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# Nutraceutical and Health Benefits of Two Underutilized Leafy Vegetables (*Pterocarpus santalinoides* and *Napoleona imperialis*)

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author NNU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JIO and AIA managed the analyses of the study. Author NNU managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

The aim of this study was to evaluate the nutritional and health implication of *Pterocarpus santalinoides* (*Uturukpa*) and *Napoleona imperialis* (*Mkpodu*) leaves. The vegetables were harvested from the forest in Udi Local Government area in Enugu State and identified at Department of Agronomy, Enugu State University of Science and Technology, Enugu, Nigeria. The vegetables were trimmed and washed with deionized water and drained. The vegetables were ground using hammer mill into paste separately and coded as sample A (*Pterocarpus santalinoides*) and sample B (*Napoleona imperialis*). Both samples were analyzed in the laboratory for proximate, vitamins, minerals, anti-nutrients and phytochemicals. The results were analyzed statistically using mean and standard deviation. The result showed that the proximate composition (on wet wt. basis) of sample A and B were protein 1.06 and 5.27%, fat 0.98 and 0.71%, fibre 0.90 and 1.01%, ash 2.73 and 1.27% and carbohydrate 30.63 and 23.54% respectively. The vitamin constituents were beta carotene 360.00 and 360.00 µg/100 g, vitamin C 5.20 and 7.13 mg/100 g

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and vitamin E 2.80 and 1.45 mg/100 g for sample A and B respectively. The result of the minerals were iron 3.49 and 1.40 mg/100 g, zinc 0.92 and 2.10 mg/100 g, calcium 36.00 and 25.60 mg/100 g, magnesium 20.01 and 25.20 mg/100 g and potassium 11.27 and 70.92 mg/100 g for sample A and B respectively. The result of the pyhtochemicals revealed that both leaves contained an appreciable amount of phytochemicals which are component of herbs use for ethnomedicine. The anti-nutrients in sample A and B were cyanide 0.48 and 0.94%, oxalate 1.08 and 3.87% and phytate 0.25 and 6.01% respectively. The high protein, fibre and mineral content of *Napoleona imperialis* is of interest, hence these lesser known vegetables are recommended due to its high nutritional content and health benefit.

*Keywords: Nutritional; health; underutilized; Pterocarpus santalinoids; Napolena imperialis; vegetables.*

## 1. INTRODUCTION

The number of chronically undernourished people in the world remains stubbornly high, amounting to 850 million people [1]. Half of the world or nearly three billion people live on less than two dollars a day. These conditions have caused over one billion children (more than half of those living in developing countries) to suffer from the severe effects of poverty and 674 million (over a third) are living in conditions of absolute poverty [1]. United Nations Food and Agriculture Organization [1] has widely noted that most widespread and debilitating nutritional disorders, like birth defects, mental and physical retardation, weakened immune systems, blindness and even death has resulted from poor fruits and vegetables consumption habits [2].

Vegetables and fruits play a significant role in food security of the underprivileged in both urban and rural settings [3]. They can serve as primary foods or secondary condiments to dishes prepared from other foods. They are also valuable sources of energy and micronutrients in the diets [4]. Green leafy vegetables occupy an important place among the food crops as these provide adequate amounts of vitamins and minerals for human [5]. They are rich source of carotene, ascorbic acid, riboflavin, folic acid and minerals such as calcium, iron and phosphorus [6]. Indigenous leafy vegetables represent inexpensive but high quality nutritional sources for the poor segment of the population, especially where malnutrition is widespread [7].

Underutilized species are those species with underexploited potential for contributing to food security, health (nutritional /medicinal), income generation and environmental services [8].

The low consumption of vegetables globally is responsible for the increased incidence of cardiovascular diseases as well as some cancers; the two leading causes of death worldwide. The World Health Organization (WHO) estimated that low vegetable consumptions contribute to approximately 2.7 million deaths per year from chronic diseases, 11% of cardiovascular accidents (CVA) and 31% of Ischemic Heart Diseases (IHD), worldwide [9]. Low consumption of vegetables has also been ranked the sixth major risk factor for mortality in the world. The incidences of these chronic diseases are also increasing in developing countries, largely due to their life style and dietary change [6].

Since low consumption of green leafy vegetables is one of the major factors that lead to deficiency of many nutrients, an attempt will be made to conduct preliminary assessment of the nutritional value of two underutilized green leafy vegetables in order to enhance better food selection and consequently improve the nutritional status of both the rural and urban dwellers.

*Pterocarpus santalinoides* is one of the species of tree in the legume family of *Fabacea*. It is a native to tropical western Africa and also to South America [10]. *Pterocarpus santalinoides* leaf contained ash 6.50%, moisture 9.0%, crude fibre 40.50%, protein 8.85%, fat 2.35% and carbohydrates 32.80% [11]. The plant leaves is rich in bioactive substances such as alkaloid (2.64%), flavonoid (2.0%), tannin (1.52%), Saponnin (2.5%), terpens (2.6%), cardiac glycoside (2.5%) and Steroid (1.82%) [12].

*Napoleona imperialis* a *Lecythidaceae*, belongs to the family known as the *lecythidaceae* [13]. Different tribes in Nigeria have different names for *N. imperialis*. For instance, the plant is known as “nnekeloche or abakalabak or “utim” or ovurumgbede or akbodo” by the Igbos of Southeast, “irosun-igbo orbongibongi or “boribori”

by the Yorubas in Southwest, “ukpakonrisa” by Edos, “otukuch by Igalas and “mabungi” by Hausas of Northern Nigeria [14]. *Napoleona imperialis* has moisture content of 87.5%, protein 1.5%, crude fibre 1.0%, ash 0.35%, carbohydrate 9.9%, crude fat 1.0%, total sugar 2.5%, potassium 13 mg/100 g and sodium 15 mg/100 g [15].

## 2. MATERIALS AND METHODS

The vegetables were obtained from the forest in Udi Local Government area in Enugu State and identified at Department of Agronomy, Enugu State University of Science and Technology, Enugu, Nigeria.

### 2.1 Sample Preparation

The fresh leafy vegetables of *Pterocarpus santalinoides* and *Napoleona imperialis* were plucked and handpicked to remove extraneous materials. They were washed with deionized water and drained. The vegetables were ground using hammer mill into paste and used for analysis.

### 2.2 Chemical Analysis

#### 2.2.1 Moisture determination

The moisture content of the samples was determined using the air oven method of AOAC [15].

#### 2.2.2 Protein determination

Crude protein content of the samples was determined using the automated micro-Kjeldahl method as described by AOAC [15].

#### 2.2.3 Fat determination

The fat content was determined using the Soxhlet extraction method [16].

#### 2.2.4 Crude fibre determination

The crude fibre content of the samples was determined according to the procedure of AOAC [15].

#### 2.2.5 Ash determination

The ash content was determined according to the procedure of AOAC [15].

#### 2.2.6 Carbohydrate determination

Carbohydrate content was calculated by difference. The estimated percentages of crude protein, ash, fat, fibre and moisture was summed up and the value subtracted from 100%.

CHO = 100% - % (protein + fat + ash + fibre + moisture).

#### 2.2.7 Mineral determination

The mineral contents, namely: Na, K, Ca, Mg, Cu, Mn, Hg and Pb contents were determined by the method described by Pearson [16] using a Pye Unicam SP9 Atomic Absorption Spectrophotometer (AAS) connected to an SP9 computer (Pye Unicam Ltd, York Street, Britain). Total phosphorus was determined by the spectrophotometric molybdovanadate [16].

#### 2.2.8 Determination of ß-carotene

The extraction of carotenoids was carried out according to the method of Seo et al. [17] with slight modifications.

**Fig. 1. *Pterocarpus santalinoides* leaves**

**Fig. 2. *Napoleona imperialis* leaves**

#### 2.2.9 Determination of vitamin E profile

Vitamin E content was analysed by the method described by Burri [18] using High performance liquid chromatography (HPLC).

#### 2.2.10 Vitamin C determination

Vitamin C determination by iodine titration as described by Anne Helmenstine was carried out [16].

### 2.3 Phytochemical Screening

A small portion of the extract was subjected to the phytochemical test using Traese and Evans [19] and Harbourne [20] methods to test for alkaloids, flavonoids, saponins, lycopene, phenol and cardiac glycoside. The Folin-Denis Spectrophotometer method was used to determine the tannin content of the foods. The method was described by Pearson [16].

#### 2.3.1 Anti-nutrient determination

Cyanide was determined by Wang and Filled method [21]. Phytate was determined from duplicate samples of food using diluted HCL [22]. Oxalate determination was carried out as described by [23].

### 2.4 Statistical Analysis

All the analysis reported in this study was performed in triplicates and data obtained is reported as mean ± standard deviation using SPSS version 23.0.0 [24].

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate Composition

The result obtained from proximate analysis of the leaves of *Pterocarpus santalinoides* (sample A) and *Napoleona imperialis* (sample B) shows that vegetables are not good sources of protein. The protein content was 1.06 and 5.27% with sample B having higher protein content compared to that of sample A. These values agreed with 0.2 and 1.4% of protein reported by Kalu et al. [25] on *Ficus capensis*. However, sample B had a protein content of 5.27%. Eyo et al. [26] observed that the protein levels of some vegetables are comparable to those of cereals (7.90%). Their protein content makes their leaves suitable for consumption as well as necessity for body growth and development. The protein value of *Napoleona imperialis as* observed in this study confers on them the advantage as a rich source of vegetable protein over some vegetable such as *Pterocarpus santalinoides* (1.06%). Consumption of *Napoleona imperialis* is important in fighting kwashiorkor in a community where protein energy deficiency is endemic. *Napoleona imperialis* with high level of protein can also be used as dietary supplement for protein. The value of the fat for the leaves of the two samples; A (0.98%) and B (0.71%%) studied were lower when compared to those of *Pterocarpus santalinoides* (3.33%) [27] and *Napoleona imperialis* (4.93%) reported by Uchegbu et al. [28]. Dietary fat functions in the increase of palatability of food by absorbing and retaining flavours. The low fat content of this vegetables are imperative since high fatty foods are associated with cardiovascular diseases such as cancer, high blood pressure and obesity. Sample A and B have 0.90% and 1.01% crude fibre which is higher compared to 0.02% in *Napoleona imperialis* vegetable as reported by Etim et al. [29]. A number of studies have indicated that components of plants such as dietary fiber have beneficial effects in lowering blood cholesterol levels aside from the decreased intake of saturated fat and cholesterol that occurs with high intakes of plant foods [30]. Fibre cleanses the digestive tract, by removing potential carcinogens from the body and prevents the absorption of excess cholesterol [30]. The values for ash content of the leaves was higher in sample A (2.73%) compared to sample B (1.27%).

The ash content of these leaves are lower than (3.82%) ash of some leafy vegetables commonly consumed in Nigeria [28]. Ash is an indication of minerals in food. Food with high ash is said to possess high mineral constituents. Sample A (63.70%) had lower moisture content compared to sample B (68.20%). The result of this study is lower than the value 84.3-94.7% reported by Grivet and Ogle [4] on leafy vegetables studied. The high moisture content of vegetables indicates freshness and perishability, as well as indicating that they may play a key role in aiding the digestion of food. Total carbohydrate was most abundant (30.63%) in sample A compared to sample B which had the least carbohydrate content (23.54%). Compared with other vegetables reported by [11] with 32.80% and Etim et al. [29] with 63.44%, the carbohydrate content of these vegetables in this study is relatively low. Carbohydrates are essential nutrients required for adequate diet. Vegetable

are poor sources of dietary carbohydrates and so recommended to patient with low need for dietary carbohydrate and energy.

## 3.2 Minerals

The potassium content were 11.27 and 70.92 mg/100 g. Potassium was least in sample A (*Pterocarpus santalinoides*) but higher in sample B (*Napoleona imperialis*). These values were higher than the result obtained by Aja et al. [31] that reported a range of 3.8-20 mg/100 g for some local vegetables. Potassium is the major cation in intracellular fluid and functions in the maintenance of weight, regulation of acid-base balance, conduction of nerve impulse, muscular contraction (especially of the cardiac muscle), correct functioning of the cell membrane, regulation of the sodium-potassium adenosine triphosphatase (ATPase) system and the maintenance of fluid volume [32]. It also plays a vital role in the transfer of phosphate from adenosine triphosphate to pyruvic acid. The metabolism of potassium is regulated by the hormone, aldosterone. Vegetables, fruits and nuts tend to contain many times more potassium than sodium and the results of this study provide proof of this. According to Institute of Medicine [33] the Recommended Daily Allowance (RDA) for potassium for both normal healthy males and non-pregnant females between the ages of 19 and 50 years is 4700 mg/day. The range of potassium content reported in this study shows that the vegetables may be capable of providing about 0.24% and 1.51% of RDA for healthy living. The result of sodium content ranged from 1.20 to 2.33 mg/100 g. This range of values is low compared to the range of values obtained by Alaekwe and Mojekwu [34] that had 15 mg for *Napoleona imperialis*. The lower sodium content obtained could be due to the age of the samples used. Sodium plays a key role in the maintenance of body fluid composition, especially water content. Its interaction with potassium is important for the maintenance of proper acid-base balance as well as in the transmission of nerve impulses [35]. Variation of sodium and potassium is of significant importance to a hypertensive patient as it enhances blood pressure. This blood pressure enhancement leads to the development of hypertension [36]. The RDA requirement for sodium is 1500 mg and 2300 mg/day for normal healthy male adults aged 19 to 50 years and female non-pregnant adults aged 19-50 years respectively [36]. The low sodium content reported for the vegetables in this study show that they can be consumed by hypertensive patients as they can keep body sodium levels low.

The result of calcium content of both leafy vegetables (36.00 and 25.60 mg/100 g for sample A and B respectively) analyzed is relatively high when compared to the range of values (0.08 to 0.18 mg/100 g) obtained by Agbaire [32] for some local vegetables in Nigeria. The variation could be due to the soil nature. The calcium content of sample A (*Pterocarpus santalinoides*) with the value of 36.00 mg/100 g is relatively higher than that of sample B (*Napoleona imperialis*) with the value of 25.60 mg/100 g in this study. Calcium plays a vital role in the development and sustenance of strong bones and teeth (especially in foetus, infants, children, and the elderly), regulation of muscular contraction and relaxation, regulation of nerve function and absorption of cyanocobalamin (vitamin B12). Calcium may therefore be useful in the prevention of osteoporosis in the elderly [37]. It also plays a key role in the coagulation of blood as it activates the process leading to the conversion of prothrombin to thrombin. The result of phosphorus content of sample B was 220.91 mg/100 g but was not detected in sample A. This value in sample B is very high when compared with the range of values obtained by Agbaire [32] for some local vegetables (3.4 to 4.7 mg/100 g). However, phosphorus content variation could be due to age and the soil nature. Phosphorus is concerned with many metabolic processes including those involving body fluid buffers, maintenance of normal kidney function as well as in the transfer of nerve impulses [38]. Like calcium, phosphorus also plays a key role in strengthening bones and teeth and in the maintenance of muscle growth [38]. According to Eze et al. [39], for good calcium absorption to occur, calcium-phosphorus ratio must be 1:1. The average calcium-phosphorus ratio for the leaves of the vegetables analyzed in this study indicates that diets containing these vegetables may need to be supplemented with other calcium and phosphorus sources. This is backed up by the fact that RDA requirement for phosphorus in both adult males and non-pregnant females is 700 mg/day [38]. Result of magnesium content was lower in sample A (20.01 mg/100 g) than sample B (25.20 mg/100 g). The magnesium content in this study was higher than the value obtained by Eze and Unachukwu [38]; [k/=k] for *Napoleona imperialis,* (9.85 mg/100 g). This may be due to harvesting stage, seasonal variations, soil differences and differences in methods used

in analysis. The magnesium status of the body is greatly influenced by the health of both the digestive and renal systems. Any disorder of the gastro-intestinal tract that impair absorption processes, such as Crohn's disease, can limit magnesium absorption by the body leading to depletion in body magnesium stores which could, in extreme cases, lead to chronic magnesium deficiency which may include symptoms like erythemia, hyperaemia, neuromuscular hyper-irritability which increases if the deficiency is unchecked and may be accompanied by cardiac arrhythmia and generalized tremours [40]. Magnesium deficiency can be prevented by consumption of magnesium rich diets as well as supplementation of diets with magnesium if the diets are poor in magnesium content [40]. The copper contents were (0.21 mg/100 g) and (0.60 mg/100 g) for sample A (*Pterocarpus santalinoides*) and sample B (*Napoleona imperialis*) respectively.

Copper contributes in hemoglobin formation, red blood cells in iron and energy metabolism [41]. It also helps in elastin formation, a vital skin protein that helps to keep skin healthy and flexible, also helps in collagen formation, another vital protein for building bones, muscles, and connective tissues. It is needed to maintain healthy nerves and joints. It is not necessary to supplement this mineral as excessive copper intake can lead to toxicity. Toxic levels of copper can cause vomiting, joints and muscle pain, and with extreme overdosing it can even be fatal [42]. These values are similar to those obtained from other study for *Pterocarpus santalinoides* (0.38 mg/100 g) [43]. The RDA of copper is 0.9 mg/day which indicates that the vegetables studied, when taken in adequate amounts can meet the RDA of copper [41]. The result of the zinc content of the studied vegetables, sample A (0.92 mg/100 g) and sample B (2.10 mg/100 g) are lower than the value 3.61 mg/100 g reported for *Pterocarpus santalinoides* [43]. Zinc supports healthy immune system, helps in wound healing, synthesis of DNA and maintenance of sense of taste. It also helps in normal growth and development during pregnancy, childhood, and adolescence. It is essential for growth and sexual development in man [44] and important in cell proliferation and protein synthesis [45]. The RDA of zinc for children (1–3 years) is 3.0 mg/day [44]. Zinc supplementation reduces the effect of diarrhea. Iron content of sample B (*Napoleona imperialis*) with the value of 1.40 mg/100 g was lower than that of sample A (*P. santalinoides*) (3.49 mg/100 g). Iron plays numerous biochemical roles in the body, including oxygen binding in hemoglobin and acting as an important catalytic centre in many enzymes such as the cytochrome oxidase [46]. The RDA for iron is 8 mg/day indicating that the studied vegetable could be recommended in diets for reducing anemia, which affects over one million people worldwide [41]. Manganese content of sample B (*Napoleona imperialis*) was 4.30mg/100 g and was not detected in sample A (*P. santalinoides*). The value obtained in sample B compared well to the report from *Napoleona imperialis* (7.401 mg/100 g) by Eze and Unachukwu [38] and higher than the RDA for manganese (1.8 mg/ day) showing that *Napoleona imperialis* are rich sources of manganese, which is a component of several metalloenzymes e.g., superoxidase dismutase.

## 3.3 Vitamins

The beta carotene content of the vegetables analyzed was 360.00 and 347.00 µg/100 g for sample A and B respectively. There was higher beta carotene in sample A than that of sample B. Beta carotene content of *Pterocarpus santalinoides* and *Napoleona imperialis* in this study were higher than the value obtained by Kawade [43] for *Pterocarpus santalinoides* (2.91 µg/100 g). Beta carotene is invaluable for the promotion of growth of cells and tissues, resistance to diseases and for delaying the ageing process. It is also important for the maintenance of eye, skin, nails and hair health. The RDA requirement for Beta carotene for a normal healthy, active adult man and non-pregnant woman is 0.3mg/day and 0.27 mg/day respectively [41]. The beta carotene content for vegetables in this study suggests that the vegetables may be capable of providing adequate levels of beta carotene for healthy living. Vitamin E content were from 1.45 and 2.80 mg/100 g with sample A having the higher vitamin E content than that of sample B. This range was similar to that obtained by [47] for *Napoleona imperialis* which was 2.02 mg/100 g. According to FAO [48] the RDA requirement for vitamin E is 10 mg/day for normal healthy adult men between the ages of 19-65 years while that of adult non-pregnant women within same age range is 7.5 mg/day. Vitamin E is a very potent antioxidant that helps to protect body cells from damage due to reactive oxygen species. It is very important for the formation and normal function of erythrocytes and muscles [49]. Results showed that vitamin C content were 5.20 and 7.13 mg/100 g, which is lower when

compared to the values for vitamin C obtained by Agiang et al. [27] for *Pterocarpus santalinoides* (59.03 mg/100 g). These results were, however, relatively low when compared to the vitamin C content reported by Edeoga et al. [50] for some Nigerian vegetables (10 to 76 mg/100 g). Vitamin C is a potent antioxidant that facilitates non-haem iron transport and uptake at the intestinal mucosa, the reduction of intermediates of folic acid as well as the synthesis of cortisol. It also aids in the purification of blood [36]. The recommended daily requirement for Vitamin C according to FAO [41] is between 45.83 mg/day to 68.50 mg/day for both male and female adults between the ages of 19 to 65 years. Furthermore, the availability of reasonable amounts of vitamin C in the vegetables in this study provides a new source of antioxidants required for the maintenance of health and the prevention of conditions such as stress and prostate cancer [36]. Since the wild vegetables in this study are often consumed in their cooked forms, losses of micronutrients such as vitamins may occur. Loss of vitamins due to cooking may depend largely on cooking time, temperature and cooking method. Some vitamins are quite heat stable while others are heat labile. For example, fat soluble vitamins such as vitamins A and E are relatively heat stable while water soluble vitamins such as vitamin C and B6 are heat labile and so are susceptible to loss on exposure to heat [36].

## 3.4 Anti-nutrients

Oxalate content of sample A (*Pterocarpus santalinoides*) with the value of (1.08%) and sample B (*Napoleona imperialis*) with the value of 3.87% are higher than those reported for the leafy vegetables studied in Nigeria (0.88%) [27] but lower than the critical value of oxalate consumption (2.0%–5.0%) reported by WHO [51]. This indicates that the oxalate level of the tested plant may not cause kidney disease, which is associated with the consumption of food high in oxalate. Phytate content was observed to be 0.25 and 6.01% for A and B respectively. These values were in line with the findings of Agiang et al. [27] that had 7.17%. According to Dias [36], a diet containing phytate in the range of 1-6 mg/100 g for a long period of time tends to decrease the bioavailability of mineral elements in mono-gastric animals. Studies shows that phytate had been linked to the prevention of kidney stones, dental decay and calcification of blood vessels. Phytic acid is known to be a very potent chelator, forming protein and mineral-phytic acid complexes thereby decreasing protein and mineral bioavailability. Also, phytate has been associated with some nutrition-related diseases such as rickets in children and osteomalacia in adult humans respectively. Processing like fermentation, drying, roasting, boiling, malting etc reduces the anti-nutrient content of food. Consumption of Naponeon imperial with the phytate level of 6.01% may not inhibit the bioavailability of protein and minerals after cooking since cooking educes antinutrient in foods. The result of cyanide content was 0.48 and 0.94% and non-toxic to both humans and animals at these amounts. According to Dias [36] it has been established that diets containing high amounts of cyanide could cause cerebral damage and lethargy in both humans and animals. It could also lead to inhibition of cytochrome oxidase activity, thereby stopping the formation of ATP and the release of inorganic phosphate to body tissues. As a result, the body is deprived of needed energy, leading to death. These values were lower than the findings of Uchegbu et al. [28] that had 1.874%. According to World Health Organization, the recommended cyanide safe level in food is 10 mg/kg [52].

## 3.5 Phytochemicals

The phytochemical content of the studied vegetables indicated that the alkaloid contents were 0.41 mg/100 g and 0.64 mg/100 g for sample A and B respectively. Pure isolated plant alkaloids are used as medicinal agents for analgesic, antispasmodic, and bactericidal effects [53]. *Napoleona imperialis* has higher alkaloid content than *Pterocarpus santalinoides* and this may be attributed to its efficacy in soup preparation for nursing mothers immediately after leaving the labor room instead of *Pterocarpus santalinoides.* The values obtained in this research were lower than the reports of Ukpabi and Ukpabi [12] with 2.50 mg/100 g and Vunchi et al. [38] with 6.50 mg/100 g for *Pterocarpus santalinoides* and *Napoleona imperialis* respectively. Glycosides content of sample A (1.98 mg/100 g) is higher than that of sample B (0.31 mg/100 g). These values were lower than those reported for *Pterocarpus santalinoides* as 6.13 mg/100 g by Agiang et al. [27] and also, lower than the critical level, 20 mg/100 g [50]. Toxicity of glycoside shows symptoms of diarrhea, vomiting, and heart failure in human. Its level in leafy vegetables can be reduced during processing such as soaking, boiling or frying [51]. Consuming foods rich in glycosides helps in fighting cancer. It helps in reducing pain associated with arthritis and also, in lowering high blood pressure

(www.brighthub.com/health/alternative). The saponin content in this study were 0.028 and 0.180 mg/100 g for sample A and B respectively. Saponins are glycosides containing polycyclic aglycone moiety of either C27 steroid or C30 triterpenoids attached to a carbohydrate sugar [36]. They have the capacity to affect the digestibility of proteins and inhibit a handful of enzymes involved in the digestion of proteins such as trypsin and chemotrypsin resulting in the reduction of bioavailability of proteins and other nutrients [36]. However, they may also produce hypocholesterolemic, anti-cancer, anti-infertility and anti-inflammatory effects, which are healthy. The low level of saponin content in this study with 0.028 and 0.180 mg/100 g for sample A and B suggests that on consumption, the probability of these vegetables to cause reduction in nutrient uptake could be low. This view is supported by the findings made by [28] with the value of 0.68mg/100g which reported that saponins were safe and non-toxic at low levels of < 10 mg/100 g. Tannin content in this study were 0.46 and 3.04 mg/100 g. These values are similar to the value obtained by [28] that had 1.35 mg/100 g for *Napoleona imperialis*. Tannins are phenolic compounds that are water soluble with the ability to precipitate proteins from aqueous solutions. They are capable of binding to proteins, making them bio-unavailable [7]. Tannin act as antinutrient when the value is above safe level but below safe level (0.15-0.20%) it functions as phytochemicals Hotz and Gibson [54]. Ladeji et al. [55] suggested that many traditional methods of food preparation such as fermentation, cooking and malting increases the nutritive quality of plant foods through reducing certain anti nutrients such as phytic acid, tannins, polyphenols and oxalic acid. Subjecting the vegetables to these processes will reduce the toxic level and at the same time boast the phytochemical properties of the vegetables [54]. Tannins may be employed medically in anti-diarrheal, haemostatic and anti-hemorrhoidal treatment. The anti-inflammatory effects of tannins help to control all indications of gastric enteritis and irritating bowel disorders. Tannins not only heal burns and stop bleeding, but they also stop infection while they continue to heal the wound internally.

**Table 1. Proximate composition of some underutilized vegetables**

| Sample | Protein | Fat | Fibre | Ash | Moisture | Carbohydrate |
|---|---|---|---|---|---|---|
| A | 1.06±0.23 | 0.98±0.10 | 0.90±0.27 | 2.73±0.41 | 63.70±0.19 | 30.63±0.02 |
| B | 5.27±0.61 | 0.71±0.13 | 1.01±0.87 | 1.27±0.32 | 68.20±0.07 | 23.54±0.12 |

*Values are mean ± standard deviation of 3 replicates*
*Keys: Sample A - Pterocarpus santalinoides; Sample B - Napoleona imperialis*

**Table 2. Mineral composition of some underutilized vegetables in mg/100 g**

| Parameter | A | B |
|---|---|---|
| Iron | 3.49±0.08 | 1.40±0.32 |
| Copper | 0.21±0.67 | 0.60±0.44 |
| Zinc | 0.92±0.00 | 2.10±1.02 |
| Manganese | ND | 4.30±0.74 |
| Calcium | 36.00±0.21 | 25.60±0.04 |
| Magnesium | 20.01±0.05 | 25.20±0.14 |
| Sodium | 1.20±0.03 | 2.33±0.09 |
| Potassium | 2.33±0.09 | 70.92±0.56 |
| Phosphorus | ND | 220.91±0.72 |

*Values are mean ± standard deviation of 3 replicates*
*Keys: Sample A - Pterocarpus santalinoides; Sample B - Napoleona imperialis*
*ND – Not Detected*

**Table 3. Vitamin composition of some underutilized vegetables in mg/100 g**

| Sample | Betacarotene (µg/100 g) | Vitamin C (mg/100 g) | Vitamin E (mg/100 g) |
|---|---|---|---|
| A | 360.00±0.19 | 5.20±0.12 | 2.80±0.03 |
| B | 347.00±0.03 | 7.13±0.28 | 1.45±0.17 |

*Values are mean ± standard deviation of 3 replicates*
*Keys: Sample A - Pterocarpus santalinoides; Sample B - Napoleona imperialis*

**Table 4. Anti-nutrient composition of some underutilized vegetables in percentage (%)**

| Sample | Cyanide (%) | Oxalate (%) | Phytate (%) |
|---|---|---|---|
| A | 0.48±0.23 | 1.08±0.02 | 0.25±0.26 |
| B | 0.94±0.18 | 3.87±0.07 | 6.01±0.01 |

*Values are mean ± standard deviation of 3 replicates*
*Keys: Sample A - Pterocarpus santalinoides; Sample B - Napoleona imperialis*

**Table 5. Phytochemical composition of some underutilized vegetables**

| Sample | Flavanoid (mg/100) | Saponin (mg/100) | Lycopene (mg/100) | Alkaloid (mg/100g) | Tannin (mg/100) | Phenol (mg/100g) | Glycoside (mg/100g) |
|---|---|---|---|---|---|---|---|
| A | 0.20±0.6 | 0.028±0.32 | 0.60±0.38 | 0.41±0.00 | 0.46±0.06 | 2.74±0.08 | 1.98±0.70 |
| B | 0.012±0.07 | 0.180±0.20 | 3.10±0.07 | 0.64±0.41 | 3.04±0.12 | 0.45±0.67 | 0.31±0.18 |

*Values are mean ± standard deviation of 3 replicates*
*Keys: Sample A - Pterocarpus santalinoides; Sample B - Napoleona imperialis*

The flavonoid content of the vegetables in this study was 0.20 mg/100 g and 0.012 mg/100 g for sample A and B. They were relatively low compared with the values reported by Agiang et al. [27] that worked on *Pterocarpus santalinoides* with mean value of 0.05 mg/100 g. However, the fact that these vegetables contained relatively low flavonoid levels did not deny the fact that they may yet possess some bio-active functions such as anti-oxidative, anti-allergy, anti-viral, anti-tumorigenic, anti-inflammatory and anti-microbial as well as protection against free radical damage, platelet aggregation and hepatoxins [56]. Flavonoids are potent water soluble antioxidants and free radical scavengers which prevent oxidative cell damage, and have strong anti-cancer and anti-ulcer activity and protection against the different levels of carcinogenesis [56]. They also inhibit low density lipoprotein (LDL) by free radicals and reduce the risk of cancer and Cardiovascular diseases [57]. Flavonoids are also involved in platelet aggregation, antimutagenic and antiproliferative properties [58]. Flavonoids lower high blood pressure and have strong anti-inflammatory properties [59]. The lycopene content was higher in sample B with mean value of (3.10 mg/100 g) than that of sample A with (0.60 mg/100 g) means value and also lower than the findings of Joanne [60] with lycopene value of 60 mg/100 g. Studies have shown that intake of lycopene-rich foods reduced risk of prostate cancer. Lycopene scavenges free radical which causes oxidative damage to cells. Lycopene may improve male fertility because its consumption by men improved the morphology and mobility of sperm cells. Studies suggests that as little as 6 mg per day may be useful for prevention [61]. Therefore, consuming 200 g of *Napoleona imperialis* is capable of supplying the daily requirement of lycopene in man. The phenolic content in this study were 2.74 mg/100 g in sample A and 0.45 mg/100 g in sample B. Phenolic content from plant extracts have been found to correlate with radical scavenging activity [62]. This is because polyphenolics have high redox potentials which allow them acts as reducing agents, hydrogen donors and singlet oxygen quenchers. Phenolic compounds; flavonoids and flavanols are known to possess good medicinal properties [62]. These phytochemicals have a lot of pharmacological properties which allow them to act as reducing agents.

## 4. CONCLUSION

The proximate, mineral, vitamin, anti-nutrient and phytochemical composition of these vegetables (*Pterocarpus santalinoides*) and (*Napoleona imperialis*) analyzed in this study showed that the vegetables contained appreciable amounts of nutrient. However, *Napoleona imperialis* had higher amount of protein and fibre making the leaves a good supplement for malnourished children.

Macro-minerals like copper, zinc, manganese, magnesium, sodium, potassium and phosphorus were observed higher in *Napoleona imperialis*, These minerals work synergistically to maintain optimal health by keeping the body and tissue fluids from being either too acidic or too alkaline. The observed low sodium make these plants healthy alternative dietary components in the management and prevention of hypertension.

All the vegetables were observed to be, relatively, poor sources of beta carotene, vitamin C and vitamin E. However, since vegetables like *Pterocarpus santalinoides* and *Napoleona*

*imperialis* were observed to be poor sources of beta-carotene, vitamin C and E, this study has further showed that no single plant food could provide all required nutrients in recommended amounts and so there is the need to consume these vegetables in combination with other dietary sources (diet diversification) of nutrients to ensure an adequate nutritional status, thus reducing the problem of micronutrient deficiencies within Nigeria and beyond.

Although, the anti-nutrient contents of these vegetables are low, they should be removed to improve their nutritional quality by cooking and not consuming raw. Therefore, these plants could serve as supplementary diet supplying the body with micronutrients; hence, contributing to the alleviation of micronutrient deficiencies, if consumed in sufficient amount.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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