GINGER POWDER PRODUCTION AND CHARACTERIZATION

BY

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CERTIFICATION

This is to certify that this project work was carried out by **GEORGE OGHENETEKOME JOHN** with **Matriculation Number PSC1908740** of **The Department of Chemistry,** Faculty of Physical Science, University of Benin, Benin city under the supervision and guidance of **Dr. E.N Dibie** in partial fulfilment of the requirement for the award of Bachelor of Science Degree in Industrial Chemistry.

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DEDICATION

This research endeavor is dedicated to the divine providence of God Almighty, whose unwavering love and wisdom have been instrumental in the successful completion of this project. Additionally, I extend my heartfelt dedication to my parents, Mr. and Mrs. Afor-George, for bestowing upon me the invaluable gift of formal education. Their enduring support and guidance have profoundly influenced my academic journey, for which I am deeply grateful.

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Also, to my colleagues who made my school experience worthwhile (Rukky, Oseiwe, Faith and Sylvia), I appreciate you all.

ABSTRACT

This study entailed the production of ginger powder and analysis for selected phytochemicals and minerals element constituents. Examined phytochemicals were flavonoid, saponin, glycoside, phenols, alkaloid, tannin, coumarin, quinones and steroids while selected mineral elements analysed were iron, magnesium, calcium, zinc, potassium and sodium.

The ginger rhizomes for this study were obtained from New Benin Market, Edo State, Nigeria. Standard methods were used for processing the ginger powder. Specifically, the presence or absence of the selected phytochemicals was determined. Findings indicated that for fresh ginger rhizomes, the examined minerals are of the following values: Fe (1.00mg/L), Mg (0.75mg/L), Ca (0.50mg/L), Zn (0.80mg/L), K (19.7mg/L) and Na (2.2mg/L). For the processed ginger powder, the obtained values for the examined mineral constituents are: Fe (1.60mg/L), Mg (1.08mg/L), Ca (0.30mg/L), Zn (1.20mg/L), K (61.1mg/L) and Na (11.4mg/L).

Based on findings from this study, ginger powder is a good source of the examined food minerals.

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CHAPTER ONE

1.0 INTRODUCTION

Due to its many uses, the ginger plant (*Zingiber Officinale*) is one of the most significant plant discoveries. This is due to the fact that ginger is utilized not only as a spice in cooking but as well as an ingredient in many forms of processed food and beverage item, traditional herbal medicine, medications and cosmetics (*Pradita et al.,2022).* The ginger is one of the most well-known members of the Zingiberaceae family, which consists of roughly 53 genera and more than 1200 species *(Koga et al.,2016 , Seow et al.,2017).* It is distinguished by its unique flavour and pungency *(Dhingra and Kumar 2005).* The West Indies, Brazil, China, Japan, and Indonesia are among the nations that cultivate ginger on a large scale. Kerala, Orissa, Andhra Pradesh, Himachal Pradesh, Meghalaya, and West Bengal are significant states in India that are expanding. In 2008, there were 2,750,000 tons of ginger produced worldwide. 3.43 metric tons of ginger are produced on average per hectare *(Charan 2007).* Ginger has traditionally been grown as an export item, but its widespread growth has not been accompanied by optimal or sustainable farming, which has led to low quality and productivity. Ginger is a common culinary component found in almost every region of Indonesia. It is thought to have numerous health benefits, including the ability to relieve bloating, warm the body, and soothe irritation. In conventional healing, ginger root is used for a variety of ailments, such as headaches, colds, and appetite stimulation (*Redi Aryanta, 2019).*

FIGURE 1. THE GINGER RHIZOME

1.1 BACKGROUND OF STUDY

The Sanskrit term "srngaveram" (horn root) is where the word "ginger" originates, but the Middle English word "gungivere" is where the name "ginger" originates *(Benzie and Wachtel-Galor, 2011).* Due to its beneficial properties, including its pungency, aroma, nutrients, and pharmacological

activity with minimal side effects worldwide, the rhizome of ginger, which is the horizontal stem from which the roots grow, is a plant of medicinal importance that has been used for more than 3000 years in Ayurvedic, Chinese, and Tibb-Unani herbal medicines in the Asian region, including Indonesia, Sri Lanka, Japan, Burma, China, India, and others like the Arab nations, Congo, Germany, Greece, Tibet, and the United States of America *(Kiyama, 2020).*

Two types of materials are found in the rhizomes: volatile compounds, which make up the essential oil, and non-volatile compounds, which include oleoresin (a source of pungency) as well as phytochemicals with biological activity that are good for human health, like flavonoids and phenolics. *(Motawi et al.,2011).* Ginger has been included into a number of goods, including ginger tea, ginger beer, ginger powder, ginger sweets, and ginger juice, thanks to advancements in science and contemporary culinary technology *(Krüger et al., 2018).*

1.2 STATMENT OF PROBLEM

Although the processing of ginger is an effective method for enhancing its shelf life, it may present challenges when converting ginger into powder form. Across various stages such as grinding, drying, pounding, packaging, and storage, there exists the potential for the loss of essential phytochemicals crucial for providing nutrients to consumers. This diminishment in phytochemical content could result in a reduction of ginger's nutritional potency, thereby depriving consumers of its medicinal benefits.

1.3 AIM

The aim of this study is to ascertain the nutritional composition of ginger powder, encompassing its proximate composition, phytochemical content and mineral elementa and how sun-drying affects these compositions.

1.4 OBJECTIVES OF STUDY

To achieve the above aim, the following specific objectives were set to:

1. Gather and categorize the ginger samples.
2. Remove the outer skin of the ginger and cut it into smaller pieces to expedite the drying process.
3. Mill the ginger crisps into a finely ground powder.
4. Conduct a range of analyses including proximate composition analysis, phytochemical analysis and mineral element analysis.

1.5 SCOPE OF STUDY

Fresh ginger rhizomes were obtained from New Benin Market, Benin City, Edo State, Nigeria. This was followed by the visual inspection as the defective ones were removed manually. The skins of the remaining ginger rhizomes were peeled off with a knife after which they were rinsed thoroughly with clean water. They were chopped off into small pieces to quicken the drying process under sunlight for 5 days. Once dried, the ginger crisps were grinded into a fine powder using a blender. Subsequent analysis such as phytochemical analysis, mineral element analysis and proximate analysis were later conducted.

1.6 JUSTIFICATION OF STUDY

The ginger plant, scientifically known as Zingiber Officinale, serves both culinary and medicinal purposes. Medicinally, ginger is employed to alleviate nausea induced by pregnancy, chemotherapy, or morning sickness. It can be consumed raw or processed into ginger juice. Some cancer studies suggest a reduced risk of colorectal cancer with ginger supplements, attributed to its antioxidant properties and its capacity to modulate various proteins. Additionally, ginger aids in maintaining normal blood glucose levels .Culinarily, ginger adds spice and flavor to dishes. It can be brewed into tea, cooked into jam, preserved in sugar syrup, or dried and coated in sugar for crystallized ginger snacks. This research aims to further examine and validate the diverse benefits of ginger.

1.7 LITERATURE REVIEW

Taxonomy of ***Zingiber Officinale*** (Ginger plant)

Kingdom: Plantae

Phylum: Magnoliophyta

Class: Lilopsida

Order: Zingiberales

Family: Zingiberaceae

Genus: Zingiber

Specie: Officinale

Common names of ginger: Ginger goes by many names in different languages such as jiang (Chinese), adrak (Hindi), jengibre (Spanish), zenzero (Italian), gingembre (French), zanjabeel (Arabic), and ingwer (German) (*Gernot Katzer, 2012*)

1.7.1 PHYTOCHEMICALS

It has long been believed that certain physiologically active compounds found in plants have therapeutic qualities and can be used to treat a variety of illnesses, such as asthma, gastrointestinal issues, skin conditions, respiratory and urinary complications, hepatic and cardiovascular disease, etc. Because these plants contain chemicals that have a good physiological effect on humans, their medicinal value indicates a tremendous potential for the discovery and development of new medications. *(Dilfuza Egamberdieva., 2017).* Medicinally significant plants derive their pharmacological advantages from the accumulation of bioactive phytochemicals within their tissues, categorized as primary and secondary metabolites. Primary metabolites encompass organic compounds such as glucose, starch, polysaccharides, proteins, lipids, and nucleic acids, essential for human body growth and development. Secondary metabolites, on the other hand, are compounds like alkaloids, flavonoids, saponins, terpenoids, steroids, glycosides, tannins, and volatile oils, which plants produce to serve various biological functions *(Dilfuza E.,2017; Arvind Kumar, 2016).*

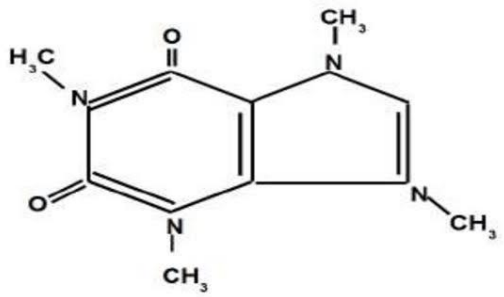
Phytochemicals, secondary plant metabolites, are categorizable according to their chemical composition (presence of nitrogen), chemical structure (e.g., rings, sugar content), biosynthetic pathways (e.g., phenylpropanoid for tannin production), or their solubility in different solvents *(HN Zulkefli., 2013).*

1.7.2 ALKALOIDS

Alkaloids are one of the primary and most abundant substances that plants produce *(Naseem, 2014).* While only a small number of alkaloids have been identified in lower plants, alkaloids are typically found in higher plants, especially in dicots. Both the entire plant and a particular plant organ can contain alkaloids. Alkaloids are mostly generated from amino acids, which have one or more carbon rings, most of which include nitrogen. The location of the nitrogen atom within the carbon ring determines the kind of alkaloids and plant groups *(Dilfuza E.,2017)*. In addition to carbon, hydrogen and nitrogen, alkaloids may also contain oxygen, sulfur and more rarely other elements such as chlorine, bromine, and phosphorus. The boundary between alkaloids and other nitrogen-containing

natural compounds is not clearcut. Compounds like amino acid peptides, proteins, nucleotides, nucleic acid, amines, and antibiotics are usually not called alkaloids. Natural compounds containing nitrogen in the exocyclic position (mescaline,serotonin, dopamine, etc.) are usually attributed to amines rather than alkaloids *(Manske RH, 1965).*

Numerous pharmacologically significant alkaloids include those with antihypertensive properties (several indole alkaloids) and effects that are antiarrhythmic (quinidine, spareien), Quinine's antimalarial and anticancer properties (vincristine, vinblastine, and dimer indoles). A couple of Alkaloids include morphine, nicotine, and caffeine. etc. having the stimulating quality that is employed as the analgesic and quinine as a medication to prevent malaria *(Mamta Saxena.,2013).*



Caffeine

FIGURE 2*:* Chemical Structure of Nitrogen in heterocyclic rings

1.7.3 FLAVONOIDS

Plant secondary metabolites (phytochemicals) known as flavonoids have anticancer properties. Their molecular structure is characterized by a variety of phenolic structures *(Dilfuza E.,2017).* Plants are constant sources of flavonoids, a broad class of polyphenolic chemicals with a benzoyl-γ-pyrone structure. The phenylpropanoid pathway is responsible for their synthesis. The majority of findings that are now available indicate that flavonoids and other secondary phenolic metabolites are in charge of the wide range of pharmacological effects *(Mahomoodally et al.2005; Pandey 2007).* The position of the benzenoid substituent, such as isoflavone (3-position) and flavone (2-position),

divides flavonoids into two types. Flavanoids can be classified as monoglycosidic, diglycosidic, or any other class. Generally, they are produced naturally and are coupled with sugars in conjugated form. The carbohydrate unit can be L-rhamnose, Dglucose, glucorhamnose, galactose, or arabinose, and the glycosidic linkage is typically found at positions 3 or 7 *(Mamta Saxena.,2013).* Numerous beneficial characteristics of flavonoids have been reported, including anti-inflammatory action, enzyme inhibition, antibacterial activities. anti-allergic, oestrogenic, active activity, vascular activity, antioxidant activity, anticancer action that is cytotoxic (*Tapas AR et al.,2008*). Flavonoids represent a variety of compounds that play crucial function in preserving biological systems opposing the negative consequences of oxidative processes regarding macromolecules like carbs, DNA, lipids, and proteins (*Atmani D et al.,2009*).

1.7.4 TANINS

Phenolic compounds are characterized by the presence of at least one aromatic ring system that is substituted with a hydroxyl. Conversely, substances that have ten hydroxyl groups or more are known as **tannins**. The term "tannin" is commonly used to describe a complex, big, polyphenolic biomolecule with enough hydroxyls and other appropriate groups, like carboxyls, to form potent complexes with different macromolecules *(Michael Wink, 2015; Navarrete, 2013).* Another way to describe tannins is as a heterogeneous group of high molecular weight polyphenolic compounds that have the ability to combine with proteins, polysaccharides (cellulose, hemicellulose, pectin, etc.), alkaloids, nucleic acids, minerals, and other substances to form both reversible and irreversible complexes *(Schofield P. et al, 2001).* Thus, the tannins can be categorized into four main groups according to their structural traits: ellagitannins, complex tannins, gallotannins, and condensed tannin *(Mamta Saxena, 2013).*

(1) All tannins that have galloyl units or their meta-depsidic derivatives attached to various polyol-, catechin-, or triterpenoid units are known as **GALLOTANNINS.** These plant-wide gallotannins are frequently found in the bark, leaves, and fruits of plants. *(Michael Wink, 2015*).

(2) **ELLAGITANNINS** are tannins without a glycosidically attached catechin unit and at least two galloyl units that are C–C coupled to one another.

(3) **COMPLEX TANNINS** are tannins that have a ellagitannin or gallotannin unit glycosidically linked to a catechin unit.

(4) All oligomeric and polymeric proanthocyanidins that are found in **CONDENSED TANNINS** are created when the C-4 of one catechin links with the C-8 or C-6 of the subsequent monomeric catechin.

1.7.5 SAPONIN

A class of secondary metabolites called saponins is broadly distributed in monocot families and less common in dicot groups (Araliaceae, Fabaceae, Solanaceae, Plantaginaceae, and Scrophulariaceae). Many dicots contain large amounts of triterpene saponins groups, including the Ammaranthaceae (previously Chenopodiaceae), Phytolaccaceae, Caryophyllaceae, Ranunculaceae, Poaceae, Primulaceae, and the family Sapotaceae (*Michael Wink, 2015*). The term "saponin" comes from the stable foam that they produce in aqueous solutions like soap. Saponins, as a chemical group, comprises glycosilated steroids, steroid alkaloids and triterpenoids (*Bohlmann J et al., 1998*). The substance that remains when a hydrogen atom replaces the glycosyl group on a glycoside is known as an agylone.Spirostan and furostan are the names of two derivatives of steroid aglycones. The bond with the carbohydrate portion, which is made up of one or more sugar moieties including glucose, galactose, xylose, arabinose, rhamnose, or glucuronic acid glycosidically, is another significant characteristic of sapogenin (aglycone) *(Michael Wink, 2015).* Monodesmoside saponins are saponins with a single sugar molecule linked at the C-3 position, and those that possess two

sugars at least, one linked to the C-3 and the C-22 are referred to as bidesmoside saponins *(Laszetity R et al., 1998).*

It is well recognized that several saponins have antibacterial properties, limit the growth of mold, and shield plants from insect damage. Since saponins are a component of a plant's defense mechanisms, they have been included in phytoanticipin-named plants or phytoprotective agents *(Lacaille - Dubois M.A, Wagner H., 2000*).

1.7.6 GLYCOSIDES

A glycoside is a family of natural compounds made up of two molecules: (1) sugar, usually D-glucose, though it can also occasionally be L-fructose or L-rhamnose; and (2) an aglycone, which can be either a terpene or a flavonoid. Aglycone is a highly poisonous component of cardiac glycosides, which are present in a variety of plants. Aglycone of cardiac glycosides, which fall within the cardenolide and bufadienolide chemical families *(Afolabi Clement Akinmoladun, 2014).*

1.7.7 STEROIDS

Based on the cyclopentane perhydrophenanthrene ring structure, steroids and triterpenes are produced. Sterols were formerly mostly thought to be animal molecules (such as bile acids, sex hormones, etc.), but in recent years, more and more of these compounds have been found in plant cells. It is likely that higher plants contain all three of the so-called "phytosterols" (campesterol, stigmasterol, and sitosterol; formerly known as B-sitosterol). These typical sterols exist as simple glucosides as well as free forms. Aspinasterol, an isomer of stigmasterol present in spinach, alfalfa, and senega root, is a less frequent plant sterol. Some sterols are exclusive to lower plants; ergosterol, which is present in yeast and several fungi, is one such example. Others, like fucosterol, are mostly found in lower plants but can also sporadically be found in higher plants.

1.7.8 MINERAL ELEMENTS

The mineral element composition of a food sample can be determined by mineral analysis using Atomic Absorption Spectroscopy (AAS) and Flame Emission Spectroscopy (FES). The various elements found in ginger are as follows:

1. **POTASSIUM (K):** Potassium has many health benefits when present in the diet. Sufficient intake of potassium-rich foods lowers the incidence of stroke and coronary heart disease and is beneficial for bone and heart health (*US Department of Agriculture, Agricultural Research Service, 2011*). Additionally, it might lessen the chance of osteoporosis and kidney stones. (*Barzel US et J Bone Miner Res, 1995*). Hypokalemia, or a potassium deficit, can cause a number of health problems, including constipation, weariness, cramping in the muscles, irregular heartbeat, paralysis, and respiratory failure in extreme situations.
2. **CALCIUM (Ca):** Much of the construction of bones and teeth is composed of calcium, which also maintains tissue robust, flexible, and rigid, allowing for regular physical mobility (*Institute of Medicine*, *2011).* Deficiency in calcium can cause rickets in children, weak bone formation in children and adults which is characterized by an increased risk of falling due to excess fatigue.
3. **ZINC (Zn):** Zinc is an important mineral that is required for many body processes, such as DNA synthesis, wound healing, and immunological function. Meat, shellfish, legumes, nuts, seeds, and dairy products are good dietary sources of zinc. Zinc deficiency can lead to a number of health issues, such as weakened immune system, slower wound healing, decreased appetite, hair loss, skin issues, and stunted infant growth and development. Additionally, it may result in less sensitivity to taste and smell.
4. **IRON (Fe):** Red blood cells, which distribute oxygen throughout the body, are produced in large part by the vital mineral iron. Red meat, chicken, fish, beans, lentils, tofu, spinach, and fortified cereals are good dietary sources of iron. Dietary iron comes in two forms: heme iron,

which is present in animal products(fish, red meat, poultry, etc) , and non-heme iron, which is present in plants products (legumes, spinach, pumpkin seeds, etc). Iron deficiency causes anemia, which leads to weakness, exhaustion, and poor cognitive function. Iron absorption can be improved by eating meals high in vitamin C along with foods high in iron.

5. **SODIUM (Na):** A vital mineral, sodium is necessary for neuron activity, muscular contractions, and fluid homeostasis in the body. Table salt, processed meals, canned soups, packaged snacks, ketchup and soy sauce, and cured or smoked meats are common dietary sources of sodium. Although excessive sodium consumption raises the risk of high blood pressure, heart disease, and stroke, it is nevertheless important for good health. Conversely, hyponatremia, or a sodium deficit, is an uncommon occurrence that can be brought on by vomiting, diarrhea, excessive perspiration, or other medical disorders.

1.7.9 PROXIMATE ANALYSIS

Estimating the quantitative content of food and food substances, such as moisture, crude protein, crude fat , total carbohydrate, and crude fiber is done using proximate analysis *(Thangaraj P. 2016).* The food business may find certain food ingredients useful for developing new products, ensuring quality control (QC), or meeting regulatory requirements.

- **MOISTURE CONTENT:** This is the amount of water and volatile compounds lost during drying (*Puwastein P. et al, 2011*). Moisture content is significant from a financial perspective since it offers useful information about yield and quantity. Furthermore, since increased moisture promotes mobility and decreases the glass transition temperature, moisture content can reveal information regarding texture. Foods high in water generally deteriorate more quickly as a result of chemical and biological processes. Due to this, the amount of moisture can be considered as one of the main factors for storage of foods.

- **CRUDE PROTEIN CONTENT:** The amount of protein in a food sample that is calculated by multiplying the nitrogen content by 6.25 is known as the crude protein content. The average grams of protein that contain one gram of nitrogen is represented by the factor 6.25. The term "crude" describes the fact that most food samples does not contain all of its nitrogen in the form of protein. The common method used in this analysis is the Khedjahl's method of determining nitrogen.
- **CRUDE FAT CONTENT:** Crude fat refers to the crude mixture of fat-soluble substance found in a sample . Crude fat content, sometimes referred to as ether extract or free lipid content, is the phrase used to describe the conventional method for calculating the quantity of fat in food products. Triglycerides, diglycerides, monoglycerides, phospholipids, steroids, free fatty acids, fat-soluble vitamins, carotene pigments, chlorophylls, and other lipid components may be present. The solubility of lipids in non-polar organic solvents, such as hexanes, petroleum ether, or supercritical liquid carbon dioxide with or without a solvent modifier, is the basis for the conventional method for determining total crude fat.
- **ASH CONTENT:** Theash content of a food sample indicates how much inorganic, noncombustible material is present. As opposed to the ash left over from incomplete combustion, the residues left over from a fully burned sample usually comprise oxides of the inorganic elements that were once present in the sample. This analysis is also known as digestion.
- **CRUDE FIBER CONTENT:** The insoluble residue of an acid hydrolysis followed by an alkaline one, containing genuine cellulose and insoluble lignin, is called crude fiber, or Weende cellulose.
- **TOTAL CARBOHYDRATE CONTENT:** The overall amount of carbohydrates in a food sample is referred to as its total carbohydrate content. This include dietary fiber, sugars, starches, and other types of carbohydrates.The percentage that remains after measuring every

other ingredient can be used to calculate a food's carbohydrate content: %carbohydrates = 100 - %moisture - %protein - %lipid - %mineral.

1.8 SPECTROMETRY

Spectrometry is the measurement of light-matter interactions, reactions, and wavelength and intensity measurements of radiation. Stated differently, spectrometry is a widely used technique for the spectroscopic investigation of sample materials. It is a way of looking at and measuring a particular spectrum. It can also be simply put as the spectroscopic method used to determine the quantity or concentration of a certain chemical species (atomic, molecular, or ionic). The instrument that is responsible for spectroscopic measurements is the **SPECTROPHOTOMETER.**

1.8.1 TYPES OF SPECTROMETRY

1. **ATOMIC ABSORPTION SPECTROMETRY (AAS)** Atomic Absorption Spectrometry is used to quantitatively identify chemical elements using free atoms in a gaseous condition. It is merely predicated on light being absorbed by free metallic ions.The method is used in analytical chemistry to ascertain the amount of a certain element (the analyte) present in a sample that has to be examined. In pharmacology, biophysics, archeology, and toxicology research, AAS is utilized to determine over 70 distinct elements in solution or directly in solid samples using electrothermal vaporization. AAS method uses a sample's atomic absorption spectra to determine how much of a certain analyte is present in it. To establish the relationship between the observed absorbance and the analyte concentration, standards with known analyte content are necessary, and the Beer-Lambert law is thus relied upon.

   BEER-LAMBERT'S LAW

   According to the Beer-Lambert law, the absorbance of a solution is directly proportional to the concentration of the absorbing material present in the solution and path length. The Beer-Lambert law is a linear relationship between the absorbance and the concentration, molar absorption coefficient and optical path length of a solution and it is represented mathematically as:

A=£ c L

A=Absorbance

£= molar absorption coefficient (M^{-1}/cm)

c= molar concentration (M)

L= optical path length (cm)

The molar absorption coefficient, which indicates how strong an absorber the sample is at a specific wavelength of light, is a sample-dependent parameter. The optical path length, which is usually 1 cm, is the width of the cuvette used for the absorbance measurement, and the concentration is just the moles L^{-1} (M) of the sample dissolved in the solution.

INSTRUMENTATION OF AAS

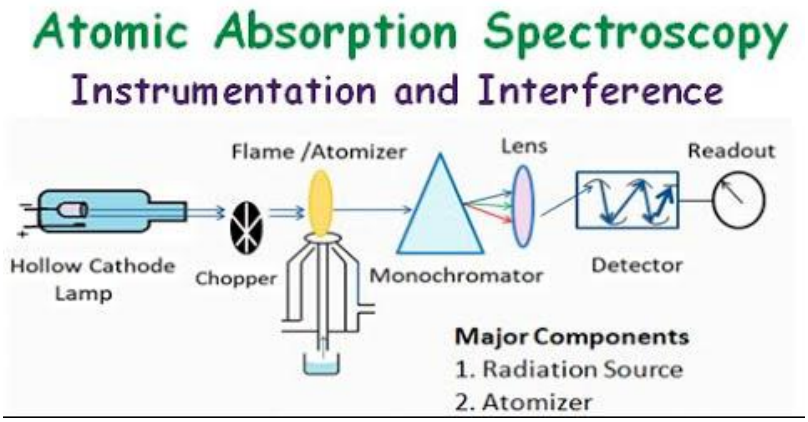


FIGURE 3.

ATOMIZATION is the initial step in examining a sample to determine its atomic composition. These days, electrothermal atomizers (graphite tubes) and spectroscopic flames are the most widely utilized atomizers. The next step in the procedure is to **RADIATE** the atoms using radiation sources. These sources can be continuum or element-specific line radiation sources, such as electrodeless discharge lamps, hollow cathode lamps, and deuterium lamps. The radiation is then monitored by the **DETECTOR** after passing through

a monochromator to isolate the radiation specific to each element from any other radiation released by the radiation source.

2. FLAME EMISSION PHOTOMETRY

Flame Emission Spectrometry can be used to examine metal ions in solution. It is mostly employed for Group I and Group II element analysis. Heat-producing chemicals frequently release energy in the form of light. This is caused by excited electrons jumping up one or more energy levels and then returning to their initial energy level. When a sample is exposed to a very hot flame, flame emission spectrometry measures the intensity and wavelength of the light emitted.

PRINCIPLES OF FLAME EMISSION SPECTROMETRY

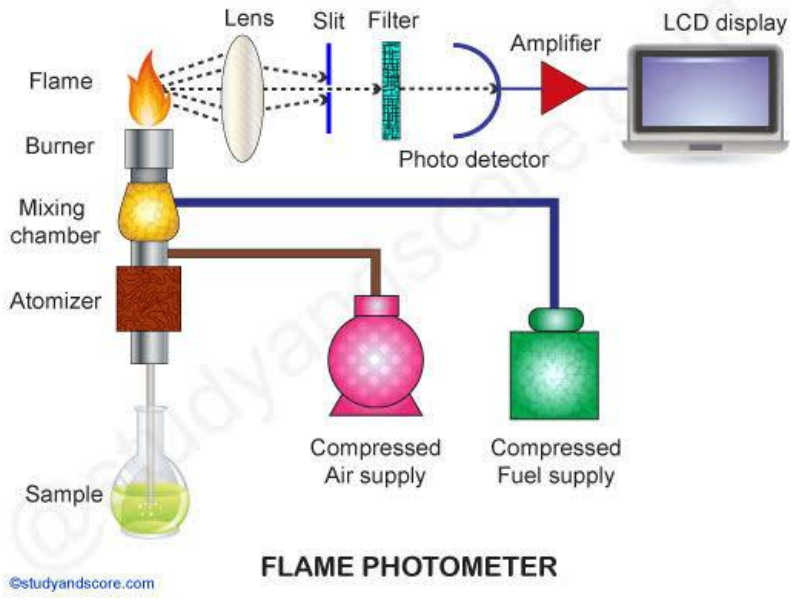


FIGURE 4.

Below is a summary of the procedures that take place during flame photometer analysis:

● **Desolvation:** This process entails allowing a sample to dry in a solution. The solvent evaporates as a result of the flame dehydrating the metal particles in the solvent.

● **Vaporization**: The sample's metal particles have likewise lost moisture. This caused the solvent to evaporate as well.

● **Atomization**: The dispersion of every atom within a chemical compound is known as atomization. The flame turns the sample's metal ions into metal atoms.

● **Excitation**: A specific amount of energy is absorbed by the electrons in an atom thanks to the electrostatic force of attraction between their nucleus and electrons. When the atoms are stimulated, they then move to a higher energy state.

● **Emission:** Atoms return to the ground state or low energy state in order to become stable because the higher energy state is unstable. This atomic leaping produces radiation with a distinct wavelength. The photo detector measures the radiation.

CHAPTER TWO

MATERIALS AND METHODS

2.1 APPARATUS

1. Muffle furnace
2. Soxhlet apparatus
3. Hot air oven
4. Desiccators
5. Beakers
6. Conical flask
7. Test tubes
8. Volumetric flask
9. Crucibles
10. Atomic Absorption Spectrophotometer
11. Flame photometer
12. Weighing balance
13. Spatula and thong
14. Retort stand
15. Burette
16. Clamps

2.2 REAGENTS

1. Hager's reagent
2. Ferric chloride
3. Glacial acetic acid
4. Hydrochloric acid

5. Sulphuric acid
6. Chloroform
7. Sodium hydroxide
8. Hexane
9. Methanol
10. Distilled water
11. Potassium sulphate
12. Copper sulphate
13. Selenium
14. Boric acid/methyl red indicator

2.3 METHODOLOGY

2.3.1 SAMPLE COLLECTION AND PREPARATION OF DRIED GINGER POWDER

Fresh ginger rhizomes were obtained from New Benin Market, Benin City, Edo State, Nigeria. This was followed by the removal of their skin with a knife after which they were rinsed thoroughly with clean water. Subsequently, the peeled rhizomes underwent a 20-second soak in hot water to eliminate germs gotten as a result of the scraping process. They were then chopped into smaller pieces to quicken the drying process under sunlight for 3-5 days. Once dried, the ginger crisps were ground into a fine powder using a blender.

2.3.2 EXTRACTION OF GINGER

Preparation of Fresh Ginger Extract

Aqueous extract of fresh ginger was prepared by measuring a suitable amount of the fresh ginger sample and pounding it thoroughly using a mortar and pestle. The sample was then transferred into a thimble and placed in the soxhlet extractor under heat (°C) using methanol as the solvent.

Preparation of Powdered Ginger Extract

Aqueous extract of the powdered ginger sample was obtained by measuring a suitable amount of the powdered ginger sample into the thimble and placing it in the soxhlet extractor under heat using methanol as the solvent.

2.3.2 DETERMINATION OF MOISTURE CONTENT

Association of Official Analytical Chemists standard method was used

The weight of the dry, clean crucible was measured and noted (W1). The crucible (W2) was filled with 2g of the sample by weight. Oven temperature was adjusted to 105°C, and the crucible containing the sample was put inside. The sample-containing crucible was left in the oven for roughly three hours. Until a constant weight (W3) was achieved, it was left to dry. This was carried out twice (one for the fresh ginger sample and the other for the dried ginger powder sample). Next, the following formula was used to get the percentage moisture content: %moisture

$$= \frac{Loss\ in\ weight}{Weight\ of\ sample\ before\ drying} = \frac{W_2 - W_3}{W_1}$$

Where W_1 = initial weight of empty crucible

W_2 = weight of crucible + sample before drying.

W_3 = weight of crucible + sample after drying**.**

%Dry matter = 100 - %Moisture content

2.3.3 DETERMINATION OF ASH CONTENT

Association of Official Analytical Chemists standard method was used

2g of the ginger sample was put into a crucible that had previously been weighed in order to calculate the ash content. The sample was ignited at 550°C for three hours while the crucible and sample were inside a muffle furnace (Gallenkamp model size 2). After the ignition period has elapsed, the muffle furnace was allowed to cool after which the crucibles were removed using a pair

of thongs and put in a dessicator to cool. The weight of ash and crucible was then taken. This was done in duplicate (one for the fresh ginger sample and the other for the dried ginger powder). The percentage ash can be calculated as follows:

$$\%ash = \frac{Weight\ of\ ash}{Weight\ of\ sample}\ x\ 100 = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where W_1= Weight of crucible

W_2 = Weight of crucible + sample.

W_3 = Weight of crucible + ash.

2.3.4 DETERMINATION OF CRUDE FIBRE

Association of Official Analytical Chemists standard method was used

A conical flask weighing 2g of the ginger sample was filled with 1.25% sulfuric acid and allowed to boil for 30 minutes. To lessen the acidity of the residue, the solution was filtered and then washed. After that, the residue was put in a second conical flask and heated to boil, adding 1.25% sodium hydroxide this time. After another filtering of the solution, the residue was cleaned. After 1 hour of drying at 300°C in the muffle furnace, the residue was cooled and weighed. The percentage crude fiber was calculated as follows:

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

Where W_1=weight of sample used.

W_2=weight of crucible+ dried residue.

W_3=weight of crucible + ash.

2.3.5 DETERMINATION OF CRUDE FAT

Association of Official Agricultural Chemists standard method was used

To determine the crude fat content of the ginger sample, 2g of the sample was placed in a thimble and put in a Soxhlet apparatus. The flask containing methanol was placed on a heating mantle working at a temperature of 60°C. As the solvent got heated up, the hot methanol solvent rose and dripped through the sample in the thimble causing the fat extraction to occur. This process continued until all the fat was extracted from the sample (this lasted for 5 hours). After the extraction process, the solvent was evaporated off the flask and the fat was dried in the oven at 60°C for 1 hour and weighed. This was done in duplicate (one for the fresh ginger sample and the other for the dried ginger powder sample). The percentage crude fat was calculated as follows:

$$\%\text{Crude fat} = \frac{Weight\ of\ fat}{Weight\ of\ sample} \text{x } 100$$

2.3.6 DETERMINATION OF CRUDE PROTEIN

Association of Official Analytical Chemists standard method was used

In the determination of crude protein content, the Kjedahl's method was utilized and there were three stages involved.

Digestion stage: A Kjedahl flask was filled with 1g of the ginger sample and 15ml of sulfuric acid. In addition, 2.5g of potassium sulfate, a little pinch of copper sulfate, and a pinch of selenium were added (as catalysts). After that, the mixture was placed on a heating mantle set at 75°C to allow digestion to occur until the mixture turned clear, changing from a dark brown to a golden yellow color.

Distillation stage: Following digestion, the flask was allowed to cool, and water—five times the amount of digest—was added to lessen the acidity of the digest. Following that, an excess of 40% sodium hydroxide was added to the mixture. After that, the flask was placed back on the heating mantle and the contents were distilled into a flask with a flat bottom flask that held 5 ml of a boric

acid/methyl red indicator solution. This process was continued until 100 ml of the golden yellow distillate were obtained. Sodium hydroxide was then added to release the ammonia.

Titration stage: The distillate that was obtained was then titrated with 0.01N hydrochloric acid the end point. The end point is achieved when the golden yellow distillate turns pink.

The crude protein content was obtained by multiplying the nitrogen content by a factor of 6.25. The nitrogen and crude protein contents can be calculated as follows:

$$\%\text{Nitrogen content} = \frac{Na \times Va \times 14\ V\ 100}{1000 \times wt\ of\ sample}$$

where:

Na = Normality of acid

Va = Volume of acid obtained on titration

14 = Atomic weight of Nitrogen

Wt = Weight

Further resolving the equation, we have:

$$\%N = \frac{Na \times Va \times 1.4}{wt\ of\ sample}$$

$$\%Crude\ Protein = \frac{Na \times Va \times 1.4 \times 6.25}{wt\ of\ sample}$$

2.3.7 DETERMINATION OF CARBOHYDRATE CONTENT

Association of Official Analytical Chemists standard method was used

The carbohydrate content determination of the ginger samples was calculated using the formula for food analysis and instrumentation:

%carbohydrate =100 - %(protein+fat+ash+moisture content)

2.3.8 MINERAL ANALYSIS

Determination of minerals was done according to AOAC method. 2g of the ginger sample was ashed in a muffle furnace at the temperature of 500^0C for 2 hours and the ash of the sample was dissolved in 10% nitric acid, filtered and made up with distilled water to the mark in a 100ml volumetric flask. This was used to determine the minerals Fe, Mg, Zn and K by the use of atomic absorption spectrophotometer (AAS). Also, Ca and Na were determined with flame photometer.

2.3.9 PHYTOCHEMICAL SCREENING

Aqueous extract of the ginger samples was obtained by measuring a suitable amount of the ginger samples into the thimble and placing it in the soxhlet extractor under heat using methanol as the solvent. Phytochemical screening was then carried out on the aqueous extract of the ginger samples using standard procedures to identify the constituents.

Test for alkaloid: 2ml of 10% picric acid (Hager's reagent) was added to 1ml of ginger extract.

Test for glycoside: To 1ml of ginger extract, 1ml of glacial acetic acid , 1 drop of ferric chloride and 1ml of concentrated sulphuric acid were added.

Test for phenolic compound: Few drops of 10% ferric chloride was added to 1ml of the ginger extract

Test for tannins: 1ml of ginger extract was dissolved in 2.5ml of distilled water and 10% NaCl was added to the solution.

Test for saponin: 2ml of distilled water was added to 1ml of ginger extract and was shaken vigorously.

Test for flavonoids:1ml of ginger extract was taken and 10% of lead acetate was added.

Test for steroids: To 2ml of ginger extract, 2ml of chloroform and 2ml of concentrated sulphuric acid are added.

Test for terpenoids: 2ml of the extract was measured and 1ml of chloroform and 1.5ml of concentrated sulphuric acid are added carefully along the sides of the tube.

Test for quinones: To 1ml of ginger extract, few drops of 10% NaOH were added.

Test for coumarin: To 1ml of the ginger extract, 10% NaOH was added in drops along with chloroform.

CHAPTER THREE

RESULTS AND DISCUSSIONS

3.1 SENSORY OBSERVATIONS DURING DRYING: While drying, the ginger chops lost their vibrant color as a result of exposure to solar heat. Additionally, a reduction in size and weight was noted due to the gradual loss of moisture content, resulting in a crisp texture. Furthermore, it was noted that the aroma of the ginger intensified following the grinding process.

3.2 PROXIMATE COMPOSITION VALUES OF THE GINGER SAMPLE

SAMPLE	% Moisture Content	% Dry Matter	% Ash Content	% Crude Fibre	% Crude Protein	% Crude Fat	% Total Carbohydrate Content
Fresh Ginger	70.00	30.00	2.00	6.70	7.88	7.85	12.15
Sun-dried Ginger powder	15.50	84.50	2.30	7.24	11.80	19.00	51.40

3.2.1 DISCUSSION

Sun-drying proved highly effective in significantly reducing the moisture content of the ginger sample, as indicated in the table above. Precise control of moisture content is crucial in food processing, as it helps mitigate microbial activity and extend the shelf life of the food product. Additionally, an increase in ash content was observed, as depicted in the table. Ash content refers to the inorganic residue remaining after the burning off of organic components, comprising minerals such as calcium, magnesium, iron, and others. Thus, an increase in ash content in the dry ginger

powder suggests a potential increase in minerals from the fresh ginger samples during the drying process. This increase can be attributed to the elimination of moisture which initial dissolved these inorganic materials leading to a higher concentration of them in the dry ginger powder sample. An increase in the crude fibre content in the dry ginger powder compared to the fresh ginger indicates an increase in the indigestible portions of the ginger usually composed of cellulose, hemicellulose, lignin and other non - starch polysaccharides. This can be due to the processing methods involved such as grinding and sieving which may break down or remove the non-fibrous components of the food leaving behind a higher portion of fibrous materials in the processed product (dried ginger powder). Dehydration, another processing technique, removes water and other soluble components leaving behind a higher concentration of fiber per unit weight of the dried ginger powder. Moreover, the levels of crude fat, crude protein, and nitrogen-free extract exhibited an increase post-processing. This augmentation can be attributed to the removal of moisture from the fresh ginger sample through sun-drying, resulting in a heightened proportion of these components. The reduction in moisture content, which previously diluted the components, led to a greater concentration of them in the dried product.

3.3 PHYTOCHEMICAL ANALYSIS

PHYTOCHEMICALS	FRESH GINGER POWDER		DRIED GINGER	
	Presence	Observation	Presence	Observation
Flavonoids	+	Cloudiness	+	Cloudiness
Alkaloids	+	Yellow precipitate	+	Yellow precipitate
Glycosides	+	Brown ring obtained at interface	+	Brown ring obtained at interface
Tannins	–	No color change	–	No color change
Phenolic compounds	++	White precipitate	+	White precipitate
Terpenoids	+	Reddish brown color	+	Reddish brown color
Steroids	+	Red color at lower layer	+	Red color at yellow layer
Quinones	–	No color	–	No color
Coumarins	–	No color	–	No color
Saponins	+	Foamy at upper layer	+	Foamy at upper layer

NB: ++ represents higher concentration, + represents lower concentration, – represents no presence.

3.3.1 DISCUSSION

Based on the phytochemical analysis conducted on both fresh and dried ginger powder extracts utilizing methanol as a solvent, the presented table illustrates the presence of specific phytochemical constituents. Flavonoids and phenolic compounds exhibited a higher concentration in the fresh ginger extract. This was because there was an immediate change observed in the extract during the analysis. Saponins, terpenoids, alkaloids, glycosides and steroids were also identified in both extracts. Notably, the absence of tanins, quinones and coumarins was confirmed through analysis.

An observed decline in the concentration of phenolic compounds and flavonoids following processing (in the dried ginger powder) suggests a potential impact of the drying method employed (sun-drying) and the inherent photosensitivity of these phytochemicals.

Phytochemicals, recognized for their natural occurrence in plants, are renowned for their antioxidant activity, thereby mitigating the risk of cancer and cardiovascular diseases in humans. Additionally, their anti-inflammatory properties contribute to the reduction of various diseases such as arthritis and diabetes.

Furthermore, phytochemicals play a pivotal role in enhancing the sensory attributes of plants, including flavor, aroma, and color, thereby influencing consumer perception and acceptance.

3.4 MINERAL ELEMENT ANALYSIS

Table 3.

Elements (mg/L)	**Iron (Fe)**	**Magnesium (Mg)**	**Calcium (Ca)**	**Zinc (Zn)**	**Potassium (K)**	**Sodium (Na)**
Fresh Ginger	1.00	0.75	0.50	0.80	19.70	2.20
Dry Ginger Powder	1.60	1.08	0.30	1.20	61.10	11.40

3.4.1 DISCUSSION

The trend of increase in mineral element values, apart from calcium, in fresh ginger to dry ginger powder (as shown in table 3) can be attributed to the loss of moisture through sun-drying. Since the moisture which dissolved these minerals has been eliminated, the concentration of the minerals in the processed ginger powder is therefore increased. This is different in calcium as there is a decrease in the calcium value from 0.50 mg/L in fresh ginger to 0.30 mg/L in dried ginger. This can be due to the photosensitive nature of some calcium compounds when exposed to sunlight. This exposure might have triggered reduction reactions leading to the formation of new compounds.

3.5 CONCLUSION

From the analyses carried out so far, the presence of certain photochemicals such as flavonoids, terpenoids, saponins, tannins, glycoside, etc, have been confirmed. These phytochemicals possess antioxidants properties that are useful in human health and medicine. Also, the presence of some trace elements have been confirmed with potassium being the most abundant of them. Potassium is vital in regulating the movement of fluids in and out of the cells thereby leading to proper fluid balance. It also helps in proper muscle function including the contraction of the muscle of the heart. Proximate composition and phytochemical analyses carried out on fresh ginger and dried ginger powder also shows the effects of processing (drying and grinding) on the amount of proximate compositions and phytochemicals in the ginger sample. Proper moisture control aids in increasing the shelf life of the ginger by inhibiting microbial and oxidation reactions.

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