COMPARISON OF PROXIMATE COMPOSITIONS AND NUTRITIONALLY VALUABLE MINERAL CONTENT OF SELECTED COCONUT VARIETIES

Elizabeth Adeteju Omimakinde[1,2]

1 Science Policy and Innovation Department, National Centre for Technology Management Headquarters, O.A.U., Ile-Ife, Osun State, Nigeria.

2 Department of Chemical Sciences, Redeemer's University, Ede, Osun State, Nigeria.

Email: lizzyfavourbethy@gmail.com

ABSTRACT

Proximate and mineral compositions of some varieties of coconuts (Cocos nucifera) from Nigeria Institute for Oil Palm Research (NIFOR), Badagry, Lagos State, were estimated using standard methods. The proximate analysis covers crude protein, ether extract, moisture content, crude fibre, carbohydrate, and ash content. The proximate analysis portrayed that the Dwarf green meat sample contained the highest value of crude protein and ether extract at 3.54% and 37.69% respectively. The Dwarf yellow and Dwarf red meat samples had the largest percentage of fibre (11.62%) and carbohydrate (70.15%) contents, respectively. The mineral elements determined in the coconut meat and water were sodium, potassium, magnesium, calcium, iron, copper, cobalt, chromium, zinc, and manganese. Hybrid coconut water (HW) had the highest potassium content while dwarf red water possessed the highest calcium and magnesium contents. The high contents of fibre, potassium, magnesium, and calcium indicated that sufficient health, medicinal and nutritional benefits can be derived from consuming fresh coconut water, coconut meat as well as coconut milk and other coconut products.

Keywords: proximate analysis, coconut meat, coconut water, crude protein,

1.0 INTRODUCTION

The scientific name for coconut is Cocos nucifera, from the family Aracaceae. Coconut provides a nutritious source of juice, milk, minerals, and oil that has fed and nourished populations around the world for generations. On many islands, coconut is a staple in the diet and provides much of the food eaten. Nearly one-third of the world's population depends on coconut to some degree for food and economy. Among these cultures, the coconut has a long and respectful history (Codjoe et al., 2021; Oduro-Yeboah et al., 2020).

Coconut is highly nutritious and rich in fibre, vitamins, and minerals. It is classified as a "functional food" because it provides many health benefits beyond its nutritional content (Kaur et al., 2019). Coconut oil is of special interest because it possesses healing properties far beyond that of any other dietary oil and is extensively used in traditional medicine among Asian and Pacific populations (Salian and Shetty, 2018).

Pacific islanders considered coconut oil to be the cure for all illnesses (Boateng et al., 2016). The coconut palm is valued by them as both sources of food and medicine that it is called "The Tree of Life" (Chan and Elevitch, 2006). Only recently has modern science unlocked the secret of coconuts' amazing healing powers.

Every part of the coconut is useful to man. The white nutmeat can be eaten raw or shredded and dried and used in most cooking recipes. The protein content of single coconut is as much as a quarter-pound of beefsteak (Banu and Palanivel, 2019). Copra, the dried meat of the kernels, when crushed is the source of coconut oil. Coconut water can be used as a remedy in gastroenteritis; it is a ready and handy boom to combat the dehydration of patients suffering from severe diarrhoea and vomiting and is a cheap substitute for glucose, saline, or plasma. Tender coconut water contains not only glucose but also other nutrient elements such as P, S, Na, Cu, Fe, K, fat, sugars, amino acids, and vitamins, which vary in proportions according to the maturity of the nuts ((Kaur et al., 2019).

This study was carried out to analyse the proximate, macro, and micro-nutrient parameters of the kernel from different coconut varieties grown at NIFOR.

Coconut Meat is the kernel (endosperm) enclosed by the hard strong shell (endocarp) and to which the testa (thin brown seed coat) firmly adheres. It is normally a layer of about 12mm or thicker, lining the central cavity, which in the ripe nut is partly filled with water.

Coconut Water is the water of tender coconut, technically, the liquid endosperm. It is perhaps the purest, most nutritious, and wholesome beverage that nature has provided for the sun-scorched children of the tropics (Naika et al., 2015). The amount present depends upon the size, variety, maturity, and freshness of the coconut. The cavity inside of the nut may contain up to 141.5g or 170g of water when fresh, but it is gradually lost by evaporation and respiration.

Coconut Varieties: coconut is a diverse species, which is generally divided into two groups. These groups are the tall and dwarf varieties. What are called varieties are variable because the coconut cannot be propagated asexually but only by seed (Omotayo, 2020) thus all varieties are subject to some variations. Apart from the typical dwarf and tall types, there are intermediate types:

Hybrid - the crossbreeding between tall and dwarf types. These have productive characteristics of tall and dwarf, which are superior to ordinary tall. Within these three categories, a distinction is also made by the colour of the fruit. Some of the dwarf varieties are Dwarf Green, Dwarf Red and Dwarf Yellow, these are also applicable to the tall and hybrid types.

The aim of this paper is thus to determine the proximate percentage of each variety of coconut samples as well as their mineral constituents and to compare the proximate content and mineral composition of the varieties.

1.2 Proximate Analysis

The routine analysis of food for its basic component is termed the proximate or Wende analysis; after the Wende Experiment station, Germany, developed in 1865 (Oyeleke, 1984). Estimations were made of nitrogen, (as an index of crude protein), water, fat, ash, and crude fibre, carbohydrate content was taken to be the value obtained when the total of all other components was subtracted from a hundred percent.

1.2 Moisture content

The moisture content of a food is often an indication of its keeping qualities, for example, milk, having very high-water content is highly perishable. While derived milk powder, having most of the water removed is much more stable. The moisture content also affects the nutritive value of nuts, its relative humidity, the types of microbial species present in it and also the length and temperature of its storage (Vera Zambrano et al., 2019). However accurate determinations of moisture content are often difficult since the water present in foods is not all in the free state, i.e the form in which water freezes and the form which is easily lost by evaporation. Various amounts may be present in a bound form resulting from attraction involving hydrogen bonds and polar species in the food. Consequently, the moisture content of the food is often satisfactory as a measure of the likely keeping qualities of the food than water activity (Isengard, 2001). Other forms in which water is present in nuts or fruit includes:

(i) As a solvent for the molecule dispersion of crystalloids such as sugar, salts, and acids of low molecular weight or as a dispersing medium for hydrophobic macromolecules or colloidal solution.

(ii) Absorbed as a very thin mono or poly molecules or poly molecular layer on the internal or external surface of the solid components by molecular forces or fine compliance by capillary condensation.

(iii) In a chemical combination as water of hydration in carbohydrates such as dextrose, maltose, and lactose from stable monohydrates such as potassium tartrate also remain in their gels as water of hydration is firmly held by a hydrogen bond (Iyilade et al., 2018).

The moisture content of any food must be known in determining the nutritive value of the food and in expressing results of analytical determinations on a uniform basis and meeting compositional standards. The moisture content can be determined by using oven- drying method which is based on the weight loss of water due to evaporation (Ahn et al., 2014).

Carbohydrates

Carbohydrates may be classified into various categories based partly on their chemical nature and partly on their utilization by the human body. This classification has a major bearing on the analytical methods chosen for estimating the various fractions present in foods.

Two major nutritional classes of carbohydrates may be classified as Available carbohydrates and Unavailable carbohydrates (Megazyme, 2018).

Available Carbohydrates

Available carbohydrates may be defined as those, which are susceptible to the endogenous enzymes of the upper digestive system of humans, and are characterized as those carbohydrates that produce energy in the human body. They include the monosaccharides glucose and fructose, found in fruits, the disaccharides sucrose, lactose, and maltose, the disaccharide raffinose, and the tetrasaccharide stachyose. Also included are the reserve polysaccharides starches and dextrin, which are partly hydrolyzed molecules. Some starch, described as resistance starch, is, however, not digested by the endogenous secretions of the human body and is not included in this category of available carbohydrates (McCleary et al., 2019).

Unavailable Carbohydrate

Unavailable carbohydrates often described alternatively as dietary fiber or non-starch polysaccharides, or by the older term roughage, are those which are resistant to the endogenous enzymes of the human digestive system but which may be either resistant or susceptible to bacterial enzymes in the large intestine. When susceptible to such bacteria, this carbohydrate may produce energy following their metabolism to fatty acid; when resistant, they are excreted unchanged. Unavailable carbohydrates are found in plant cell walls and are responsible for providing the structural component of the plant. Their chemical nature tends to be much more complex than that of the available carbohydrate. The simplex unavailable carbohydrate, chemically, is cellulose, which is composed of glucose molecules linked by 1;4β – linkages. The difference in the nature of the glucose linkages between starch and cellulose has a major bearing on the digestibility of the two carbohydrates, human being unable to hydrolyze the β - linkage and thus incapable of digesting cellulose. The other unavailable carbohydrates are similar to cellulose in being polymeric in nature but are composed of a number of alternative molecules (Lunn and Buttriss, 2007).

Dietary Fibre

Definitions of dietary fibre fall into one of two types, physiological definitions and chemical definitions. The former defines the dietary fibre as the plant cell wall material that resists digestion by endogenous enzymes of the human digestive system or alternatively as those food components resistant to digestion in the small intestine. Chemical definitions describe dietary fibre as the sum of the non-starch polysaccharides and lignin (CFW Report, 2001). The method of estimating dietary fibre is thus based either on weighing the residue left after simulated digestion procedures (in one with the physiological definitions) or on the chemical analysis of the residue left after a similar process of simulated digestion with various enzymes.

Crude Fibre

Crude fibre is the residue that remains after the food sample has been treated under standardized conditions with petroleum spirit, boiling dilute sulphuric acid, boiling dilute NaOH solution, alcohol and ether. Crude fibre consists largely of cellulose together with a little lignin. Based on the fact the recovery of cellulose

using the specified procedure seldom exceeds 4/5 of that actually measured of a specific group of substances (Madhu, 2017).

Proteins

Proteins are highly complex nitrogenous organic compounds occurring naturally in all living matter and forming an essential part of animal food requirements. They are very important for many cellular functions, some of which are (i) Proteins are the chief structural units of protoplasm (ii) Proteins in the diet serve as the primary source of amino acids, the building block of cellular proteins (iii) The biological catalysts known as enzymes are proteins. (iv) Some of the hormones, the regulators of the chemical reactions are proteins or peptides. (v) Antibodies are complex proteins. (vi) Proteins play an important role in the transport of water, inorganic ion, organic compounds, and oxygen (vii) The ability of proteins to form gels, sols, foams, emulsions, e.t.c. provides some indication of their functional role in foods. In addition, they can contribute to the colour and flavours of foods by participating in Maillard and other browning reactions (Bernhard, 2010)

Components of Protein

The five elements that are present in most naturally occurring proteins are carbon, hydrogen, oxygen, nitrogen and sulphur (Rajasekaran, 2009). Other elements such as phosphorous, iodine and iron may be essential constituents of certain specialized proteins. Casein of milk contains phosphorous, an element of utmost importance in the diet of infants and children (**Bhat, 2016)**. Iodine is a basic constituent of the thyroid gland. Haemoglobin of the blood is an iron-containing protein (Abbaspour, 2014; Gell, 2017). Most protein shows little variation in their elementary composition, the average content of the main elements is as follows: Carbon 50%, Hydrogen 7%, Oxygen 23%, Nitrogen 16%, Sulphur 0-3%, and Phosphorus 0-3%.

The relatively high content of nitrogen differentiates proteins from fats and carbohydrates. The majority of proteins have a nitrogen content of 16%. This fact is utilized when deriving values for the approximate protein content of foods. The total nitrogen in food is obtained by the Kjeldahl method and converted to protein content by multiplying by the factor of 6.25 (100/16) for most foods.

Crude Protein

Nitrogen is used as an index of the protein termed “crude protein” as distinct from true protein. A number of methods are available for protein estimation, the method chosen to be dependent on the degree of accuracy and precision required and, on the facilities, available. Kjeldahl Method is the most reliable particularly for insoluble foodstuff (Saez Plaza, 2013). This method was first published in 1883 by Kjeldahl, head of the chemistry department of the Danish brewing companies Carlsberg, and remains the main method of nitrogen and protein essays in foods, both for routine analyses and for the calibration of modern instruments.

The principle of the method involves the estimation of the total nitrogen content of food and the conversion of the percentage of nitrogen to protein, assuming that all the nitrogen in food is present as protein and using a conversion factor based on the percentage of nitrogen in the food protein i.e: % Protein =% N x F

Where F = conversion factor = 100 (% Nitrogen in protein)

A number of commercial organizations have developed automated or semi-automated procedure for Kjeldahl estimations. E.g., the Kjeltel Tecator system, the Foss Kjel-Foss system and the Buchi system. These are based on the following general procedure and principles. A known weight of food is digested with concentrated sulphuric acid (oxidizing agent), anhydrous sulphate (to raise the boiling point of the mixture) and a catalyst such as copper, titanium, selenium, or mercury. This process converts the nitrogen in the food other than nitrate and nitrite nitrogen into ammonium sulphate.

N (food) $\longrightarrow$ $(NH_4)_2SO_4$

The ammonium sulphate is then converted into ammonia gas by heating with sodium hydroxide in the presence of steam:

$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + H_2O + 2NH_3$

The ammonium formed is collected in an excess boric acid:

$2NH_3 + 2H_3BO_3 \rightarrow 2NH_4BO_3$ (3.1)

And is then estimated by titration of the ammonium borate formed with standard sulphuric or hydrochloric acid.

$2NH_4H2BO_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_3BO_3$ (3.2) Or

$2NH_4H_2BO_3 + 2HCl \rightarrow 2NH_4Cl + 2H_3BO_3$ (3.3)

Adding equations (3.1) an (3.2) gives the following overall reaction for titration using sulphuric acid:

$2NH_3 + H_2SO_4 \longrightarrow (N H_4)_2 SO_4$

Whilst adding equations (3.1) and (3.3) gives the following overall reaction for titrations using hydrochloric acid.

$2NH_3 + 2HCI \rightarrow 2NH_4CI$

From these equations

1 mole H_2S0_4 = 2 moles N = 28g N or

I mole HCI= 1 mole N = 14g N

And thus

1ml 0.1 M $H_2 S0_4$ = 0.0028g N

And

1ml 0.1M HCI = 0.0014g N.

The Kjeldahl method is widely used internationally and is currently the standard method for comparison against all other methods. Its universality, high precision, and good reproducibility made it the major method for the estimation of protein in foods (Saez-Plaza, 2013).

Fat

The estimation of the fat content of food almost invariably involves the estimation not of the true fat content, but of the lipid fraction of the food, i.e those food constituents soluble in non-polar organic solvents such as petroleum ether (petroleum spirit) or diethlyether (ethoxyethane). This fraction includes fats known as tryiglycerides (or triacylglycerols), Phospholipids, sphingolipids, waxes, steroids, terpenes and fat-soluble vitamins.

Lipids are one of the most important constituents of all food materials. They serve as a rich source of energy, yielding approximately kilocalories per gram. They serve as carriers of the fat-soluble vitamins A, D, E and K while, certain components of the fats themselves (linoleic, linolenic, arachidonic acids) are essential components in all diets (Hamam, 2013). Fats usually make up around 99% of the lipid fraction of food, and their relative ease of estimating the total lipid content rather than the true fat content has resulted in the terms fat and lipid becoming vertically indistinguishable as far as food analysis for compositional purposes is concerned.

The Soxhlet extraction method (AOAC, 1990) was used. This is based on the continuous extraction of food with a nonpolar organic solvent such as petroleum ether for about 4 hours.

A known weight of food is placed in a porous thimble and the extracting solvent is placed in a dried, weighed distillation flask. The solvent is then heated, after volatilizing and it is collected after condensing, in a container housing the porous thimble. The solvent is then mixed with the food, dissolves out the fat, and eventually siphons back into the original distillation flask. The process is then repeated continuously for a period of about 4 hours, after which it is assumed that all the fat has been extracted from the food and now is present in the solution in the distillation flask. Removal of the solvent leaves the fat as a residue. The flask is reweighed and the increase in weight of the flask is taken as the weight of fat present in the original food. The Soxhlet method, along with its various modifications, finds universal applicability and exhibits good accuracy and reproducibility. It is, however, time-consuming and makes use of inflammable solvents, although the hazards associated with the latter may be reduced using Soxhlet modification (James 1995). Coconut meat is very rich in fat, it contains about 36% fat of the coconut meat (McCance 1960).

Elemental Composition of Coconut

Minerals can be called inorganic matter. When a plant or animal tissue is bunt; the organic matter is destroyed leaving a residue known as ash. This represents the salt of the mineral element, which previously existed in the tissues in combination with the organic matter. Adequate knowledge of the mineral composition of food is important to the health, well-being, and safety of the consumers (FAO/WHO, 2001).

Some of the minerals are required in greater quantity than the others and some are known to be linked individually with specific metabolic reactions (Soetan et al., 2001). Minerals in food are grouped into two categories, namely: Macro-minerals and Micro-minerals or trace elements. The macro-minerals are the ones that are required in large amounts in the body. They are required in an amount greater than 10mg per day (Khalid et al., 2014), these include Ca, Mg, K, and Na. Micro-minerals or trace elements refer to the inorganic elements which are present in foods in amounts usually well below 50ppm. Micro minerals occur at ppm levels or below and exert some influence on plants or animals' physiological activities and cell functions. These include Cu, Mn, Cr, Co, etc. (Mousa et al, 2019)

General Importance of Mineral Elements

Although the quantities of minerals in the body are very tiny, their importance is correspondingly enormous. Minerals participate in a great number of enzymes and metabolic processes. Minerals can either reinforce or counteract each other in the organism, and quantities in which they are found give no due as to how vital they are for health. Tiny quantities of selenium are in every bit as important as large quantity of calcium and magnesium. Minerals contribute to the building up of tissues. Calcium, to the building up of the bones and teeth, while sulphur and selenium participate in certain amino acids (cysteine and methionine), which are the building blocks of hair, nails, and skin. Iron and copper are essential ingredients in haemoglobin and myoglobin in the blood. A vitamin B_{12} molecule contains an atom of cobalt and iodine is vital to the functioning of the thyroid gland. Minerals are the cornerstones of thousands of enzymes and chemical compounds. Sodium and potassium have an influence on the osmotic pressure in the tissues and on the elimination of various fluids from living organisms (Robinson, 2015).

The Essential Nutritive Metals

Sodium: The adult human body contains about 100g of sodium, half of which is in the cells, primarily in the bones. The remainder is concentrated in tissue fluids, which surround the cells. Sodium regulates the electrolyte and acid-alkali balances, the conductive capacity of the nerves, muscle contractions, and the production of adrenaline and amino acids. It also regulates the absorption of glucose (Gałeska and Wrzecinska, 2022)

Potassium: Potassium is one of the minerals of which there are the largest quantities in the human organism, 115-150g. Almost all this (98%) is in the cells. Potassium plays a vital role in the nervous system, the muscles, and the heart. Potassium and sodium are partners in the mineral world. This is because they have the opposite effects. Potassium is required for the normal functioning of the nerves and muscles, sugar metabolism, acid-base balance, and oxygen metabolism in the brain. The heart also needs potassium. The correct potassium balance is necessary for the heart to avoid arrhythmias and the damage that ensues from

such abnormal rhythms. In addition, potassium participates in several enzyme systems and in protein metabolism (Macdonard, 2004).

Calcium: Calcium is the mineral, which occurs in our bodies in the largest quantities- around 1200g for an adult human, 99% of which is concentrated in the bones and teeth. Calcium participates in the regulation of nerve and muscle functions, in the production of hormones, in the maintenance of the fluid balance, in the activity of the heart, in the coagulation of the blood, and in the secretion of milk. Other function of calcium includes neuromuscular irritability and myocardial function (Bove-Fenderson and Mannstadt, 2018).

Magnesium: There is 20-28g of magnesium in the adult human body, of which 99% is located within the cells, where it regulates a number of enzyme systems. The greater parts of our magnesium is concentrated in the bones (60%) and the muscles (20%), while only 1% is to be found in the fluids between the cells, in serum, for example. Magnesium is an essential mineral for cell functions and it occupies a key role in all reactions with phosphates. The cells also require magnesium for cell division and enzyme production, which in turn regulates the protein, carbohydrate, lipid, nucleic, and nucleotide metabolisms. Normal Muscle function requires the presence of magnesium, which is why a deficiency of this mineral leads to muscle weakness and fatigue. Furthermore, magnesium is of importance for the heart and the entire circulatory system as magnesium prevents blood pressure from rising. Magnesium appears to improve the functioning of both the cellular and the antibody-mediated immune defences (Tam et al., 2003).

Iron: Adults have about 3-4g of iron in their bodies, and the greatest proportion of this (about 65%) is in the haemoglobin; 10% is concentrated in the myoglobin in the muscles, while the rest is stored in the liver, the spleen, the kidneys, the bone marrow, and other organs. There is about 500mg of iron in one litre of blood (Alleyne et al., 2008). The production of red blood corpuscles, oxygen transportation, and the functioning of many enzymes in the organism requires iron. In addition, the metabolism of B vitamins is dependent on iron (Mahmood, 2014).

Zinc: Zinc is of great importance for the health of several population groups: growing children, pregnant women, the elderly, and people with allergies and chronic diseases. Following the original demonstration of the occurrence of zinc in living tissues this metal was found to be present in all plants and animals and to occur in animal tissues at concentrations like those of iron and usually much greater than those of copper and manganese. The adult human contains 2-4g of zinc of which the greater part (78%) is concentrated in the bones, the muscles, and the skin. Zinc is an integral component of almost 100 different enzymes; it protects the skin, and improves resistance to infection, diseases, inflammations, and allergies. Zinc is vital

to about 200 different enzymes, to the formation of bone tissue in the healing of wounds and sore, to the production of proteins, the regulation of ribosomal, ribonucleic acid (RNA) synthesis, and insulin, and carbohydrate metabolism. Zinc is also an important participant in the copper-zinc superoxide mutase enzyme, which has antioxidant properties. The adult RDA for zinc is 15mg, but the actual intake of a great part of the population is considerably less. During pregnancy and breastfeeding, the requirements increase by 50-75% (McCall et al., 2000).

Zinc Therapy: Zinc is of value in the treatment of skin wounds because it accelerates the healing process. There are also indications that zinc could also be useful as an adjunct therapy for pre-post-operation patients. In addition, zinc is a component of many skin-protective ointments. Zinc may also be a valuable adjunct therapy for cancer patients because it has an anti-metastatic effect (Skrajnowska and Bobrowska-Korczak, 2015). The possible importance of zinc for the human nervous system has also been demonstrated in studies, which have compared zinc levels in the placenta with the circumference of the baby's skull. Indications are that low zinc levels are associated with small skull circumference and corresponding delays in brain development. Zinc has also been used experimentally in the treatment of eye diseases, senile degeneration of the macula, which is one of the commonest causes of impaired eyesight or even blindness in the elderly.

Copper: There are only about 80-120 milligrams of copper in the adult human organism, but it is nevertheless an immensely important cell found in the liver, the muscles, the bones, the heart, and the brain. A copper intake of 1.3 mg/day appears to maintain balance in adults (Lee et al., 2015). Copper participates in many enzyme systems, but it is best known for its active role in the superoxide dismutase (SOD) enzyme. CU-ZN SOD is the fifth most common protein in the human organism. It is found in the red blood corpuscles and in all tissues, where it renders oxygen-free radicals harmless. Ceruloplasmin is a dark blue plasma protein, which contains eight copper atoms. It regulates the levels of the hormones, adrenaline, noradrenaline, serotonin, and melatonin in plasma. This plasma protein is also required for the production of red blood corpuscles (Hellman and Gitlin, 2002).

Manganese: The normal content of manganese in the body of an average 70kg man is 10-20mg and is only 1/5 of the estimated total of copper and 1/100 of that of zinc. It tends to be higher in tissues rich in mitochondria and is associated with the presence of melanin of the cells (Li and Yang, 2018). The recommended daily allowance (RDA) for manganese is 3.8mg, and a number of studies have indicated that the actual daily intake is closer to 5-6mg. Manganese is required in the formation of the bone, for the metabolism of fats and carbohydrates, and for fertility (Li and Yang, 2018).

Cobalt: Cobalt is widely distributed throughout the body, without excessive accumulation in any organ or tissue. The total quantity of cobalt in the body of a normal 70kg mass has been reported to be 1.1mg. Cobalt is an integral component of Vitamin B_{12} (Osman et al., 2021) and its significance in human health and nutrition is confined to this. There have been several reports of responses to cobalt, in addition to iron, in the treatment of iron deficiency anaemia in children and in pregnant women. Similarly, cobalt has been tried as a means to reduce high blood pressure but this treatment has never become generally accepted (González-Montaña et al., 2020).

1.6 Atomic Absorption Spectrophotometer

Atomic absorption spectrophotometer was used for the analysis of all the metals that were determined in this paper. The technique (Atomic absorption spectroscopy) requires atoms in their ground state to be atomized by absorption of radiation at their characteristic wavelengths. The flame used depends on the metal to be analyzed e.g. air acetylene flame can be used for non-refractive metals like copper (EPA, 2015). Atomic absorption spectrophotometry is based on the fact that although the electrons of most medals may not be sufficiently excited to allow the type of transitions associated with the emission spectroscopy, atoms of these metals may absorb energy when radiation containing their characteristic wavelengths is passed through an atomized sample of a solution containing the particular element. The reduction in the intensity of the radiation will be proportional to the concentration of the element present.

2.0 MATERIALS AND METHODS

All the reagents used for this analysis are of analytical grade and are products of B.D.H Limited and May and Baker Limited, England. All the glassware were washed with detergent solution, well rinsed with tap and distilled water respectively, and then oven-dried before use.

Coconut samples of five varieties were obtained from the Nigeria Institute for Oil Palm Research (NIFOR), Badagry, Lagos State. They were de-husked, stacked in bags and transported to Poultry Meat Laboratory of the Faculty of Agriculture, Obafemi Awolowo University, Osun State Nigeria for subsequent analysis. The coconut shells were carefully drilled at the indentation points and the fluid was collected and filtered into air-tight sample bottles and then stored in the refrigerator prior to analysis. The meat was removed

from the shells, washed, grated with a plastic grater, and then packed in airtight containers and refrigerated prior to analysis.

2.1. Determination of Nitrogen and Crude Protein

Nitrogen is used as an index of the protein termed "crude protein" as distinct from true protein (Aremu et al., 2017). Most proteins have a nitrogen content of 16 % (Mæhre et al., 2018; Boulos et al., 2020). This fact is utilized when deriving values for the approximate protein content of foods. The total nitrogen in food is obtained by the Kjeldahl method and converted to protein content by multiplying by the factor of 6.25 (100/16) for most food (Omimakinde et al., 2018). The Kjeldahl method determines the total nitrogen as -NH - in the foods i.e., true protein N, amino nitrogen, and amide N (Saez-Plaza et al., 2013). This is then converted into protein by multiplying this percentage of nitrogen by the conversion factor.

Reagents Preparation: 40% NaOH: 40g of sodium hydroxide pellets were dissolved in an l00ml volumetric flask and were made up with distilled water.

2% Boric acid: 2ml of boric acid was measured from the stock into an l00ml volumetric flask and made up to the mark with distilled water.

0.0105M HCI: This was prepared by measuring 0.9m1 from the stock into a 100ml volumetric flask and it was made up with distilled water.

Procedure

0.5g of the prepared sample was accurately weighed into a Kjeldahl digestion flask; a scoop of the digestion mixture and 20ml of concentrated sulphuric acid was added. The mixture was placed in the electro thermal digestion heater for about two (2) hours until a clear solution was obtained.

After digestion, the flasks were removed from the digester, cooled and diluted with water and made up to 50ml. 50ml of 2% boric acid (plus indicator) was placed into a 250ml Erlenmeyer flask. The flask was placed under the receiving tube of the distillation unit in such a way that the end of the tube was below the level of the boric acid. 50ml of 40% NaOH was added carefully to the 20ml diluted digested sample and then attached to the distillation unit.

The heater was turned on and regulated, and the flask swirled to mix the contents. The distillation proceeded until the total contents of the Erlenmeyer flask were about 150m1. The distillate was titrated with standard HCI until the blue colour disappeared.

The equation for the reactions

$2C\text{-}NH_3 + 0_2 + 2H_2SO_4 \rightarrow (NH_4)_2S0_4 + 2CO_2 + 2SO_2$

$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_20$

$NH_3 + H_3BO_3 \rightarrow \ NH_4H_2BO_3$

$NH_4H_2BO_3 + HCl \rightarrow H_3BO_3 + NH_4CI$

Calculations

% N in sample = net vol. of acids × conc. of acid × 14 × l00 × dilution factor / Weight of sample in mg

% Crude proteins = 6.25 × % nitrogen in the sample.

2.2. Determination of Crude fibre

Principle: Crude fibre is part of the sample left after the removal of crude protein, fat, and nitrogen-free extract (Omimakinde et al., 2018; Adeleye et al., 2020). It, therefore, consists of cellulose, hemicelluloses and some of the materials that cover the cell walls such as lignin and peptic substances. Crude fibre is obtained by hydrolyzing the fat with dilute acid and dilute alkali (Fahey et al., 2020).

Reagents Preparations: 1. 2.5% H_2SO_4: This was prepared by measuring 2.5 ml con. H_2S0_4 into a 100 ml volumetric flask and it was made up to the mark with distilled water.

1.25% NaOH: 2.5g of NaOH was measured and dissolved in a 200 ml volumetric flask with distilled water and made up to the mark.

Procedure

2g of the coconut meat was weighed into the 600ml beaker. 200ml of 1 .25% boiling sulphuric acid was added. This was placed on the crude fibre apparatus which has been pre-set to maintain steady boiling. It was refluxed for about 30 minutes. The solution was filtered. The residue was washed with boiling water until it was free from acid. The residue was returned as cleanly as possible (using a tin spatula) to a beaker containing boiling 200ml of 1.25% sodium hydroxide solution. The mixture was then brought a to boil within one minute and then refluxed on the crude fibre apparatus for 30 minutes. The solution was filtered through a Whatman no.4 filter paper. The residue was washed with boiling water then with 1% HCI and again with boiling water until free from acid. The residue was then washed with 95 % alcohol, and then

three times with petroleum ether, using small quantities. The residue was allowed to drain and oven-dried overnight at 70°C, cooled and weighed. It was then ashed at 500°C for 3 hours, cooled, and weighed. The loss in weight is taken to be the crude fibre.

Calculation

% Crude fibre = loss in wt. in ashing × 100 / Wt. of sample

2.3. Determination of Moisture Content

Principle: A known weight of the sample is oven-dried to a constant weight and the loss in weight is equated to be the moisture content of the coconut meat (Sulistiawati et al., 2018, Omimakinde et al., 2018).

Procedure: 2g of the grated coconut meat was weighed into the crucible of known weight. The weight of the crucible plus the sample was recorded; this was dried in the oven at 70°C overnight. It was removed and cooled in desiccators. The weight of the crucible plus ash was recorded and the moisture content was calculated by assuming that the loss in weight of the sample on drying is due to loss of moisture only.

Calculation

$\%Moisture = W_2-W_3/W_2-W_1 \times 100$

Where W_1 = initial weight of the empty crucible

W_2 = weight of crucible + coconut meat sample

W_3 = final weight of crucible + sample after drying

2.4 Determination of Crude Fat

Principle: In the Soxhlet system of fat estimation, lipids are extracted out of the coconut samples by continuous extraction with petroleum ether (Ellefson, 2017).

Procedure: The Soxhlet extractor with a reflux condenser and a distillation flask, which has been previously dried and weighed, was set up. 2g of the grated coconut sample were accurately weighed into a fat-free thimble and plugged lightly with cotton wool. It was placed in the extractor and petroleum ether was added until it siphons over once. The petroleum ether was added more until the barrel of the extractor was half-full the condenser was replaced and the joints were tightened and placed on a boiling water bath. The heat was adjusted so that the solvent bobs gently and extraction was then carried out for 4hours. Finally, it was watched until the ether was just short of siphoning over, then the flask was detached and its content

siphoned into the stock bottle. It was well-drained. The flask was detached; the extractor was cleaned and then dried in the oven to constant weight.

Calculation

% Crude Fat = W_2-W_1/W_3 ×100

Where W_1 = weight of the empty flask

W_2 = Weight of flask + fat (in grams)

W_3 = Weight of grated coconut meat taken (in grams)

2.5 Determination of Ash Content

Principle: The total mineral content of the coconut meat samples may be estimated as the ash content, which is the inorganic residue remaining after the organic matter has been burnt away (Harris and Marshal, 2017).

Procedure: 2g of the sample were accurately weighed into a previously ignited, cooled, and weighed crucible. It was heated gently over a Bunsen burner until the sample was charred. The crucible was transferred into a muffle furnace at about 550°C and was left until a white or light grey ash resulted. It was cooled in a desiccator and reweighed.

Calculation

% Ash = weight of ash/weight of original coconut meat × 100

=W_3 -W_2/W_2-W_1 × 100

Where W_1 = weight of the empty crucible

W_2 = weight of crucible + sample before drying and ashing

W_3 = weight of crucible + ash

2.6 Determination of Carbohydrates: This was obtained by calculation having estimated all other fractions by proximate analysis (Kassegn, 2018, Omimakinde et al., 2018).

Calculation

% Carbohydrate = Nitrogen free extract +crude fibre

Nitrogen free extract= l00 – (% moisture + % ash + % protein + % crude fibre)

2.7 Determination of Mineral Content

The coconut meat samples were ashed, the ash was dissolved in hydrochloric acid, and the mineral elements were estimated (Harris and Marshal, 2017) using Alpha 4 atomic absorption spectrophotometer, ChemTech Analytical model.

Principle of Atomic Absorption Spectrophotometer

When a solution is aspirated into a flame, the heat of the flame first causes the solvent to evaporate. The micro-crystals remaining are partially or wholly dissociated into elements in their gaseous form (atomization). Some of these atoms can absorb radiation of a characteristic wavelength and become excited to a higher electronic state, or they may absorb energy from the flame and become thermally excited (Pawar, 2015). The atoms lose their excitation energy either as heat by collision with other atoms as the electron returns to a lower excited state or as radiation of characteristic wavelength as the electrons return to a lower excited state or to the ground state.

Elements and Their Absorption Wavelengths

Element	Wavelength	Element	Wavelength
Ca	422.7nm	Na	589.0
Cr	357.9	Zn	213.9
Co	240.7	K	766.5
Cu	324.7	Mg	285.2
Fe	248.3	Mn	279.5

Preparation of standard solutions

A range of standard solutions of each element to be analyzed was prepared by serial dilution of the stock solution. The concentration used was in the linear range of the instrument and appropriate for the amount of the element likely to be present in food extract. These were in the order of 1-10 ppm.

Calibrations and Elemental Analysis

The atomic absorption spectrophotometer was set up and the wavelength was adjusted to that of the element to be analyzed, after which the calibration curve was prepared for each element. The absorbance of each element was measured after calibration. In the case of concentration of high concentration, a known volume of the sample solution was diluted with a given volume of distilled water before analysis. The concentration of each ash solution was recorded in ppm and the hard copy was printed by the computer interface of the spectrophotometer.

3.0 RESULTS AND DISCUSSION

Tables 3.1, and 3.2 contain the proximate and mineral compositions of varieties of coconut meat and water samples respectively.

3.1 Proximate Analysis

A significant difference was observed in the moisture content, crude fat, crude fibre, and total carbohydrate contents of the coconut samples. The Dwarf Green (DG) sample has the highest value of crude protein (3.54%). This is very close to the value of 3.8 % reported in the literature (McCance & Widdowson,2014). DR has the lowest value of crude protein (2.66%). Although these values are very low, they are nevertheless; a potentially important source of protein because of the high volume of the world's production of coconuts, primarily in regions deficient in high-protein foods. The results confirmed the high oil content of DG and H nuts and thereby endorsing them as the best varieties for commercial vegetable oil production.

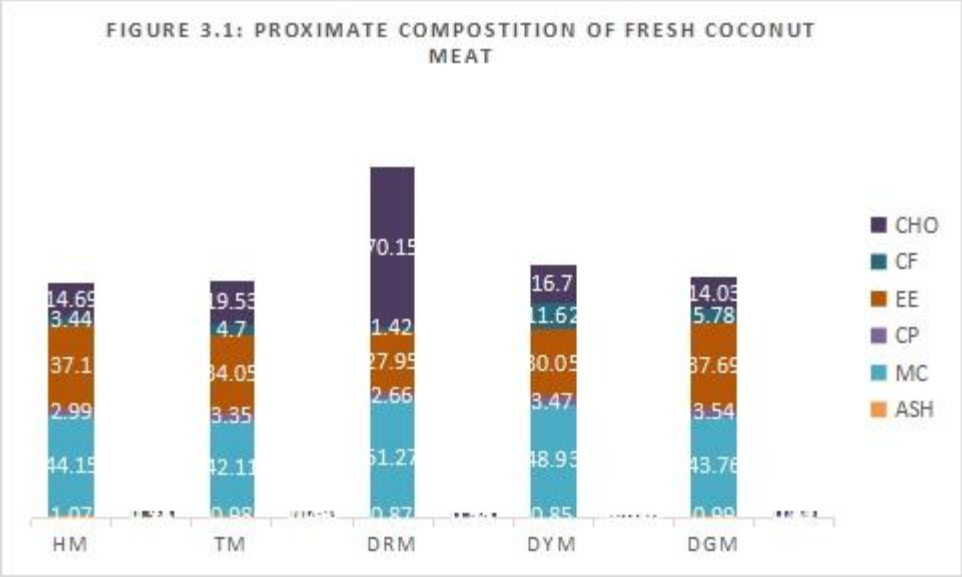
The considerably high fibre content in DY (11.62%) indicates that it could serve as a good source of dietary fibre, which may improve bowel functioning and reduce plasma cholesterol (Vuksan et al., 2011).

TABLE 3.1: PROXIMATE COMPOSITION OF FRESH COCONUT MEAT (%)

	ASH	MC	CP	EE	CF	CHO
HM	1.07 ± 0.11	44.15 ± 0.54	2.99 ±0.25	37.10 ±0.78	3.44 ±0.21	14.69 ±1.47
TM	0.98 ± 0.12	42.11 ± 0.21	3.35 ±0.45	34.05 ±0.60	4.77 ±.40	19.53 ±0.072
DRM	0.87 ± 0.21	51.27 ±0.57	2.66 ±0.25	27.95 ±0.08	1.42 ±0.19	17.15 ±0.18
DYM	0.85 ± 0.032	48.93 ±.014	3.47 ±0.033	30.05 ±0.007	11.62 ±0.65	16.70 ±0.013
DGM	0.99 ± .000	43.76 ±0.74	3.54 ±0.32	37.69 ±0.42	5.78 ±0.11	14.03 ±0.84

CP	Crude Protein		CF	Crude Fibre	
	ASH	Ash Content		CHO	Carbohydrate Content
	MC	Moisture Content		EE	Ether Extract

The moisture contents of the varieties are 43.76 % for DG, 44.15% for H, and 48.93% for DY with DR having the highest moisture content of 51.27% and T with the lowest moisture content of 42.11% respectively. The varieties have the following ash content, 0.98% (T), 0.87% (DR), and 0.99% (DG) with H having the highest ash content of 1.07% and DY with the lowest ash content of 0. 85%.



3.22 Mineral Composition

The mineral analyses of the various samples were shown in Table 3.2. Sodium, potassium, calcium, iron, copper, magnesium, zinc, chromium, and manganese were detected in both coconut meat and water. Cobalt was detected in all the coconut meat samples except TM. The sodium and potassium contents in both meat and water samples were the highest, followed by calcium and magnesium (6.70-55.70, 2.24- 33.50mg/100g) while others are less than 1mg/100g except zinc, which is between 1.49 and 2.74mg/100g respectively. Iron was not detected in DYW, DGW and DRW respectively while DYM has the highest level of iron (0.63mg/100g). Chromium was not detected in DRW, DRM and TM. The levels of trace metals (Cu, Co, Zn, Cr and Mn) are within the levels recommended for daily allowance (e.g., Mn: 3.8mg, Co:0. 008mg, Zn: l5mg, Cr: 0.6mg and Cu: 2.5-7mg) (Udousoro, 2017).

From table 3.2, it can also be seen that coconut water samples are richer in calcium content than coconut meat samples, especially DRW and HW (55.70mg/100g and 33.73mg/100g).

Figure 3.2: Mineral Composition of Fresh Coconut Meat and Water

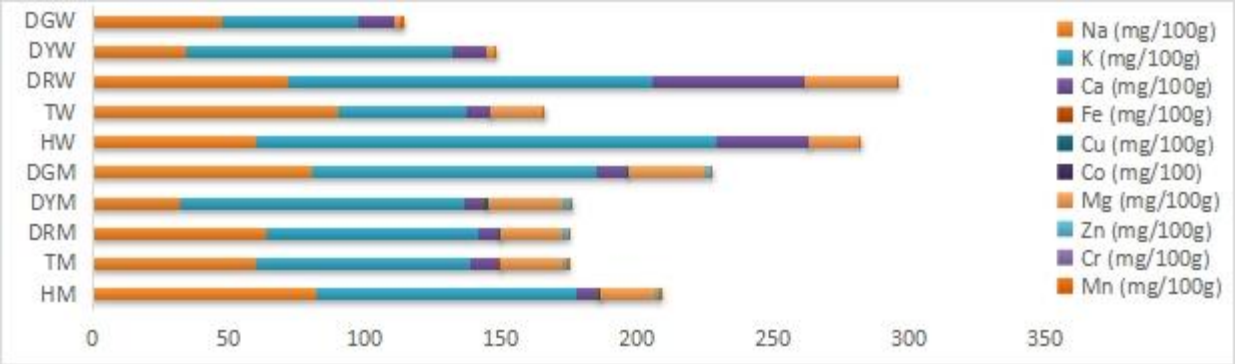


Table 3.2: Mineral Composition of Fresh Coconut Meat and Water

	Na	K	Ca	Fe	Cu	Co	Mg	Zn	Cr	Mn
SAMPLES	(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)	(mg/100g)
HM	82.03	95.46	7.4	0.425	0.59	0.025	20.28	1.6	0.013	0.55
TM	59.78	78.6	10.58	0.39	0.34	ND	22.28	1.49	ND	0.68
DRM	63.76	78.05	6.75	0.55	0.29	0.038	22.96	1.88	ND	0.98
DYM	31.91	104.16	7.20	0.63	0.95	0.013	27.28	2.75	0.025	0.88
DGM	80.35	104.16	11.01	0.4	0.49	0.025	28.33	1.76	0.063	0.75
HW	60.25	168.3	33.73	0.015	0.009	ND	18.49	0.026	0.018	0.25
TW	90.32	46.56	8.99	0.002	0.008	ND	18.82	0.01	0.011	0.26
DRW	71.77	133.67	55.7	ND	0.006	ND	33.5	0.019	ND	0.24
DYW	34.37	97.32	13.04	ND	0.002	ND	2.81	0.009	0.019	0.02
DGW	47.36	49.73	13.52	ND	0.009	ND	2.24	0.011	0.015	0.42

HM	Hybrid Meat	HW	Hybrid Water
TM	Tall Meat	TW	Tall Water
DRM	Dwarf Red Meat	DRW	Dwarf Red Water
DYM	Dwarf Yellow Meat	DYW	Dwarf Yellow Water
DGM	Dwarf Green Meat	DGW	Dwarf Green Water
ND	Not Detected		

CONCLUSION AND RECOMMENDATION

Generally, results of the proximate analysis of coconut kernel grown at NIFOR did not differ significantly across the varieties. The result has demonstrated that coconut meat and water are good sources of fat, protein, and essential minerals and these can serve various health and economic purposes. It can also be deducted from the result of the proximate analysis that the hybrid type sample has characteristics between that of the dwarf and tall varieties. All the coconut varieties have one or more unique properties attributed to each of them. For the production of oil, dwarf yellow coconut will be a good source, whereas dwarf green with the highest percentage of protein can be a good source of protein especially in regions of prevalence protein deficiency. Dwarf red contained the largest percentage of carbohydrate, therefore is a good source of energy.

RECOMMENDATION

Based on the result observed in the study, I would like to recommend that:

1. Coconut recipes should be encouraged in homes.
2. Mothers should be enlightened on the use of coconut water as the best therapy for dehydration and its drinking generally should be encouraged as a result of its high calcium content.
3. Planting of coconut trees should be encouraged in every home as a "tree of life".

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