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Phytochemical and Nutritional Profiles of *Tetragonia tetragonioides* Leaves Grown in Southeastern Nigeria

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ABSTRACT
The phytochemical and nutritional profiles of *Tetragonia tetragonioides* leaves were investigated. The phytochemical analysis showed that flavonoids (402.00±0.42 mg/100 g) registered the highest concentration followed by alkaloids (250.71±0.72 mg/100 g), phenol (109.12±1.37 mg/100 g), saponins (67.67±0.45 mg/100 g), glycosides (64.25±0.35 mg/100 g) and tannins (25.23±0.09 mg/100 g). The proximate analysis revealed high percentage moisture (92.77±0.03), carbohydrate (50.65±0.70) and crude protein (18.25±0.14); moderate percentage crude fibre (13.94±0.00), ash (13.91±0.12) and low fat (4.15±0.07 %). The vitamins detected include ascorbic acid (50.55±0.66 mg/100 g), β-carotenoid (14.50±0.70 mg/100 g) and the B-vitamins – thiamine (0.16±0.01 mg/100 g), riboflavin (0.30±0.01 mg/100 g) and niacin (0.80±0.01 mg/100 g), with ascorbic acid, β-carotenoid and the B-vitamins present in high, moderate and trace amounts respectively. The mineral elements composition of *T. tetragonioides* leaves were dominated by potassium (270.65±0.77 mg/100 g), followed by phosphorus (106.60±0.42 mg/100 g), sodium (72.70±0.70 mg/100 g), calcium (37.54±0.70 mg/100 g), magnesium (35.97±0.71 mg/100 g), iron (4.54±0.19 mg/100 g) and zinc (1.29±0.19 mg/100 g). This investigation revealed that *T. tetragonioides* leaf is of high nutritional value and may serve as a food supplement and raw material in the pharmaceuticals. The present findings recommend its adequate consumption for the maintenance of good health.

Keywords: Food supplement, Nutritional profiles, Phytochemicals, *Tetragonia tetragonioides*

INTRODUCTION
Vegetables are the edible plant parts which include leaves, seeds, fruits, stem, tubers, roots, flowers and bulbs, which may be consumed wholly or in parts (Iheanacho and Udebuani, 2009). Normally, vegetables are classified as leaf, root, stalk, fruit and flower based on the plant part used for nutrition. Vegetables are often referred to as protective foods owing to their varied health benefits that are linked to their richness in bioactive compounds such as vitamins, amino acids, essential fatty acids, dietary fibre and phytochemicals. Specifically, leafy vegetables are rich in vitamin C, carotenoid, magnesium and chlorophyll (Butnariu and Butu, 2014) whose increased consumption has been reported to reduce the risk of cancer, high blood pressure, heart disease and obesity (Insel *et al*., 2007; Morris *et al*., 2018).

Southeast Nigeria is endowed with diverse nutritional and medicinal plants. But despite the availability, potential nutritional and health benefits of these indigenous leafy vegetables, some are still underutilized such as *Tetragonia tetragonioides. Tetragonia tetragonioides* commonly known as New Zealand spinach is a perennial plant belonging to the family *Aizoaceae*. The vernacular names among the Ngwa and Umuahia people of Abia State, Nigeria are "Ojungu" and "Okorobom" respectively. The plant is native to Africa, Eastern Asia, Australia and South America. The Ngwa and Umuahia people, Abia state, Nigeria uses it in soup preparation as well as dishes for nursing mothers. The aqueous extract is taken by Ngwa people to prevent and treat malaria, hepatitis, boost the immune system and as a blood tonic. While it is used by Umuahia people to treat menstrual pain and as a blood boost. Furthermore, *T. tetragonioides* is used to improve heart health, reduce symptoms of rheumatoid arthritis, prevent asthma, regulate blood clotting, fight cold and flu as well as alleviate premenstrual syndrome. The pharmacological properties such as the anti-inflammatory, antidepressant, anti-obesity, anti-hyperuricemia and the neuroprotective potential against memory dysfunction have been reported (Ko *et al*., 2017; Lee *et al*., 2018; Kim *et al*., 2020; Choi *et al*., 2021). Therefore, the object of this work was to explore the phytochemical and nutritional contents of *T. tetragonioides* leaves.

MATERIALS AND METHODS
Sample Collection and Preparation
T. tetragonioides leaves were collected from Ndiolumbe Nvosi, Isiala-Ngwa South, Abia

State, Nigeria. The plant material was identified and authenticated in the Plant Taxonomy Section, Forestry Department, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The leaves of *T. tetragonioides* were washed under tap water and rinsed with distilled water, air-dried under shades. Thereafter, the dried plant leaves were powdered using electric blender and then stored at room temperature for analysis.

Determination of Plant Chemicals

Photochemical Analysis

Alkaloids, saponins and glycosides were determined by the method of Harbone (1973) while tannin, flavonoids and phenols were determined according to the method of AOAC (2006).

Proximate Analysis

The moisture, crude fat, crude protein, ash, fibre and total carbohydrate was determined according to AOAC (2006).

Vitamin Contents

Ascorbic acid was determined using the method of the Association of Vitamin Chemists described by Kirk and Sawyer (1998). The B-complex vitamins (thiamine, riboflavin, and niacin) were determined according to the method described by Okwu (2004) while carotenoid was determined according to the method described by John (2014).

Mineral Contents

The macro and micro elements comprising potassium, sodium, magnesium, calcium and iron were determined using the method of AOAC (2006), while phosphorus and zinc were determined using the method of AOAC (2010).

Statistical Analysis

The results obtained were expressed as means ± SD (Standard Deviation) of three replicates and were statistically analyzed using one way analysis of variance (ANOVA). Means were separated by Duncan multiple tests using statistical analysis software.

RESULTS AND DISCUSSIONS

The phytochemical composition of *T. tetragonioides* leaves are shown in Table 1. Table 2 gives the proximate composition while the vitamin and mineral elements composition of *T. tetragonioides* leaves are shown in Tables 3 and 4 respectively.

Phytochemical composition of *T. tetragonioides* leaves (Table 1) indicated that their concentration was in the order; flavonoids > alkaloids > phenols > saponins > glycosides > tannins. The health benefits of these phytochemicals for man and animals have been well highlighted (Sha'a *et al*., 2019). For instance, flavonoids possess antioxidant, anti-inflammatory and anti-allergic properties (Sha'a *et al*., 2019; Okwunodulu *et al*., 2020). It had been demonstrated that food rich in flavonoids reduces the risk of heart diseases and lowers blood pressure in hypertensive patients (Friday *et al*., 2018). Considering that *T. tetragonioides* is rich in flavonoids (402.00±0.42 mg/100 g), it may be expected to help in the prevention of diseases caused by free radicals. Alkaloids are reported to possess antibacterial, anti-malarial, analgesic, anticancer, antihyperglycemic, vasodilatory and antiasthmatic activities (Sha'a *et al*., 2019). The high amount of alkaloid (250.71±0.72 mg/100 g) present in *T. tetragonioides* may play a contributory role in its use to relieve asthma, malaria, hepatitis and menstrual pain.

Phenolic compounds protect the body from diseases emanating from free radicals through their antioxidant mechanism. They also act as anti-inflammatory and antimicrobial agents (Igwe and Okwu, 2013a). Saponins exhibit anticarcinogenic activity, protect against heart diseases through their anti hypocholesterolemic property as well as have beneficial effects in bone health and stimulation of the immune system (Gemede and Ratta, 2014; Okwunodulu *et al*., 2020). Tannins are used to relieve sore throat and diarrhoea as well as have a protecting effect on the kidney. All these phytochemicals were reasonably quantified in *T. tetragonioides*, and thus may impart those biological benefits.

Table 1: Phytochemical composition of *T. tetragonioides* leaves

Phytochemical	Composition mg/100 g
Flavonoids	402.00 ± 0.42^{a}
Alkaloids	250.71 ± 0.72^{b}
Phenols	109.12 ± 1.37^{c}
Saponins	67.67 ± 0.45^{d}
Glycosides	64.25 ± 0.35^{e}
Tannins	25.23 ± 0.09^{f}

Means with different superscript differs significantly at ($P<0.05$).

The proximate composition of *T. tetragonioides* leaves shown in Table 2 revealed the percentage composition in the order; moisture > carbohydrate > crude protein > crude fibre> ash > dry matter > fat. Moisture is a reflection of the shelf-life of the plant. Thus the high amount of moisture (92.77±0.03%) implied that *T. tetragonioides* has a short shelf life and could easily be invaded by microorganisms. On the contrary, high moisture content provides for greater

activity of water-soluble enzymes and co-enzymes required for metabolite activities (Iheanacho and Udebuani, 2009). Water also serves as a medium for transportation of nutrient (Igwe and Okwu, 2013b). Carbohydrates supply energy to the blood, muscle and brain. The high carbohydrate content (50.65±0.70 %) is an indication that the plant is a good source of carbohydrate and could contribute to the daily calorific requirement. The percentage crude protein (18.25±0.14 %) detected from the leaves of *T. tetragonioides* signified that the plant is a good source of protein. This is according to Ali (2009), who opined that plant foods which provide more than 12 % of their calorific value from protein are good sources of proteins. Also, proteins play an important role in the regulation of body metabolism, structure and cellular functions (Venu *et al*., 2019); body defense system, production of amino acid and energy (Igwe and Okwu, 2013b). Dietary fibre may help to reduce constipation, diabetes, obesity, colon cancer and the risk of cardiovascular diseases (Venu *et al*., 2019). Green leafy vegetables have been reported as good sources of dietary fibre (Venu *et al*., 2019). Ash is a measure of the total amount of mineral elements present in plant sample.

Table 2: Proximate composition of *T. tetragonioides* leaves

Proximate	Composition %
Moisture	92.77±0.03[a]
Dry matter	7.30±0.14[e]
Crude protein	18.25±0.14[c]
Crude fibre	13.94±0.00[d]
Ash	13.91±0.12[d]
Fat	4.15±0.07[f]
Carbohydrate	50.65±0.70[b]

Means with different superscript differs significantly at (P<0.05) while means with the same superscript at (P>0.05) has no significant difference respectively.

The vitamins composition of *T. tetragonioides* leaves (Table 3) reveals that ascorbic acid and β-carotenoid (provitamin A) were present in high concentrations, while niacin, riboflavin and thiamine were present in low concentrations. Ascorbic acid is an antioxidant and is vital for growth, development, strengthening of the immune system, prevention of scurvy and wound healing (Haskell 2012; Igwe and Okwu, 2013b). β-Carotenoid (a precursor of vitamin A) is an excellent antioxidant and helps in preventing cardiovascular diseases. Vitamin A helps to improve eye health and strengthen the immune system to resist infections (Haskell, 2012). Thiamine (vitamin B1) is a co-enzyme (thiamine pyrophosphate) in the metabolism of branched-chain amino acids and carbohydrate. The deficiency of thiamine lead to decrease in amino acid and carbohydrate metabolism (Adebayo 2019). Riboflavin exhibits antioxidant and neuroprotective effects against neurological disorders like Parkinson disease, migraine and sclerosis (Venu *et al*., 2019). Niacin is a co-enzyme which improve digestion and as a natural remedy for arthritis and blood pressure (Friday 2021). The detection of ascorbic acid, β-carotenoid, thiamine, riboflavin and niacin in the leaves of *T. tetragonioides* suggests that the plant can be a good source of vitamins.

Table 3: Vitamin composition of *T. tetragonioides* leaves

Vitamin	Composition mg/100 g
Ascorbic acid	50.55±0.66[a]
Thiamine	0.16±0.01[c]
Riboflavin	0.32±0.01[c]
Niacin	0.80±0.01[c]
β-Carotenoid	14.50±0.70[b]

Means with different superscript differs significantly at (P<0.05) while means with the same superscript at (P>0.05) has no significant difference respectively.

The ash content (13.91±0.12 %) of *T. tetragonioides* is an indication that the vegetable contains appreciable amounts of mineral elements (Table 4). Thus, determination of the mineral composition gives the order as; potassium > phosphorus > sodium > calcium > magnesium > iron > zinc. Potassium and sodium are required to maintain plasma volume, acid-base balance and normal cell function. Increased sodium consumption has been associated with increased blood pressure, while increased potassium intake helps in blood pressure reduction and balance as well as reduce the risk of stroke (WHO, 2012). *T. tetragonioides* leaves may be beneficial to hypertensive subjects due to its high amount of potassium (270.65±0.77 mg/100 g) in comparison to sodium (72.70±0.70 mg/100 g). Phosphorus is important for normal cell growth and repair, bone

growth, kidney function as well as in the maintenance of blood sugar levels and normal heart contraction. Calcium is essential for blood clotting, formation of teeth and bone and as a co-factor in some enzyme catalysis (Achi *et al*., 2017). The use of *T. tetragonioides* in traditional medicine to improve heart health and to regulate blood clotting may be linked to its richness in potassium, phosphorus and calcium. Adequate magnesium intake decreases the risk of atherosclerosis, hypertension and anxiety. Iron is required in building red blood cells, while zinc is important for wound healing and carbohydrate metabolism. (Igwe and Okwu, 2013a; Okwunodulu *et al*., 2021).

Table 4: Mineral elements composition of *T. tetragonioides* leaves

Mineral elements	**Composition mg/100 g**
Sodium	72.70 ± 0.70^{b}
Potassium	270.65 ± 0.77^{a}
Calcium	37.54 ± 0.70^{d}
Magnesium	35.97 ± 0.71^{e}
Phosphorus	106.60 ± 0.42^{c}
Iron	4.54 ± 0.19^{f}
Zinc	1.29 ± 0.19^{g}

Means with different superscript differs significantly at ($P<0.05$).

CONCLUSION

Phytochemical composition of *Tetragonia tetragonioides* leaves revealed its richness in bioactive compounds such as flavonoids, alkaloids, phenol, saponins, glycosides and tannin, while the proximate analysis showed that the vegetable contains high moisture, carbohydrate and crude protein as well as moderate amount of crude fibre and ash. Also, the presence of vitamins such as ascorbic acid, β-carotenoid (provitamin A), thiamine, riboflavin and niacin as well as minerals such as potassium, phosphorus, sodium, calcium, magnesium, iron and zinc. All important substances may add to the nutritional and health benefits of *T. teragonioides* leaves. This finding therefore encourages adequate consumption of *T. tetragonioides* leaves.

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