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Original Research Article

Biochemical Evaluation of Nutrient-Complementary Components of Vitex Doniana (Black Plum) Relating to Health and Food Security

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ABSTRACT

Vitex doniana produces a commonly consumed fruit in many places where the tree grows. This wild fruit could contribute to nutrition and food security. Therefore, nutrients and phyto constituents of aqueous extract of the fruit were investigated to evaluate its benefit to consumers. Samples of the fruits were collected from Navrongo in the Upper East Region of Ghana for laboratory analyses. Calcium, potassium, phosphorus, magnesium, sodium, zinc and manganese, as well as vitamins A, C, and Beta carotene; crude fat, carbohydrates, proteins, fibre, ash, and energy contents were determined in the pulp. Oven determination of moisture content, and Atomic Absorption Spectroscopy determination of minerals were carried out. The other parameters were analysed using other appropriate standard methods. The study found that the fruit pulp contains flavonoids, phenols, alkaloids, terpenoids and saponins, as well as vitamins A, C, and β-carotene. The proximate compositions were 19.045% of moisture, 31.597% fat, 4.056% crude fiber, 0.698% crude protein, 4.234% ash, 36.610% carbohydrate, with a total energy of 448.283 kcal/100g. The pulp also had high levels of potassium (1422 mg/100g), calcium (350 mg/100g), magnesium (132 mg/100g) among others, and also trace levels of manganese (0.943 mg/100g), zinc (2.770 mg/100g). Copper was undetected. The fruit pulp of Vitex doniana has vital nutrients and vitamins that can complement other sources of nutrients, and contribute to food security and good health. It has potential for making valuable commercial juice. Comprehensive studies of wild fruits are recommended to generate policy on the fruits.

Keywords: Vitex Doniana, Fruit Extract, Nutrients, Vitamins, Phytochemicals

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INTRODUCTION

Vitex doniana is a deciduous tree, usually 4-8 m high, with some reaching a height of up to 15 m. It is a member of the common Vitex specie in West Africa and of the family Lamiaceae. It is one of the most abundant and widespread tree species occurring in woodland and savannah regions of tropical Africa [1]. The fruits Figure 1 and 2 are ellipsoid to oblong, up to 2.5 cm long, clasped by a calyx cup and green, turning black on ripening. The ripe black pulp has a sweet taste and is eaten raw. Both the skin and pulp are edible, but the skin is sometimes removed before consumption.

Figure 1. Ripe Vitex doniana fruit (Amadou, 2009)

Figure 2. Unripe *Vitex doniana* fruit (Emeline, 2013)

The fruit is commonly known as black plum. They are usually eaten as snacks either fresh or dried and have a velvet like texture [2]. It has a sweet flavour, and a syrup similar to honey has been made from the fruit and its physiochemical and sensory results showed that it can be substituted for other syrups as a nutritive sweetener [3]. Mostly children collect and consume the fruits but they are also eaten by adults during food shortage periods. Leaves, bark, roots and seeds of the tree are also used in traditional medicine in Africa to treat a wide range of ailments [4]. Some commonly found fruits produced in Ghana mainly for domestic consumption are pineapple, pawpaw, banana, mango, and citrus Figure 3. Some of these fruits have become major nontraditional exports through government policy that supported increased production to take advantage of the international, regional and domestic markets [5].

Figure 3. Fruits vending in Accra © Mohamed Ag Bendech. Downloaded on 08/08/2023

Some researchers have also indicated that there is insufficient implementation of food environment policies in Ghana, and that among others, there is need for evaluation to support policy infrastructure [6]. But edible wild plant fruits such as black plum could be important food items in the traditional diet of people making important contribution to the health of local communities. Black plum is an indigenous tropical fruit which could be highly cherished for its pulp. It could be beneficial to human health and nutrition as well as sustaining populations during food shortage [7]. In village communities of some countries, the fruit is sold by indigenes along major roads passing through the communities. In Africa, particularly the Sahel regions where drought and other weather-related calamities reduce traditional staple crop yield, wild fruits are gaining increasing importance [8]. Apples, pears and grapes are tropical fruits often not readily accessible to some populations beyond production time, especially in developing countries, due to their high cost or scarcity in the local markets [9]. Though some wild edible indigenous fruits have become complimentary sources of nutrients in most homes, *Vitex doniana* fruits have probably not been accorded the importance they deserve in diet [10]. There are some research works on the use of *Vitex doniana* in various applications, but much attention has not been given to the fruit in most countries. However, it is one of the most abundant and widespread tree species occurring in the woodland and savannah regions of tropical Africa [1]. Consequently, it was important to create awareness of the fruit and also explore the possible contribution of the fruit to nutrition. The current paper presents findings on analyses of proximate (moisture, ash, crude fiber, crude fat, crude protein, and carbohydrate content) composition; mineral (calcium, potassium, sodium, magnesium, phosphorus, zinc, copper, iron and manganese) content; vitamin C, vitamin A, beta

carotene; and secondary metabolites (flavonoids, phenols, tannins, saponins, phlobatannins, alkaloids, terpenoids, glycosides and anthraquinones) evaluation of the fruit pulp.

MATERIALS

Vitex doniana fruit pulp; AAS, flame photometer, spectrophotometer, glassware and analytical grade reagents and chemicals.

METHODS

Sample collection and identification

Fresh ripped Vitex doniana fruits that had fallen from the trees were collected from around C. K. Tedam University of Technology and Applied Sciences, Navrongo. The samples were identified and authenticated by a botanist in the Applied Biology department of the university and then used for all the analyses.

Sample preparation

The fresh fruits were first washed under running tap water to remove sand and other impurities, and further rinsed with distilled water. The clean fruits were then peeled manually to expose the sample (pulp) which was also removed manually into a clean container. The sample was then spread in a flat plastic pan to give it enough surface area to air dry under shade. It was then crushed and sieved with a stainless sieve. The sieved pulp was again spread to continue with the drying for 7 days when the moisture content reduced to minimum while the remaining particles were discarded. The dried pulp was then grinded into powder and stored in air tight container for laboratory analysis [3].

Proximate Analyses

Proximate composition was determined using some well-known procedures [11]; standard methods [12] were used for phytochemical analyses; vitamins were determined using a modified method from a standard method [13]; analysis of the mineral content was done according to standard procedures [13]; and phosphorus according to standard procedures [14].

Moisture

The weight of a pre-dried coded petri dish was taken. 5.0 grams of the sample was weighed and distributed over the base of the coded petri dish and taken through moisture loss treatments in the oven. The percentage moisture was calculated using equation 1.0.

$$\% \text{ moisture} = \frac{W3-W2}{W1} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 1.0$$

Where W_1 = weight of sample before drying, W_2 = weight of petri dish, W_3 = weight of sample and petri dish after drying.

Ash

The weight of an already ignited and cooled porcelain crucible was taken as W_1. 2.0 g of the sample was weighed into the crucible as W_2. With the help of tongs, the crucible was placed in a Vecstar muffle furnace at a temperature of 600 °C and left to ash for 2 h. After that, the ash was cooled in a desiccator to room temperature and weighed again as W_3. The ash was calculated as indicated in equation 2.0.

$$\% \text{ ash} = \frac{W3-W1}{W2} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 2.0$$

Crude fiber

Two hundred milliliters (200 ml) of 1.5% H_2SO_4 was measured and poured over 2.0 g of defatted sample in a flat bottom flask. The flask was then set on a hot plate and connected to a condenser. The content was timed at the onset of boiling. At the end of thirty minutes, the flask was removed, and the contents filtered through a linen cloth in a funnel. The pervert crude fibre was obtained by subtraction of the weight of the ash from the weight of the dried residue before ashing, using equation 3.0.

$$\% \text{ fiber} = \frac{W2-W3}{W1} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.0$$

Crude fat

Two (2.0) grams of the sample was transferred into a paper thimble plugged at the opening with glass wool and placed into a thimble holder. Petroleum ether (150 ml) was measured into a previously dried and weighed 250 ml round-bottom flask, and this was assembled together with the thimble holder and its contents. The Quick Fit condenser was connected to the Soxhlet

Extractor and refluxed for sixteen (16) hours at low heat on a heating mantle. After extraction the flask containing the fat was dried at 105°C in an oven for 30 minutes, cooled in a desiccator, and the weight of the fat collected was determined and expressed as percentage crude fat using equation 4.0.

% fat = $\frac{W3-W2}{W1-W0} * 100$…… 4.0

Weight of empty porous thimble = W_0, weight of thimble + ground powder = W_1, weight of ground powder = $W_1 – W_0$, weight of empty extraction flask = W_2, weight of extraction flask + oil = W_3

Crude protein

Two (2.0) grams of samples were put into digestion flasks and a half tablet of Selenium-based catalyst added and used to determine the crude protein. The nitrogen content was calculated first, and the crude protein content obtained from equation 5.0.

Nitrogen (%) = $\frac{TV*NA*0.014*DF}{volume\ of\ aliquot*weight\ of\ sample} * 100$

Where

NA= normality of acid used (0.01N), TV = titer value, DF = dilution factor; volume of aliquot =10ml

Crude Protein = Nitrogen % * 6.25 …….. 5.0

Carbohydrate

The carbohydrate content of the sample was determined by difference. It was calculated as indicated in equation 6.0.

Carbohydrate (%) = 100% - (% moisture + % fat + % protein + % ash + % fiber) …… 6.0

Energy

The Atwater factors were used to calculate the energy content of the sample. It was calculated as indicated in equation 7.0.

Total Energy (kcal/100 g)

= [(% available carbohydrates * 4) + (% proteins * 4) + (% fat * 9)] ……7.0

Qualitative Phytochemical Screening

40g of the dried sample was weighed and soaked in 160 ml of distilled water. The mixture was then kept at room temperature for 24 hr and then filtered twice; initially with a muslin cloth and repeated using a filter paper. The filtrate was evaporated to dryness at 45°C using an evaporator. The extract was then used for analyses of flavonoids, phenols, tannins, saponins, phlobatannins, alkaloids, terpenoids glycosides and anthraquinones content [12].

Vitamins Analyses

The vitamin C content was calculated from the expression in equation 8.0.

Vitamin C content (mg/ml) = titre value * concentration of sample ……..8.0

For Beta carotene and Vitamin A, one gram (1g) of sample was weighed into a test tube and 20 ml petroleum spirit was added and shaken for 5 minutes. The supernatant was decanted into another test tube and the absorbance read at 453, 505, 645, and 663 nm.

Concentration of beta carotene (µg/100 g)

$= (0.216 * A_{663}) – (1.22 * A_{645}) – (0.304 * A_{505}) + (0.452 * A_{453})$ …….9.0

Where A_x = Absorbance in x

Vitamin A was then calculated by converting beta carotene. Thus, multiplying beta carotene content by the conversion factor of 0.3, Vitamin A was calculated from equation 10.0.

Vitamin A (µg/100 g) = concentration of beta carotene (µg/100 g) * 0.3 ……10.0

Mineral content analyses

The minerals determined were calcium, potassium, sodium, magnesium, phosphorus, zinc, copper, iron and manganese.

Determination of iron (Fe), copper (Cu), zinc (Zn) and Manganese (Mn) was done using Atomic Absorption Spectroscopy and the prescribed calculation made according to equation 11.0.

$$\text{Conc. (Cu, Fe, Mn, Zn) (mg/kg)} = \frac{Connectration\ recorded\ from\ AAS * Nominal\ Volume}{Sample\ weight\ (g)} \quad \ldots.11.0$$

Where, Nominal volume =100 ml; Sample weight = 1.00 g

Phosphorus (P)

Treatments to determine phosphorus were according to standard procedures. The digested sample was placed in the Spectronic 20 spectrophotometer at 420 nm. The observed absorbance was used to determine the phosphorus content from the standard curve.

The percentage Phosphorus (% P) was calculated as indicated in equation 12.0.

Phosphorus content in 100 g sample (% P) = $\frac{C\ x\ df\ x\ 100}{1\ 000\ 000} = \frac{C\ x\ 1000\ x\ 100}{1\ 000\ 000} = \frac{C}{10}$ 12.0

Where;

C = concentration of P (µg /ml) as read from the standard curve;

df = dilution factor, which is 100 *10 = 1000, as calculated below:

[1 g of sample made to 100 ml (100 times); 5 ml of sample made to 50 ml (10 times); 1 000 000 = factor for converting µg to g]

Potassium (K) and Sodium (Na)

Potassium (K) and Sodium (Na) were determined using Flame Photometer according to standard procedures [13]. The measurements were applied in equation 13.0

Na content (µg) in 1.0 g of plant sample = C x df

K content (g) in 100 g plant sample, (% K,) = $\frac{C*df*100}{1000\ 000} = \frac{C*100*100}{1000\ 000} = \frac{C}{100}$ 13.0

Where

C = concentration of K (µg / ml), as read from the standard curve

df = dilution factor, which is 100 x1 = 100, calculated as:

[1.0 g of sample made up to 100 ml (100 times); 1000 000 = factor for converting µg to g].

Calcium (Ca) and Magnesium (Mg)

Calcium and magnesium were determined by EDTA titration which involved the addition of several reagents.

Calcium

5.0 ml of sample solution was transferred into a 100 ml Erlenmeyer flask and made into a mixture. The mixture was titrated with 0.02 N EDTA solution from red to blue end point.

Calcium (mg) = Titre value of EDTA x 0.4008, and percentage calcium was obtained through equation 14.0.

% Calcium = $\frac{mg\ calcium * 100}{sample\ wt. * volume}$ …….....14.0

Magnesium

5.0 ml sample solution was emptied into a 100 ml Erlenmeyer flask and eventually made into a mixture. The mixture was shaken to ensure homogeneity and was titrated with 0.02 N EDTA solution from red to blue endpoint.

Magnesium (mg) = Titre value of EDTA x 0.243, and percent magnesium obtained using equation 15.0.

% Mg = $\frac{mg\ Magnesium}{Sample\ wt\ x\ Volume} x\ 100$ ……15.0

RESULTS

Table 1. Proximate composition

Parameter	Percentage±SD (%)	kcal/100g±SD
Moisture	19.045 ± 0.041	
Fat	31.597 ± 0.105	
Crude fiber	4.056 ± 0.034	
Crude protein	0.698 ± 0.003	
Ash content	4.234 ± 0.031	
Carbohydrate	36.610 ± 0.043	
Solids	80.954 ± 0.041	
Energy		448.283 ± 0.847

Table 2. Vitamin C, A, and Beta carotene composition

Vitamin	Mean Mass±SD (mg/100 g)
Vitamin C	33.663 ± 0.009
Beta carotene	0.009 ± 0.630
Vitamin A	0.003 ± 0.190

Table 3.Mineral Composition

Elements	Mean Amount (mg/100g)
Phosphorus	161
Potassium	1422
Calcium	350
Magnesium	132
Sodium	42
Copper	ND
Zinc	2.770
Manganese	0.943
Iron	8.605

ND – Not detected

Table 4. Phytochemicals in the aqueous extract

Phytochemical	Present (+) / Absent (-)
Flavonoids	+
Phenols	+
Tannins	-
Phlobatannins	-
Alkaloids	+
Terpenoids	+
Glycosides	-
Saponins	+
Anthraquinones	-

DISCUSSION

Generally, the proximate content of the Vitex doniana fruit in this work was compared with those of thirty-six (36) fruits and vegetables indicated in a review publication on moisture and nutrients in drying food systems of a research work [15].

Proximate Composition

Proximate analyses revealed valuable results as represented in table 1. The moisture content of Vitex doniana fruit pulp was found to be 47% of the fresh wet sample, before it was air dried. After air drying the sample still contained a moisture level of 19.045 %. The sample had high moisture content than almost all the fruits and vegetables in comparison (21.6 - 0.013%), except cabbage

[15]. According to research [16], it is reported that, generally, moderate moisture content of a fruit is an indication that it can be stored for a long time without the development of moulds. However, high moisture content of a sample makes it ideal for fruit juicing. Nevertheless, in terms of natural product stability, high moisture content tends to promote microbial contamination, water activity, and chemical degradation as it provides a medium for microbial and many other reactions to occur. Ash content is the measure of total mineral content of a food [10]. The ash content of Vitex doniana in the current study was 4.234% of the dried sample. The ash content indicates that Vitex doniana fruit pulp has a sizable inorganic content. The results in table 3 suggests that the fruit could be a good source of dietary minerals. Ash contents of the 36 fruits and vegetable range from 19.9 to 0.40%, and that of the current sample is higher than 14 of those in comparison [15]. Crude protein content of Vitex doniana was 0.698%, which is considerably low compared to the levels in most of the fruits and vegetables (32.68 -0.06 %) in a review publication being compared with [15]. Compared to samples in the review, the protein content of the current sample is only higher than that of dried mango seed which had a content of 0.06%. Generally, proteins are found in smaller quantities in fruits making the fruits very suitable for consumption by the aged whose livers may not be able to digest high quantity of protein [3]. The crude fiber was found to be 4.056% of the fruit pulp which indicated the fruit as a good source of dietary fiber for humans. The level of fibre is higher than 16 of the 36 fruits and vegetables whose fibre content range was 73.52 to 0.60%. Crude fiber assist to avert bowel problems, piles and constipations. Scientific evidence show that adequate crude fiber intake has a number of health benefits including maintenance of health laxation and reduced risk of cardiovascular diseases, and cancer [17]. Lipid content of the 36 reviewed fruits and vegetables in a research work [15] ranged from 67.81 to 0.09%, while the crude fat in Vitex doniana fruit pulp was 31.597%. V. doniana has more fat than 16 of the 36 fruits and vegetables listed. This shows that, the fruit pulp has a considerably high amount of fat. The presence of fats in foods provide significant benefits to the human body. Fat functions as important depot for energy storage, offers insulation and protection, and plays important role in regulating and signaling. Dietary fats also increase the bioavailability of phytochemicals and non-essential plant compounds considered beneficial to human health. Many of these phytochemicals such as beta carotene found in some fruits, are fat-soluble, hence dietary fat improves the absorption of these molecules in the digestive tract [18]. Carbohydrates are one of the most important components in many foods and digestible carbohydrates are considered an important energy source

[19]. A constant supply of carbohydrate is necessary for proper functioning of the central nervous system, and glycogen present in the heart muscle is an important emergency source of energy for the heart [20]. The Vitex doniana fruit pulp had carbohydrate content of 36.610%, while the contents in the 36 reviewed samples were from 87.45 to 7.9%. The content in the current sample was higher than 10 of the reviewed samples. The result of a research [21] showed that the high carbohydrate content in many drupes is subject to their maturity, fruit type and the environment.

Vitamins Composition

The vitamins composition of Vitex doniana fruit pulp is presented in table 2. The Beta Carotene content of Vitex doniana fruit pulp in this study was 9.469 µg/100g (equivalent to 0.0095mg/100g) which is less than the value of 0.89 mg/100 g obtained in Vitex doniana leaves in a study [22]. In order to acquire enough Beta Carotene from the fruit, one must take a sizable amount of the fruit. Beta Carotene is invaluable for the promotion of growth of cells and tissues, and resistance to diseases. It is also important for maintenance of eyes, skin, nails and hair health. The RDA requirement for Beta Carotene for a normal healthy, active adult man and non-pregnant woman is 0.3 mg per day and 0.27 mg per day respectively [23]**.** From the results, Vitamin C content was 33.663 mg/100g which is lower than 35.58 mg/100 g obtained in a particular study [10], and also lower than the RDA value (60 mg/100 g) for adults [24]. Vitamin C is a potent antioxidant that facilitate non-haeme iron transport and uptake at the intestinal mucosa. It also aids in the purification of blood [23]**.** A research work [25] indicated that sun drying of foods could lead to loss of nutritional content especially vitamin C. But the sample in the current study was dried at room temperature to minimize loss of nutrients. The level of vitamin A obtained in the current study (0.00028 mg/100 g) is extremely lower than the result obtained by some research work [10], 0.27 mg/100g. Vitamin A is a relatively heat stable and fat-soluble vitamin needed in every part of the human body. Although its content in the fruit is relatively small, enough intake of the fruit can help alleviate Vitamin A deficiencies.

Mineral Composition

Table 3 shows the mineral composition of Vitex doniana fruit pulp. Calcium is a component of bones and teeth and is necessary for blood clotting and muscle contraction. Calcium content of the fruit pulp was 350 mg/100g which is higher than that from the same fruit reported from Nigeria

[26]. The difference would probably be due to influences by different environmental and geological factors. Availability of calcium in the body is required for critical biological functions such as blood coagulation and structural support of the skeleton. Adequate intake of calcium has been demonstrated to reduce the risk of chronic diseases such as osteoporosis, hypertension and others [27]. Magnesium is an important element in circulatory systems and calcium metabolism in bones [10]. Magnesium was found to be 132 mg/100g in the current work which is higher than 124 mg/100g reported in some Nigerian samples [26]. Magnesium is required for nucleic acids, reproduction and protein synthesis. The Vitex doniana fruit pulp would therefore be an important source of magnesium which is very essential to the human body. Sodium was found to be 42 mg/100g and lowest among the minerals that were analyzed. The sodium content was higher than 10.40 mg/100g obtained by some research work [10] in Vitex doniana from Burkina Fasso. Sodium plays a key role in the maintenance of body fluid composition, especially water content. Its interaction with potassium is important for maintenance of proper acid-base balance as well as the transmission of nerve impulse. Balance of Sodium and Potassium is also of significant importance to hypertension management as it relates pressure and development of hypertension. The RDA requirement for sodium is 1500 mg and 2300 mg per day respectively for normal healthy male adults and female non-pregnant adult between 19 to 50 years. Low sodium content found in the fruit in this study shows that the fruit can be consumed by hypertensive patients as this could keep the sodium level in the body low [23]. Potassium content in the Vitex doniana fruit pulp was 1422 mg/100g which makes Potassium the most abundant mineral in the fruit pulp. Potassium is the major cation in intracellular fluid and function in the maintenance of weight, regulation of acid-base balance, conduction of nerve impulse and muscular contraction, especially the cardiac muscles. It also plays a vital role in the transfer of phosphate from adenosine triphosphate to pyruvic acid. Vegetables, fruits and nuts tend to contain many times more potassium than sodium and the result of this study affirms that. The RDA for potassium for both normal healthy males and non-pregnant females between the ages of 19 and 50 years is 4700 mg per day. The range of potassium content reported in the study shows that the fruit pulp may be a reasonable potassium source for healthy living capable of providing about 1410 mg of RDA of the mineral [23]. Phosphorus content of the sample was 161 mg/100g, far high compared to the value obtained in samples from Burkina Fasso [10] which was 16.50 mg/100g. Phosphorus is concerned with many metabolic processes involving body fluid buffers, maintenance of normal kidney function as well

as transfer of nerve impulses. According to research [10], for good calcium absorption to occur, calcium-phosphorus ratio must be 1:1. The calcium-phosphorus ratio of the fruits in the current study is approximately 2:1 respectively which indicates that the fruit should be consumed alongside food of high phosphorus source to balance calcium consumption. The RDA requirement for phosphorus in both adult males and non-pregnant females is 700 mg per day [23]. The sample iron content was 8.605 mg/100g which is higher than 5.20 mg/100g reported by a research work [10]. The fruit has a good amount of iron; hence its consumption should be encouraged in menstruating and lactating women since iron plays a role in hemoglobin formation and oxygen transportation [28]. Considering the common occurrence of iron deficiency of people [29], the fruit is recommended to supplement diets. Zinc was found to be 2.770 mg/100 g in the Vitex doniana fruit pulp. Zinc is an essential trace mineral for cell division, and synthesis of DNA and proteins. It is also critical for tissue growth, wound healing, blood clotting, fetal growth and sperms production. Therefore, intake of Vitex doniana fruit is recommended for infants, children, lactating mothers, and pregnant women since they all have high requirement for zinc [30]. Manganese content was 0.943 mg/100 g in the fruit sample. Manganese plays an essential role in regulation of cellular energy, bone and connective tissue growth, as well as blood clotting. It is also an important cofactor for a variety of enzymes including those in neurotransmitter synthesis and metabolism. Small amount of manganese is required for brain development, cellular homeostasis and for the activity of multiples of enzymes [30]. Vitex doniana fruit is therefore important for everyone as it avails substantial amount of these vital mineral.

Qualitative Phytochemical Composition

Results of qualitative phytochemical screening of aqueous extract of Vitex doniana fruit pulp Table 3 indicated the presence of flavonoids, phenols, terpenoids, alkaloids and saponins. Phlobatannins, tannins, glycosides and anthraquinones were absent in the extract. Presence of these metabolites suggests great potentials of the fruit as a source of useful phyto-remedial effects. Food phenolic compounds, particularly flavonoids are known to play important role in human health. The presence of flavonoids indicates the possible role of the fruit as an anti-inflammatory agent as some flavonoids have anti-inflammatory effects on acute and chronic inflammation, and anti-cancer, and anti-allergy effects. The presence of flavonoids in the fruit also account for anti-oxidant properties which have the potential to protect cells and other tissues in the body from harmful

effects of oxygen radicals [12]. Isoflavonoids such as phytoestrogens have a wide range of hormonal and non-hormonal activities in animals or in vitro, suggesting human health benefits in diets rich in these compounds [31]. Saponins, also present in the fruit extract, are glycosides that occur primarily and not exclusively in plants. Saponins comprises a large family of structurally related compounds containing steroids or triterpenoid aglycones (sapogenin) linked to one or more oligosaccharide moieties [32,33]. Saponins in fruits are believed to have antioxidant, anti-cancer, anti-inflammatory and anti-viral properties. They serve as innate antibiotics that help humans fight pathogenic microorganisms and increase the efficacy of certain vaccines. They are also able to knock out some cancer cells, especially those from the blood and lungs. These compounds are also able to reduce levels of cholesterol and bile acids by forming complexes. They have therefore been found to be useful in the management of hypercholesterolemia [12]. Terpenoids are a large, diverse class of hydrocarbons or organic compounds made by various plants. Terpenoids have many desirable properties for use in pharmaceuticals, food, and cosmetics among others. They also possess antitumor and antimalarial effects, promote transdermal absorption, prevent and treat cardiovascular diseases and have hypoglycemic activities [34]. Synthetic variations and derivatives of natural terpenoids and terpenes greatly expand the range of flavours used in food additives and aroma used in perfumery [35]. Terpenoids often have a strong odour and may protect the plant that produce them by attacking predators and parasites that attack plants. They are valuable active ingredients as part of natural agriculture pesticides. Although, the name is occasionally used interchangeably with terpenes, terpenoids are modified terpenes as they have additional functional groups, often oxygen-containing. They are major constituents of turpentine, and rosin produced from resin. They are also biosynthetic building blocks of important compounds such as steroids which are from squalene. Terpenoids and terpenes are the primary components of essential oils of various types of flowers and plants. Vitamin A is also a terpenoid. Alkaloids also present, have various pharmacological effects such as anti-malaria, anti-cancer, antiasthma, vasodilatory, analgesic, and antihyperglycemic activities. They also possess stimulant and psychotropic activities and have been used as recreational drugs. Alkaloids act on a large variety of metabolic systems in humans, and they all nearly uniformly evoke a bitter taste [34].

CONCLUSION

The biochemical evaluation of Vitex doniana fruit pulp from Ghana has found that it contains good levels of macro and micro nutrients such as carbohydrate, crude protein, and crude fat levels at 36.610±0.043, 0.698±0.003, and 31.597±0.105 % respectively, as well as good amount of minerals. The appreciable levels of ash (4.234±0.031), crude fibre (4.056±0.034) attributes good nutritional value of the fruit, and its low protein level could be useful for special diet consumers, while the low moisture content (19.045±0.041) when dried suggests that the fruit can be stored for a long period of time with minimal deterioration. The fruit can serve as a good source of energy because of its high carbohydrate, protein, and fat contents. The high ash content indicated the fruit as a good source of minerals and this was confirmed in the results of the mineral content. There were good levels of the valuable minerals with levels ranging from 8.605 mg/100g (iron) to below detectable level of copper, and other frequently occurring minerals in larger amounts, such as 1422 mg/100g of potassium and 132.00 mg/100g of magnesium. The fruit was also found to contain appreciable levels of vitamins A and C, and as well as carotene. Flavonoids, phenols, alkaloids, terpenoids and saponins were also present, but glycosides, tannins, phlobatannins and anthraquinones were not found in the samples. The fruit can contribute to nutrition, food security, and also has some health benefits. Vitex doniana could be a recommendable nutrient supplementary source considering the amounts and diversity of nutrients it contains. Analyses for adverse components to health are required to be investigated to enable its recommendation or otherwise for commercialization.

RECOMMENDATION

Further work on food safety related analyses of the fruit will be useful.

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