as it aids the function of neurons and muscles. It is a buffer that maintains the pH equilibrium in the blood. Phosphorus also aids in the conversion of fat, carbohydrates and protein into energy and a deficiency in this micronutrient may lead to a blood acid condition called diabetic ketoacidosis and an excess of it could lead to loss of calcium by the bone and also chronic kidney diseases (Bonvissuto and Nazario, 2020)

Calcium is an essential micronutrient especially to maintain and build strong bones and teeth for growing children. Calcium is also required for the healthy functioning of the heart, muscles, and nerves (Mayo clinic, 2020). Cow milk has high calcium content which may be responsible for the relatively higher level of calcium in cow milk yoghurt compared with coconut milk and tigernut milk yoghurt. This finding agrees with that of Ezeonu et al, (2016). Coconut milk also contains small amounts of calcium. The percentage Ca in all the samples ranged from 0.01% - 0.25%. tigernut milk and almond milk yoghurt both had the lowest recording 0.01% and Coconut milk yoghurt recorded 0.06%.

The magnesium level for all samples ranged from 0.01% - 0.07% with Coconut milk yoghurt recording the highest and tigernut milk yoghurt having the lowest. Magnesium is a vital mineral in the human body, as it is involved in over 300 enzyme processes. It helps with muscle and neuron function, blood pressure regulation, and immune system support, among other things (Ware, 2020). Almond nut is a

Table 4.2: Mineral Profile of the Yoghurt Samples

Sample	P %	Ca %	Mg %	K %	Na ppm	Mn ppm	Fe ppm	Cu ppm	Zn ppm
XYN	0.01	0.01	0.01	0.18	6.89	250	12.93	0.51	4.37
PYN	0.04	0.01	0.03	0.24	9.80	4.89	13.90	2.24	4.43
RYN	0.09	0.06	0.07	0.18	6.40	3.38	7.40	2.07	6.35
BYN	0.12	0.25	0.02	0.38	23.31	1.03	2.88	0.26	5.90

XYN- tigernut milk yoghurt

RYN- Coconut milk yoghurt

PYN- Almond milk yoghurt

BYN- Cow milk yoghurt

good source of magnesium. Mg can be used in treating migraine (Ware 2020; Spritzler 2018). A lack of magnesium could cause muscle cramps, spasms and even seizures (Ware, 2020). Cow milk yoghurt recorded the second lowest with 0.02% and Almond milk yoghurt recorded 0.03%.

Cow milk recorded the highest potassium level with 0.38%. Potassium aids the body in fluid regulation, nerve transmission, and muscle contraction control. Human cells contain almost 98 percent of the potassium in your body. The majority of this is present in muscle cells, with the remaining 20% present in bones, liver, and red blood cells (Cheng et al., 2013). It acts as an electrolyte once inside the body. When an electrolyte dissolves in water, it forms positive or negative ions that can carry electricity. The ions of potassium have a positive charge that helps the human body to control a range of functions, such as fluid balance, nerve transmissions, and muscle contractions (Campbell, 2009). tigernut milk and Coconut milk yoghurts, which both contained 0.18% of potassium were the lowest among all samples. Almond milk yoghurt recorded 0.24% of Potassium being with the second-highest potassium level among all the samples.

Sodium is a critical nutrient for maintaining plasma volume, acid-base balance, nerve impulse transmission, and normal cell function. Excess sodium has been related to a variety of negative health effects, including high blood pressure. Sodium can be present in a range of foods, including milk, meat, and seafood (WHO, 2020). The highest Sodium Level was in cow milk yoghurt, (23.31 ppm), and Almond milk yoghurt recorded the second highest at 9.80 ppm. Na readily found in common cooking salt followed by tigernut milk and then Coconut milk yoghurt, which recorded 6.89 ppm and 6.40 ppm respectively.

Almond is said to be a good source of Mn (Seladi-Schulam, 2018). Manganese is essential for enzymes that help form bone and cartilage, Mn helps the body detoxify the free radical, which stops them from damaging cells (Seladi-Schulam, 2018). Manganese found in the samples ranged from 1.03 ppm - 4.89 ppm with all the imitation milk yoghurt being richer in Manganese than the Cow milk yoghurt, which was 1.03 ppm. Almond milk yoghurt is recorded to be the richest in Mn containing 4.89 ppm Coconut milk yoghurt was second recording 3.38 ppm. tigernut milk yoghurt recorded 2.50 ppm.

The Iron content in the imitation milk yoghurt was much higher yoghurt than in the Cow milk. Almond milk and tigernut milk yoghurts had the highest amounts of Fe (13.90 ppm and 12.93 ppm) respectively. Iron is an essential mineral and its main function is to help transport oxygen throughout the body. Hemoglobin is the mechanism used in which iron is an important component (Watson, 2011). The substance in red blood cells that transports oxygen from the lungs throughout the body is hemoglobin. About two-thirds of the body's iron is contained in hemoglobin. The body can not generate enough healthy oxygen-carrying red blood cells if there is not enough iron. Iron deficiency anemia is characterized by a shortage of red blood cells. Coconut and Cow milk Yoghurts recorded 7.40 ppm and 2.88 ppm respectively.

Copper is necessary for bone strength, heart health, immune function, and many other things. Copper deficiency can cause iron shortage, as well as issues with the nervous and immunological systems. Copper deficiency or excess has been connected to neurological illnesses including Wilson's disease, a condition in which too much copper builds up in the organs (Burham, 2021).The copper content in all the imitation milk yoghurt turned out to be higher than that of Cow milk yoghurt with the highest recorded in Almond milk yoghurt as 2.24 ppm, which is 2% of the daily value for copper. Coconut milk yoghurt recorded 2.07 ppm, tigernut milk yoghurt recorded 0.51 ppm, the lowest, Cow milk yoghurt, was 0.26 ppm.

Zinc is an essential nutrient, which means that the human body cannot make or store it. As a result, a steady supply through food must be ascertained. Zinc deficiency is estimated to affect about 2 billion individuals globally owing to insufficient dietary consumption (Jurowski et al., 2014). Zinc is needed for a variety of bodily functions, including gene expression, enzymatic activities, immunological function, protein synthesis, DNA synthesis, wound healing, and growth and development (Kubala, 2018). Diarrhea, thinning hair, decreased appetite, mood swings, dry skin, reproductive difficulties, and delayed wound healing are all symptoms of moderate zinc insufficiency. (2009, Saper and Rash). Zinc was found to be of more in coconut milk yoghurt at 6.35 ppm, followed by the cow milk yoghurt which had 5.90ppm. tigernut and Almond milk yoghurts were closely related, having 4.37 ppm and 4.43 ppm of zinc respectively. In fact, zinc is the body's second-most prevalent trace mineral, behind iron, and is found in every cell (Lim et al., 2013). Zinc is also important for your taste and smell sensations. A zinc shortage can impair the ability to taste or smell since one of the enzymes required for appropriate taste and smell is dependent on this mineral (Lyckholm et al., 2012)

4.3 Physicochemical Properties of Yoghurt Samples

All three physicochemical properties among all samples were significantly different from each other at ($p \leq 0.05$). The total titratable acid for all samples ranged from 0.38% – 1.24% Cow milk yoghurt had the highest percentage of TTA among others, this finding can be compared with that of Belewu et al., (2010) and Ezeonu, (2016) with cow milk yoghurt having the highest % TTA value among coconut milk and tigernut milk yoghurt. According to CODEX standard for fermented milks (2003), all samples except coconut milk yoghurt exceeded the minimum % TTA for fermented milk. The pH for all samples ranges from 3.89 – 4.71 with the lowest being tigernut milk yoghurt and the highest being Cow milk yoghurt. The pH is important in know the presence of lactic acid bacteria LAB which can help in quality control of the yoghurt. The higher the presence of LAB the lower the pH. The pH of Almond milk yoghurt correlated with the result recorded by Grasso et al., (2020). The % total solid of each sample was inversely proportional to their % moisture content the lowest being Coconut milk yoghurt because of its high moisture content. Cow milk yoghurt having the highest % total solid was significantly different from other samples at ($p \leq 0.05$).

Table 4.3 : Physicochemical Properties of Yoghurt Samples

Sample	TTA%	pH	Total Solid %
XYN	0.97 ± 0.04^{b}	3.89 ± 0.01^{d}	20.32 ± 0.63^{b}
PYN	1.00 ± 0.03^{b}	4.28 ± 0.02^{b}	20.14 ± 0.33^{b}
RYN	0.38 ± 0.01^{c}	4.13 ± 0.02^{c}	19.50 ± 0.12^{b}
BYN	1.26 ± 0.04^{a}	4.71 ± 0.05^{a}	21.65 ± 0.75^{a}

Mean values with different superscripts in the same column are significantly different at ($p \leq 0.05$)

XYN- tigernut milk yoghurt

RYN- Coconut milk yoghurt

PYN- Almond milk yoghurt

BYN- Cow milk yoghurt

4.4 Microbial analysis of Yoghurt Samples

The Amount of Lactic Acid Bacteria (LAB) present in the sample ranged between 2 – 3 $cfuml^{-1}$ with the highest count was in the Cow milk yoghurt with 3$cfuml^{-1}$. While the other were found to have a $cfuml^{-1}$ value of 2. This is the values attained are from the 10^{-5} diluent. There was no presence of coliform and yeast. Fungi and mold growth was in both Almond and coconut milk yoghurts with the probable organism being *Aspergillus spp.* and *Penicillium spp.* Respectively which both recorded as 1 $cfuml^{-1}$each. According to Agarwal and Prasad, 2013 statedaccording to Turkish Standards Institute (TS 1330), 1989 yoghurt standards a maximum of 100cfu/g of mould is allowed in yoghurt according to this information both Almond and coconut milk yoghurts are within the acceptable range.

4.5 Sensory Evaluation of Yoghurt Samples.

During the sensory evaluation, cow milk yoghurt was not part of the experiment. Among the lactose intolerant panelists, the general acceptability of all sample was relatively low between XYN, XYS, PYN, PYS, and RYN with RYS being significantly different at ($p \leq 0.05$) from the others, also having the highest general acceptability among all samples. This can be associated with the taste; all samples had poor taste remarks. The low ratings could be because of the information given to them that they would be taking imitation milk and they do not like milk, this mindset probably clouded their judgment. The Appearance among all samples were not significantly different.

All sweetened sample recorded the highest mark for taste with the highest being PYS where the unsweetened were marked lowest, this is due to the sweetener added. The general acceptability of all samples were higher than that recorded in (table 4.5.1) with PYS having the highest mark for general acceptability. The sweetened samples recorded the highest mark for after taste with RYN having the lowest this is the same for the taste; RYN recorded the lowest mark for taste. The appearance of all samples were not significantly different and were all rated high. The mouthfeel for all samples were significantly different at ($p \leq 0.05$) with PYS recording the highest.

Table 4.4 : Microbial Analysis of the Yoghurt Samples

Sample	Lactic Acid Bacteria $cfuml^{-1}(10^{-5})$	Coliform $cfuml^{-1}$	Yeast $cfuml^{-1}$	Mould and Fungi $cfuml^{-1}(10^{-5})$	Probable Organism
XYN	2	ND	ND	NG	-
PYN	2	ND	ND	1	Aspergilus spp.
RYN	2	ND	ND	1	Penicillium spp.
BYN	3	ND	ND	NG	-

ND- None detected. NG- No growth

XYN- tigernut milk yoghurt PYN- Almond milk yoghurt

RYN- Coconut milk yoghurt BYN- Cow milk yoghurt

Table 4.5 : Sensory Evaluation by Lactose Intolerant People

Sample	Sensory Parameters						
	Appearance	Aroma	Taste	Texture	Mouthfeel	Aftertaste	General Acceptability
XYN	5.60 ± 1.26^{a}	3.50 ± 2.32^{a}	2.70 ± 1.57^{bc}	5.20 ± 1.81^{ab}	4.40 ± 2.17^{a}	5.30 ± 1.95^{ab}	4.20 ± 1.87^{b}
XYS	5.50 ± 1.96^{a}	3.80 ± 1.40^{a}	4.00 ± 2.31^{ab}	4.40 ± 1.78^{ab}	4.90 ± 1.91^{a}	5.30 ± 1.77^{ab}	4.30 ± 2.06^{b}
PYN	5.20 ± 2.83^{a}	4.00 ± 1.25^{a}	2.10 ± 1.45^{c}	3.40 ± 2.07^{b}	2.40 ± 2.07^{b}	3.20 ± 2.66^{b}	2.80 ± 1.48^{b}
PYS	6.30 ± 1.06^{a}	4.60 ± 1.17^{a}	4.20 ± 2.10^{ab}	4.90 ± 1.60^{ab}	3.70 ± 1.95^{ab}	4.90 ± 2.18^{ab}	4.20 ± 1.99^{b}
RYN	6.10 ± 1.29^{a}	5.20 ± 1.93^{a}	4.30 ± 2.50^{ab}	5.10 ± 2.23^{ab}	4.50 ± 2.07^{a}	4.80 ± 2.25^{ab}	4.60 ± 2.32^{b}
RYS	6.90 ± 0.88^{a}	5.20 ± 2.53^{a}	5.30 ± 1.95^{a}	5.80 ± 2.04^{a}	5.50 ± 2.12^{a}	5.70 ± 2.36^{a}	6.70 ± 2.00^{a}

Mean value with different superscript in the same column are significantly different at ($p \leq 0.05$)

XYN- tigernut Yoghurt

XYS- tigernut Yoghurt (sweetened)

PYN- Almond Yoghurt

PYS- Almond Yoghurt (sweetened)

RYN-Coconut Yoghurt

RYS- Coconut Yoghurt (sweetened)

Table 4.6 : Sensory evaluation by lactose tolerating people

Sample	Sensory Parameters						
	Appearance	Aroma	Taste	Texture	Mouthfeel	Aftertaste	General Acceptabilit
XYN	6.50±1.08[a]	4.50±1.35[a]	5.80±2.35[a]	7.00±1.49[a]	6.40±1.71[ab]	7.30±1.34[a]	6.20±2.30[abc]
XYS	7.10±1.10[a]	5.30±1.49[a]	6.00±2.05[a]	6.60±2.07[a]	5.90±b1.66[abc]	5.90±2.28[abc]	6.50±2.22[ab]
PYN	6.70±2.58[a]	5.20±1.93[a]	3.50±2.55[b]	4.40±2.41[b]	3.80±2.04[d]	4.20±2.39[cd]	4.10±2.64[c]
PYS	6.90±1.73[a]	6.30±1.16[a]	7.40±1.35[a]	7.40±1.35[a]	7.20±1.40[a]	7.50±1.27[a]	7.30±1.57[a]
RYN	6.90±1.85[a]	5.40±2.37[a]	3.80±2.44[b]	4.60±2.76[b]	4.20±2.30[cd]	3.80±2.10[d]	4.40±2.67[bc]
RYS	7.30±1.64[a]	5.50±2.12[a]	5.90±1.60[a]	5.50±1.72[ab]	5.40±1.71[bcd]	5.60±1.58[bc]	6.30±1.95[ab]

Mean value with different superscript in the same column are significantly different at ($p \leq 0.05$)

XYN- tigernut Yoghurt

XYS- tigernut Yoghurt (sweetened)

PYN- Almond Yoghurt

PYS- Almond Yoghurt (sweetened)

RYN-Coconut Yoghurt

RYS- Coconut Yoghurt (sweetened)

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Generally, the nutritional characteristics of the imitation milk yoghurt were good compared with cow milk yoghurt. Iron, Copper and Manganese were higher in the imitation milk yoghurt used in this study compared to cow milk yoghurt. The potassium content of all the sample was found to be high this could mean all samples are good sources of potassium. The next best yoghurt after cow milk yoghurt was the tigernut milk yoghurt in terms of low fat and high protein content. The imitation milk yoghurt did not trigger gastrointestinal symptoms in the lactose intolerant consumers that they would normally experience after consuming cow milk products. The presence of lactic acid bacteria improves the nutritional value of the imitation milk. All imitation milk yoghurts were made without lactose which makes them good alternative for lactose intolerant persons. The imitation milk yoghurt used in this study can be recommended to individuals seeking alternative to cow milk yoghurt. They can also be recommended to individuals lacking iron, copper or magnesium. They are also good sources of potassium.

5.2 Recommendation

Due to the relatively low availability of calcium in the imitation milk yoghurt used in this study and calcium being an important nutrient found in cow milk yoghurt, calcium rich plant sources could be considered when producing imitation milk yoghurts. Fortification of the imitation milk yoghurt should improve certain micronutrients.

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APPENDIX A

RESEARCH QUESTIONNAIRE

DEFINITION OF TERMS:

- Milk: Milk from an animal source that contains lactose
- Imitation Milk: Milk that doesn't contain lactose, usually from a plant source
- Lactose Intolerance: this is when upon ingestion of milk you develop gastrointestinal discomfort as a result of the inability to digest milk
- List of Imitation milk:
    - Coconut milk
    - Tigernut milk
    - Soya milk
    - Almond milk
- List of milk product:
    - Milk cookies; it has milk as a major ingredient.
    - Yogurt
    - Cheese
    - Ice cream

Name:...

Age:..

Gender:..

Department:...

Are you lactose intolerant?:

Yes ☐ **No** ☐

Were you officially diagnosed by a doctor?:

Yes ☐ **No** ☐

How old were you when you were diagnosed?: ....

Do you take any imitation milk listed above as a substitute in place of milk?:

Yes ☐ **No** ☐

If yes, which ones do you take?

....

....

....

....

....

Can you take any of the milk products listed above:

Yes ☐ **No** ☐

If yes, which ones do you take?:

....

....

....

....

....

....

SYMPTOMS (Tick which of the following symptoms you observe/endure when you ingest milk)

Stomach Pain ☐

Farting ☐

Constipation ☐

Indigestion ☐

Mouth/Throat Irritation ☐

Stomach Irritation ☐

Diarrhea ☐

Are you willing to participate in a research project to determine which imitation milk is most acceptable as a milk substitute for you:..............

....

DATE SIGNATURE