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Nutrient Composition and Health Benefits of Underutilized Green Leafy Vegetables in Ghana: A Review

Richard Osafo [a*]

[a] *School of Health and Life Sciences, University of the West of Scotland, Paisley Campus, Scotland, United Kingdom.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Review Article

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ABSTRACT

Diverse indigenous leaf and fruit vegetables are rich sources of nutrients that cater for the populace especially for those residing in rural areas. However, inadequate knowledge of their constituents and health benefits have decreased its consumption in recent years as opposed to exotic vegetables. Hence to promote their consumption, nutritional, phytochemical, ethnomedicinal and pharmacological properties of the four most popular and widely used indigenous vegetables in several parts of Ghana; *Corchorus olitorius* (Jute mallow), *Talinum triangulare* (Waterleaf), *Xanthosoma sagittifolium* (Cocoyam leaves), and *Launaea taraxacifolia* (Dandelion) were reviewed through a vigorous literature search. They possess variety of minerals and phytochemicals and as a result exhibited a wide range of pharmacological effects. This makes them a very useful inexpensive resource for tackling undernutrition and malnutrition which is prevalent in Ghana. There is therefore, a need to create awareness that will encourage their consumption in a bid to reduce malnutrition and attain the UN Sustainable Development Goal of achieving food security, improving nutrition, promoting good health and well-being by 2030.

Keywords: Indigenous vegetables; nutrient; pharmacological; phytochemical

**Corresponding author: Email: osaforichard@gmail.com;*

1. INTRODUCTION

In 2018, the rate of global undernutrition increased from 10.6% (785 million) to 10.8% (821 million) [1]. This resulted in the prevalence of stunted growth among children, wasting and overweight affecting 240 people worldwide. In Africa however, stunted growth declined from 38.32% to 30.0 % since 2000 but remains a hotspot of undernutrition [2]. Ghana has also made some progress towards achieving the targets for improving maternal, infant and young child nutrition. However, even though progress has been made in achieving the target for wasting, 6.8% of children under 5 years are still affected. There has also been limited progress towards achieving the diet-related non-communicable diseases targets wherein 16.6% of adult women and 4.5% men battling with obesity [3].

Diet is one of the key origin of malnutrition which have serious consequences on an individuals' health and the economy. This is because, unhealthy diets have become a major risk factor for mortality and morbidity as compared to other lifestyle-risk factors especially in developing countries [4]. These unhealthy diets are characterised by low vegetable, fruits, whole grains, nuts and seeds etc. composition with high sugar-enriched beverages, processed meat, fatty foods etc. [5]. However, vegetables possess a variety of food nutrient which enhances body growth and protection [6]. In addition to the diversity they provide to foods served [7], they are important reservoir of nutrients such as macro-and-micronutrients, vitamins, fibres and other non-nutrients that are limited in our day-to-day diets especially among those living in remote areas [8]. They have been consumed for a long time and essentially useful in providing health-protecting qualities [9].

Notwithstanding, indigenous vegetables have been reported to contain more micronutrients than exotic vegetables [10,11]. Indigenous vegetables are vegetables that are cultivated and eaten in specific regions as part of their traditional diet. Since ancient times, a large number of diversified indigenous vegetables have been known all over the world and in West Africa specifically. Some of these vegetables eaten in Ghana includes *C. olitorius* (Jute mallow), *L. taraxacifolia* (Wild lettuce), *V. amygdalina* (Bitter leaf), *T. triangulare* (Waterleaf). However, the gradual reduction of indigenous vegetable cultivation and utilization have been attributed to the incidence of exotic vegetable introduction to Africa [12]. Furthermore, other authors have indicated that the drop in indigenous vegetable accessibility has resulted in their limited utilization [13]. However, some other researchers mentioned that indigenous vegetables are still prevalent in Ghana even during the wet season because they are highly adaptable to unfavourable lands which are not conducive for other crops [14]. The advancement of these undervalued indigenous vegetables in terms of 'their domestication, conservation [12] and genetic improvement' have relayed to the background due to the insufficient research on them [15]. In Ghana, they are been labelled "poor man diet'' therefore a lot of individuals are yet to see their huge gains hence, their importance and values are decreasing through low patronage for them within the market [16,17]. In the majority of developing countries including Ghana, the first source of energy and protein are from starchy based diets that constitute their main dish as compared to their vegetables and this is evident from the crops cultivated (most homes growing staple crops than vegetables) [18,19]. This was what Food and Agricultural Organization (FAO) reported to be partially responsible for the protein deficit that is more prevalent in the population [19]. Inadequate trace elements or 'hidden hunger' have negatively affected the health status of a large number of the populace in the World including Ghana [20]. In Africa for instance, infants of about 50 million are faced with the threat of Vitamin A deficiency which is the 3rd largest public health challenge behind HIV/AIDS and Malaria [21]. However, Ghana is blessed with various indigenous vegetables which when used appropriately, can help reduce the number of undernutrition probelms especially among children under five due to their inherent health promoting properties [22].

Since most of these indigenous vegetables have not been the goal of most studies and research, little is known about their health importance as well as their health-promoting constituents in Ghana [23,24]. Inadequate research implies that their potency will be undervalued and as such underutilized. This puts these indigenous vegetables in a position of being endangered and as a result face threat of extinction. This will consequentially affect the growth of the inhabitants of rural areas especially for the poverty-stricken. Hence sufficient awareness about these edible but neglected indigenous vegetables, through multiple efforts and reviews

such as this that will emphasize their needs. This review explores and summarizes the description, nutritional composition, the traditional and pharmacological activity of four commonly consumed indigenous vegetables in Ghana.

2. PRODUCTION AND DISTRIBUTION TREND OF VEGETABLES

Though the production of vegetables experienced a slight drop between 2017 and 2018, there has been a continuous surge in production within the last eighteen years (2000 to 2018) from 682.43 to 1088.9 million metric tons (Fig. 1). Interestingly, vegetable production is widely distributed among the various continents with Africa being among the world's top ten producers. These countries with the highest production include the United States of America, China, Mexico, Vietnam, Russia, India, Iran, Turkey, Nigeria and Egypt. Since production has arisen in Africa, consumption has also increased in the last twenty-three years but at a slow rate [25].

In Ghana, agriculture is the main backbone of the economy, hence it has contributed 36% of the GDP and employs 60% of Ghana's labour force [26]. About 36% of Ghana's population lives below the poverty line (US$ 1/day). Poverty is substantially higher in rural areas and in the northern Ghana than in urban areas and the southern Ghana [27]. As a result, some Ghanaians in the rural areas have resorted to the production of vegetables as a means of survival. Indigenous vegetables play a very important role in income generation and subsistence. They employ peri-urban dwellers because of their generally short, labour-intensive production systems, low levels of investment and high yield [28]. In other to boost the productivity of vegetable farming thereby reducing poverty within the region, the Government and several development partners have established small scale irrigation schemes, dug-outs and others. For example, the Government of Ghana in 2017 launched the Planting for Food and Jobs programme [29]. These interventions have contributed to the improvement in the production and supply of vegetables [30].

Moreover, most of the vegetables produced in these rural areas are transported to the urban areas where production is minimal because most of the Agricultural lands in urban areas have been converted to building sites. A majority (over 90 %) of the vegetables consumed in and around the Cape Coast municipality is supplied by rural areas within the region as well as other places like Togo or Kumasi. However, a survey conducted in Ghana has reported the production of vegetables in some urban areas. In Kumasi, there are about 41 hectares in the urban area under vegetable irrigation while the peri-urban area has more than 12,000 hectares under irrigated vegetable farming whereas an average of about 100 hectares under vegetable irrigation in Accra during the dry season. Out of the over 1000 vegetable farmers, 40% of them produce indigenous local or traditional vegetables [31].

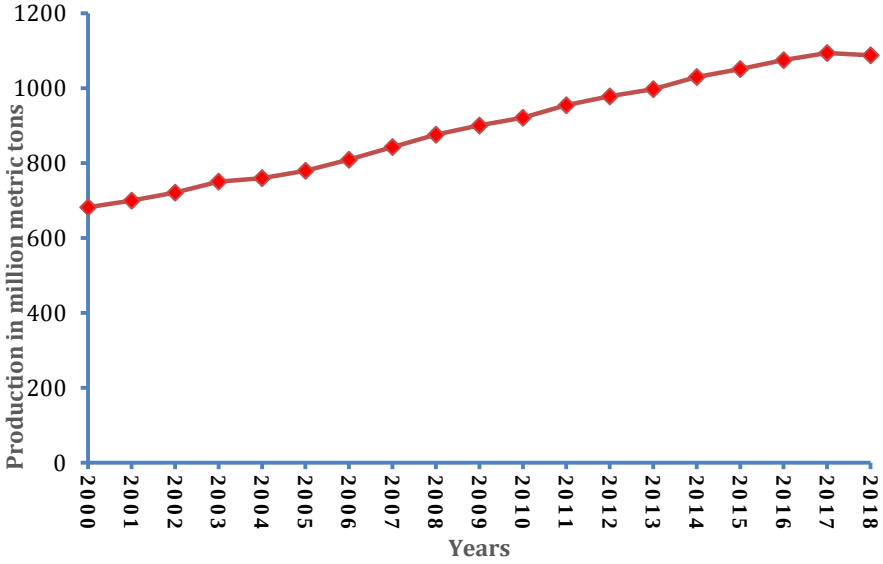

Fig. 1. Volume (in million metric tonnes) of vegetables produced globally [32]

Table 1. Summary of names and uses of selected Indigenous vegetables studied

Common Name	Plant Species (Scientific)	Local names (Ghanaian)	Edible uses	References Number
Jute mallow/Bush Okra	*Corchorus olitorius*	Twi/Akan: Ofaro Ga: Ayoyo Krobo/Ga Adangbe: Ayoyo Ewe: Sigli, Ademe, Ademademe Kasem: Ayoyo	Leaves are used in the preparation and stew. Leaves are used to produce soup of draw properties (cause) or boiled and mixed with kuli-kuli (groundnut cake) to form a dish known as kwado in the Hausa language. Herbal tea is also made from dried leaves.	[12,36,35,34].
Dandelion/African Lettuce	*Launaea taraxacifolia*	Twi/Akan: Mmrobo, Dadeduru, Nnenoa Ga: Agloke, Fie, Dan Krobo/Ga Adangbe: Kusii, Kusa Ewe: Bebletama, Anloto, Anoto	The leaves-raw, cooked or dried are used in soup, sauces, salads and tea.	[34,37]
Water leaf	*Talinum triangulare*	Twi/Akan: Busummuruadwere Nkokodwe Efan, Borkorborkor, Kotubetsew. Ga: Shee, Bleefoshee. Krobo/Ga Adangbe: Ablotsipui, Ngmloongmloo Ewe: Yevugboma, Senuma, Dentefla	Leaves were used in preparation of soup, especially in groundnut and palm-nut soup.	[33,34,36]
Cocoyam leaves	*Xanthosoma sagittifolium*	Kontomire	Leaves are cut into pieces and added to groundnut and palm-nut soups. Also used like spinach in stews.	[37,38].

3. METHODOLOGY

Using the preferred words or phrases, multiple search engines from which the published articles were selected included Google scholar, African journal online (AJOL), Science Direct and Web of Science. Other factual information was taken from Institutional Repositories and Food and Agricultural Organization (FAO). This review focuses on major and minor issues regarding the studied indigenous vegetables. Hence selection of the publications cited was done using words or phrases like Botany, Nutritional composition, Chemical constituent, Proximate composition, Phytochemical constituent, Pharmacological properties, Ethnomedicinal or traditional uses of *T. triangulare* (waterleaf) or *X. sagittifolium* (Cocoyam leaves), or *C. olitorius* (Jute mallow), or *L. taraxacifolia* (Dandelion). Other phrases like Indigenous vegetable production in Ghana, the impact of processing or cooking or boiling on nutrients composition were searched.

During the online search, three different ways were used to identify the articles and it was per the inclusion and exclusion criteria. For the first search, all articles were downloaded from various search engines using the preferred words or phrases stated above. After reading titles, abstracts and full documents, all articles that met the criteria were included for the review whereas those that did not meet the criteria were excluded. For the second search, articles obtained through articles were looked at following the criteria. Search three was conducted one week after the first search, thus ensuring newly published articles are captured. Several papers indicating the significance of these indigenous vegetable constituents were also referenced in this paper.

4. LOCAL NAMES AND ETHNOMEDICINAL BENEFIT OF THE PLANT

Four indigenous vegetables; *X. sagittifolium*, *C. olitorius*, *T. triangulare* and *L. taraxacifolia* were the selected vegetables for the review. Most of these indigenous vegetables are essential components of Ghanaian diets as well as their cultural system since ancient times therefore they are eaten regularly and in particular regions of the country [12]. These traditional vegetables were chosen because of their wide usage in Ghana. A research found that *X. sagittifolium* commonly called “Kontomire” is ranked as the first broadly consumed indigenous green leafy vegetable in Ghana. *T. triangulare* was also reported as one of the popularly leafy vegetables eaten in Ghana and Nigeria as it could be purchased cheaply from the market, grown in home gardens and obtained from the wild [33,34]. The survey has additionally indicated the wide consumption of *C. olitorius* and *L. taraxacifolia* in Ghana [33,35].

Table 1 summarises the various names as well as uses that are being known of the plant in various parts of Ghana. Apart from that, Table 2 displays various traditional uses indicated in Ghana.

5. DESCRIPTION OF INDIGENOUS VEGETABLES STUDIED

5.1 Talinum triangulare

T. triangulare commonly called waterleaf is an edible herbaceous perennial leafy vegetable that is of the portulacaee family with a genus *T. Adans* [39]. It is attributed to the name as waterleaf due to the high moisture content. Its origin is traced from tropical regions where it is now widely distributed throughout the African subcontinents. It is widely utilized in most African countries especially Ghana and Nigeria, and tropical South America [33,40]. *T. triangulare* is a smooth plant lacking hairs characterized by an erect herb, succulent stem and leaves with pink or purple flowers together with a swollen root. The seeds usually sprout as a small, aqua-coloured plant before growing into a more visible plant with larger leaves. The leaf is sticky as a result of the high pectin constituent that offers dietary fibre. It can grow well during the rainy season and also tolerate drought. Hence after planting, it takes 34-35 days before it could be harvested [41]. Table 1 displays some common names in Ghana and their uses.

5.2 Corchorus olitorius

C. olitorius, which in English is called Jute mallow and known by various names in various region (as shown in Table 1) is an annual herbaceous plant of the *Tilaiaceae* family [42]. It is an erect plant which is 15cm-20cm tall with dark green alternating leaves and a long petiole [42,43]. The flowers are bisexual with free petals. Seeds are numerous and seedlings grow with epigeal germination. The plant is found in most West African countries like Ghana, Cote d'Ivoire, Nigeria, and Benin just to mention a few [43]. Ghanaian natives in different regions of the country utilize *C. olitorius* as a source of

vegetable and also used herbal medicine. Even though this indigenous vegetable is 'important in terms of nutrition, medicine and resilience of livelihoods, they have been neglected by scientific research in Ghana and their value chain has not been developed' [44]. Also, very little is known about their role as a source of important nutrients and their subsequent health implications.

5.3 Xanthosoma sagittifolium

Cocoyam leaves commonly called 'Kontomire' (Table 1) in Ghana is one of the most consumed green leafy vegetables in West Africa and it forms a very essential component of the diet of the populace. The crop is additionally grown and eaten in other African countries such as Gabon, Cameroon, Nigeria, and the Ivory Coast apart from Ghana. The leaves are erect, sagittated, with a stout petiole [45]. Cocoyam leaves are eaten up to a short time after harvesting because they wilt and spoil rapidly as a result of loss of moisture after a short period of storage [46]. In the region where cocoyam is domesticated, they utilize the petioles and inflorescence as the flavour for soups and sauces [47], but literature is absent on their food use in West African cuisine. Thus, in seeking to boost culturally acceptable food uses, it would be a relief to focus on the already eaten and affordable leaves like cocoyam leaves. Cocoyam leaves are a delicacy in sauces and soups, especially for Ghanaian communities but remain underexploited. Limited shelf-life (3–5 days maximum) poses one of the major challenge to its utilization [47]. However, the leaves can be processed into purees or flours for end uses, as well as in novel products to tap their nutritional value. The product (s) may generate foreign exchange as it can be exported to West Africans (and other cocoyam growing areas) who must replace eating cocoyam leaves with other vegetables in the preparation of traditional delicacies abroad. Moreover, the significant nutritional value of cocoyam leaves can be explored in new markets in Europe and the United States of America, in place of other vegetables such as spinach, with such convenient product(s) [47].

5.4 Launaea taraxacifolia

L. taraxacifolia (Dandelion) is a herbaceous perennial plant found mainly in the tropics of Ethiopia, Senegal and Tanzania, but it occurs in West Africa regions also [48]. They are used in preparing a variety of dishes in Ghanaian homes (Table 1). *L. taraxacifolia* is of the *Asteraceae* family with a height of about 12 inches. The erect stem possesses rosette-like or alternative leaves below it which is enclosed by a golden yellow flower [49].

Taraxacum is a Latin word of Greek origin that means "Disease remedy'' [48,43]. Hence, this wild vegetable have been domesticated in Nigeria and is also cultivated locally in Senegal and Benin; various cultures use this medicinal plant in managing different ailments (24). During the 10^{th} to 11^{th} century, Arabian physicians were the first scientists to use *L. taraxacifolia* to cure liver and spleen diseases [50]. This medicinal plant has been labelled a wild underutilized and neglected vegetable by many authors though many cultures all over the world use it for culinary purposes [51,23]. Even though they are used as a food source in Ghanaian homes, information about their constituent is rare, however, it is seen to be nutritious and also exhibit various medicinal properties.

6. THE STATE OF FOOD SECURITY AND MALNUTRITION

One key determinant of food security is the availability of food and it's constituent. Food security exists when everyone at any given point has access to a portion of safe and nutritious food to satisfy their nutritional preferences [52]. Food insecurity has resulted in malnourishment in the world (Fig. 2) which occurs when there are inadequate nutrients in one's diet. 746 million people in the world were estimated to be presently food insecure in 2019 with South Asia leading followed by Sub-Saharan Africa (Fig. 2). This has resulted in undernourishment in the world with Sub-Saharan Africa leading by 22% (Fig. 3). In the Ghanaian population, 5% have been characterised as being food insecure ([53]. Another investigation by the World food programme in 2009 found 1.5 million people in rural and urban areas located in the southern regions (Brong-Ahafo 11%, Ashanti 10%, Eastern 8%, Volta region 7% etc.) to be at risk of food insecurity. The reminder 0.5 million were traced to the three Northern regions (34% in the Upper West region, 15% in the Upper East, and 10% in the Northern region). This means food is underutilized which is measured by the amount of sufficient nutrient taken and absorbed [54].

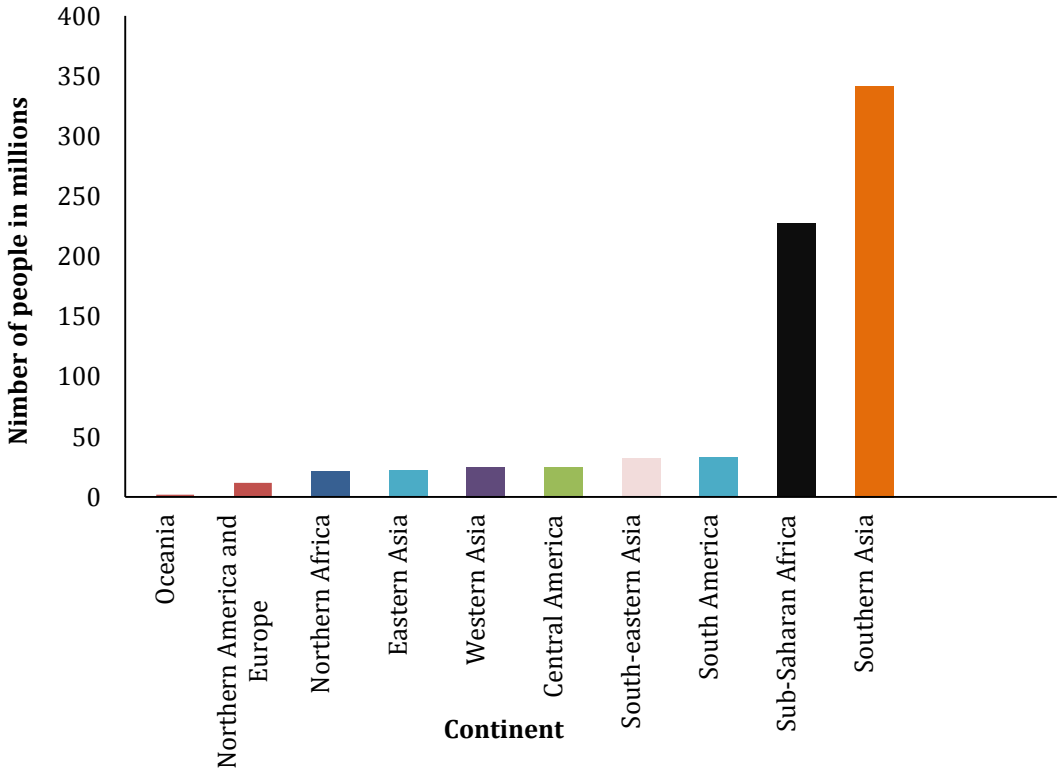

Fig. 2. Number of people experiencing food insecurity globally in 2019 [55]

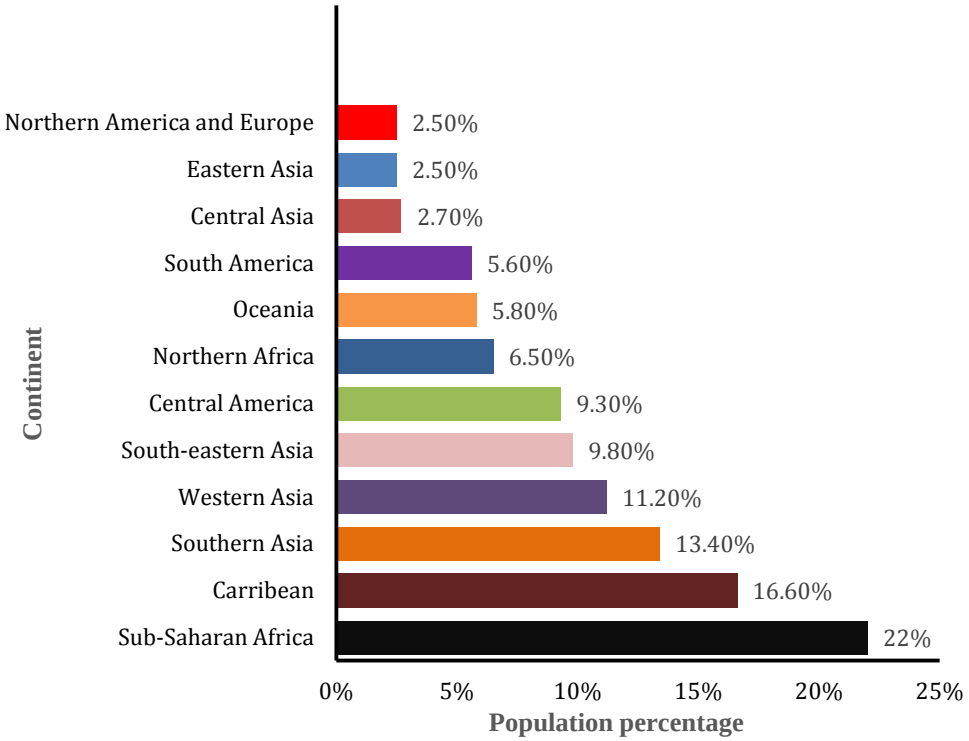

Fig. 3. Percentage of population in various continent undernourished in 2019 [55]

7. NUTRITIONAL PROFILE OF SELECTED INDIGENOUS VEGETABLES

7.1 Proximate Compositions

The chemical properties of various indigenous vegetable have been analysed across various studies where differences in protein, carbohydrate and other nutritional properties have been observed. Nyadanu and Lowor [36] indicated that, proximate constituents in indigenous vegetables (*C. olitorius* and *X. sagittifolium*) were significantly higher than their exotic counterparts. Concerning *X. sagittifolium,* a large amount of protein, fibre and carbohydrates were reported to be present [38,56,22]. Kwenin et al., [22] also reported 85.76% moisture, 4.6 % protein, 6.80% carbohydrate, 10% fibre and 71.50 Kcal/100g in *X. sagittifolium*. *C. olitorius* also possessed higher moisture (82g) [35]. Apart from that, *C. olitorius* leaves collected from Ghana harboured a lot of proteins (30%) with moderate lipid than *C. olitorius* cultivated in South Africa when they were analysed concurrently. This confirmed a large amount of protein (15.5-22.8) extracted from *C. olitorius* by [56] and this matched favourably the WHO essential amino acid limit [56]. The leaves of *T. triangulare* also contained 91.83% moisture, 5.10% protein, 1.33% fat, 1.05% carbohydrate, 8.0% fibre and supplies 36.60 Kcal/100g essential for human and animal nutrition [22]. The high moisture content was not significantly different from the result of 93.4% [57]. Therefore, the high moisture composition indicates the adequate care that the leaves have to be given due to their susceptibility to deterioration. However, Dickson et al., [58] reported an increased protein content (27.6%) in their study. Moreover, the caloric content of *L. taraxacifolia* was found to be 286.47kcal with a pH of *6.80,* which is considered slightly acidic hence essential for food preservation purposes. The proximate analysis also showed that this plant contains 30.56% of carbohydrate, 26.67% protein, 21.22% total ash, 6.50% fat, and 15.05% crude fibre [48]. Adinortey et al., [48] stated that the moisture content of *L. taraxacifolia* is 22.18% which exceeds other popular leafy indigenous vegetables eaten that is *Adansonia digitata* (9.5 %), and *X. sagittifolium* (14 %) [6].

7.2 Mineral Content

A high level of micro-and-macronutrient needed in human diets and essential for our health is found within some of these indigenous vegetables. Several authors have concluded that *L. taraxacifolia can* serve as a functional food that can curb malnutrition and disease; two major problems confronting the developing countries after analysis of their nutritional qualities [48,59]. Several studies found it to be very rich in micronutrients and macronutrients like iron, manganese, zinc, magnesium, calcium, potassium, sodium and phosphorus [48,35,60,61]. *X. sagittifolium* leaves supply a large amount of carbohydrates, calcium, copper, iron, magnesium, manganese, molybdenum, zinc phosphorus [38,56]. Nyadanu and Lowor [36] also reported that the mineral content of indigenous vegetables (*C. olitorius* and *X. sagittifolium*) was higher than exotic vegetables after his research. Interestingly, other comparable studies attributed *C. olitorius* as an inexpensive source of food nutrients due to the presence of vital nutrients such as iron, zinc, magnesium, calcium, copper, manganese, and molybdenum and potassium [56,60,58]. Comparing the nutrient composition of *C. olitorius* cultivated in South Africa and Ghana, nutrient content data revealed these leaves species had a similar quantity of zinc and iron [62].

In an aqueous extract of another notable indigenous vegetable *T. triangulare*, minerals like iron (10mg/100g), zinc (12.0mg/100g), magnesium (30.2 mg/100g), sodium (1.84mg/100g) and potassium were identified [58]. Then also Kwenin et al., [22] indicated the presence of iron (28.21mg/100g) and Phosphorus (81.90/100mg) in waterleaf and this was not significantly different from *X. sagittifolia* (80.10/100mg) in the same study. According to Dickson et al., [58] vegetables that offer between 10-19% magnesium and iron recommended daily value are good sources and if it is below 5% it is indicated as being a poor source by the Food and Drugs Authority of USA. Interestingly, *C. olitorius* and *T. triangulare* provided 9% and 8% magnesium as well as 33% and 56% iron respectively which makes them a good source. Then also in terms of sodium (480mg) and potassium (4700mg), *C. olitorius* and *T. triangulare* were within the required limit [41,58].

In light of micronutrient deficiencies; iron-deficiency anaemia [63], calcium-deficiency rickets [64] and zinc deficiency which is prevalent in Ghana as well as many other regions of sub-Saharan Africa [65], these rich indigenous vegetables in this study will be very valuable. Calcium and phosphorus found in these indigenous vegetables are essential macronutrients required for the development and

strengthening of bone, teeth and muscles [66]. Other present microelements such as copper function in blood production as they facilitate haemoglobin formation together with iron and energy metabolism [67]. Manganese is also a trace element that is a cofactor of many enzymes [67]. A similar assertion was made by Adinortey et al., [48] when they analysed dandelion as it contains a high concentration of minerals that could confer protection and boost to immune system against infections.

7.3 Vitamins

Indigenous vegetables are essential sources of vitamins needed to promote human metabolism in addition to the macronutrients they contain. Vitamins are essential micronutrients that are much needed in the body to play several significant bodily functions like the metabolism of energy, enhancing immunity and digestion of foods. 14 vitamins are available to the human body, however, in terms of their origin, vitamin D3 and niacin are synthesized naturally by the body whilst the remaining vitamins can only be ingested through diets or supplements to regulate the physiological functions of the body [68]. It is worthy to note that, vitamins can be grouped into two and this is based on the solubility of vitamins in water and non-polar organic solvents like fat and oil. Water-soluble (polar) vitamins comprising of vitamin C and 8 Vitamin B are one group whereas vitamins A, D, E, and K are another group known as fat-soluble vitamins [69]. Inadequate intake or deficiency of vitamins can result in scurvy, anaemia, nervous disorder, night blindness etc. [70]. Although water-soluble vitamins have many functions, one of the most principal tasks is the synthesis of coenzymes during biochemical processes in the human body [71]. The vitamin B subgroups consist of B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), B8 (biotin), B9 (folic acid or folate), B12 (cyanocobalamin) and B4 (choline). Whiles thiamine (B1) is a part of an enzyme needed for energy metabolism and nerve functioning [72,73], riboflavin (B2) is needed for fat, carbohydrate and protein metabolism as well as ensuring vision and skin health [73]. Niacin (B3) and thiamine are important for the nervous system, digestive system and skin health [69]. Studies have posited niacin to offer a protective effect against mental dysfunction and Alzheimer's disease. Folic acid or folate is highly needed during the pregnancy and infancy period due to its ability to facilitate DNA and new cell synthesis especially red blood cells [71]. The right amount of folate in the human system has been shown to limit the risk of cardiovascular diseases. Pantothenic acid aid in the production of fatty acids [74]. Then also, proper functioning of membrane structure, lungs and memory in infants have been attributed to choline [75]. Furthermore, Vitamin B6 (pyridoxine) is an important functionary in immune system build-up, protein metabolism and gluconeogenesis (58) whiles vitamin B12 (cyanocobalamin) is needed for erythropoiesis, nervous system functioning and DNA replication [76]. Vitamins C plays a major role as an antioxidant physiologically in the body in that it aids in iron absorption and protein metabolism [60].

With respect to fat-soluble vitamins, vitamin A facilitates vision, reproduction and cellular communication. Vitamin D is needed for proper absorption of calcium, vitamin E acts as an antioxidant that protects cells walls and vitamin K is essential for proper blood clotting [77,78]. It is worth noting that, these vegetables posit as rich sources of vitamins A which occurs as provitamin A carotenoids such as β-carotene, lutein and/or zeaxanthin which could be more preferred than vitamin-fortified food which is known to be costly and detrimental when in excess [79]. In human nutrition, β-carotene serves as the major dietary source of retinol which reduces the threat of chronic ailment [79] whereas lutein and zeaxanthin have been found to protect against blindness [80]. Hence, the consumption of β-carotene from these indigenous vegetables has been recommended as a significant and inexpensive remedy to vitamin A deficiency than vitamin A supplements [79]. Interestingly, literature has indicated these indigenous vegetables to contain these essential micronutrients. Qualitative analysis of *T. triangulare* revealed the presence of vitamins A (∝-Carotenoid), vitamin C (Ascorbic acid) and Vitamin B6 (pyridoxine) [58]. *C. olitorius* also serves as an inexpensive traditional nutraceutical leafy vegetable in Africa [81] and this is as a result of the high concentration of Beta carotenoids, lutein, zeaxanthin and total carotenoids of *C. olitorius* when compared *to S. macrocarpon* [82,83]. Wireko-Manu et al., [35] also showed the presence of higher moisture (82g), Vitamin C 48mg/100g, ∝-carotene (6.4mg/100g), lutein (22mg/100g), and total folate (89mg/100g). In other several studies, *C. Olitorius* was attributed as an inexpensive source of food nutrients in that it possessed vital nutrients such as protein, iron, zinc, magnesium,

potassium, and vitamins (A, B2, B6, B12, C, E) [84,28,30]. Furthermore, this traditional green leafy vegetable has been revealed to contain provitamin A (β-carotene, lutein), vitamin C (ascorbic acid and dehydroascorbate), vitamin B9, thiamine, riboflavin, niacin, as well as a-linolenic acid and omega-6/omega-3 [35,56]. Among the various vegetables Wireko-Manu and his colleagues studied [35] in terms of their vitamin C content, the leaves of *X. sagittifolium* was the second to have higher composition however it was higher than the amount (37 mg/100 g) indicated by [85]. It was further reported that the cooked *X. saggitifolium* leaves represent non-negligible sources of folate and hence eating 100g of it can supply up to 97% vitamin A as well as 90% vitamin C in response to the recommended dietary intakes [85] nevertheless another study observed considerable losses of nutrients after cooking [35]. Therefore, enhancing our processing methods will be useful in preserving more minerals which will be beneficial to consumers [35,85]. Because *L. taraxacifolia* can supply a higher amount of vitamin A (97%) and vitamin C (90%) as well as folate and lutein after being cooked [35]. Hence, to curb non-communicable diseases and vitamin deficiencies that are prevalent in sub-Saharan Africa, nutrition policies should be put in place to encourage the consumption of diets containing these vegetables.

8. PHYTOCHEMICAL CONSTITUENT

8.1 Phenolic compounds

Phenolic compounds are plant secondary metabolites that function in increasing the quality of fruit colour and flavour as well as having antioxidant activity among other functions [86]. These phenolic compounds such as tannins and flavonoids react with oxygen species by easily giving away electrons. This unique capability makes it useful antioxidants for protecting the body from free radicals which decreases oxidative stress especially in malarial conditions [87,88]. In addition to these functions, other researches have indicated the body protection effect and anticancer activity of these phenolic compounds [89,90].

Then also, polyphenols (like flavonoids and tannins) are one major group of such natural antioxidant which has been reported to be present in *C. olitorius, T. triangulare* and *L. taraxacifolia* [91,92,93]. Methanol fraction of *L. taraxacifolia* leaves gave a good polyphenolic compound and flavonoid compound hence the authors concluded that indigenous leafy vegetables eaten in Ghanaian homes are a viable source of these food compounds as well as antioxidants, which have the propensity of providing significant health and nutraceutical advantage to consumers [93]. This was confirmed by high total phenolic compounds and antioxidant activity observed in another study [94] Hence, the availability of these phenolic compounds in this vegetable makes its consumption useful as it will help prevent diseases such as Alzheimer's, cardiovascular diseases and cancer which are mediated by free radicals [95]. There was evidence that extracts from *X. sagittifolium* and *T. triangulare* contained non-nutrient phytochemicals such as phenols which caused a significant reducing effect of several oxidation. These phenols are free radical scavengers that exhibited higher antioxidant capacity [92]. This confirmed a similar study that noted a positive relationship between phenolic constituent of the leaves extract and antioxidant activity. However, no correlation existed between free radical activity and flavonoid contents [93]. On the other hand, when the leaves were extracted using hydro-ethanol, the antioxidant effect was seen to be much higher than leaves extracted with methanol [92]. Comparable results were also obtained from several studies conducted in Nigeria [96].

8.2 Antioxidant capacity

Apart from their nutritive potential, traditional leafy vegetables when added to the human diet have been established to be very useful as antioxidants that arise from their phenolic compounds [97]. Hence, the antioxidant role of several phytonutrients has been measured in relation to their capacity to prevent oxidation. One non-nutritive phytochemical is phenols which have been associated with antioxidant activities in several studies [92,93], in which indigenous vegetables possess promising natural antioxidant that is useful as a dietary supplement [98]. Other phyto-compounds such as flavonoid, ascorbic acid, tannin, lignin and coumarin have been reported to essentially free scavenging radicals needed to reduce the risk of several degenerative diseases and boost our immune system [99,100]. Ascorbic acid present in these indigenous vegetables is also a free radical scavenger that also can regenerate other antioxidants such as tocopheroxyl and the carotene radical cation from their radical species [99]. Ten popularly eaten indigenous leafy

vegetables in Ghanaian communities were evaluated for their antioxidant potential based on their polyphenolic (PC) and flavonoid contents (FC) by [93]. After each vegetable was partitioned into two using water and methanol, the methanol extracts of the plants displayed the highest polyphenolic content whereas the flavonoid content of the aqueous extracts was as follows in descending order; *A. incurvatus*, *H. sabdariffa*, *T. triangulare*, *C. esculenta*, *M. esculenta*, *V. amygdalina*, *O. basilicum*, *S. macrocarpon*, *L. taraxacifolia* and *C. olitorius.* Total polyphenolic compounds in the methanolic extract of *T. triangulare* yielded 12.73mg GAE/g and 3.3mg GAE/g in the aqueous phase. The flavonoid content was also 44.67 µg QE/gdw for methanolic extract. Comparing these results revealed higher polyphenolic and flavonoid content in samples analyzed in Nigeria than that which was from Ghana. Furthermore, the scavenging activity in the methanolic extract was also reported [93]. Yabani and Adotey [101] indicated that, aside the phenolic antioxidants which were earlier identified, *C. olitorius* also contain potent water-soluble antioxidants which protected from lipid peroxidation in mice. Further findings show that the intake of large quantities of this vegetable could reduce weight gain in males [101]. All plants studied in other researches revealed significant scavenging and reducing ability with notable variation existing among the different species. *A. leiocarpus* (95.86 ± 0.1) showed the topmost scavenging ability proceeded by *C. olitorius* (94.19 ± 0.06) [91]. It recorded the highest total phenolic constituent, and as a result exhibited a stronger free radical scavenging action than other two other vegetables; *Xanthosoma colocasia*, and *Allium ascalonicum* Linn studied [102,87]. Moreover, other investigation showed that these fruity vegetable revealed antioxidant properties, hence repaired a damaged DNA caused by these oxidative free radicals [103].

8.3 Other phytochemical composites

C. olitorius have been identified as an excellent source of alkaloids, glycosides, tannins, terpenoids, phytosterols [58] as well as flavonoids, saponins, cardiac glycosides and anthraquinones [104]. Phytosterol, a naturally occurring compound in plants have the power to reduce cholesterol levels and also perform antioxidant activities [86]. Adinortey et al., [48] reported the absence of cyanogenic glycoside as these secondary metabolites have been indicated as harmful to humans, hence their absence makes *L. taraxacifolia* safe for eating i.e. sauces and soups. Many authors also confirmed the presence of phytochemicals like tannins, terpenoids, flavonoids, and steroids [48,93,94]. Additionally, qualitative analysis of *T. triangulare* extract showed it possesses alkaloids, glycosides, tannins, flavonoids and phytosterols [58].

Phytochemicals in the various vegetables explain their ability to fight several diseases [105]. Terpenoids for instance fight malaria, inflammation, cancer as well as different bacterial and viral infections [106]. Anti-inflammation, anti-virus effects and destruction of tumour cells are also vital role performed by Saponins [107]. Similarly, tannins exert protection against viral, bacterial and other harmful microorganisms due to their antioxidant ability [99,108]. Plant sterols also lessen the threat of cardiovascular diseases by decreasing cholesterol in the blood [109]. Thus, indigenous vegetables possessing a significant number of phyto-compounds may have accounted for its common and wide usage as a source of food. This also supposedly confirms the underpinning reason for their use by traditional healers for disease treatment [87].

9. PHARMACOLOGICAL PROPERTIES

Classes of secondary metabolites influence these indigenous vegetable like *C. olitorius* to display a wide array of biological activities such as antimutagenic, wound healing, analgesic, anticarcinogenic, antimicrobial and anti-inflammatory properties [91,94,110]. It was reported that *C. olitorius* showed higher antibacterial activity against micro-organisms such as *Staphylococcus aureus, Klebsiella pneumonia, Citrobacter spp*., and *Escherichia coli*. Methanolic extract of *C. olitorius* against *E. coli was* recorded the highest inhibition zone [91]. Concerning *T. triangulare*, there has not been much research on their pharmacological studies in Ghana. However, in other countries like Nigeria, several studies have reported on the leaves' capacity to reduce oxidative stress and provides angiotensin-I-converting enzyme (ACE) inhibitory effects as a result of antioxidants which could help prevent diseases like hypertension [111,112].

L. taraxacifolia leaves are believed to possess several therapeutic effects including anti-inflammatory and anticholinergic properties [81]. The anticholinergic effect of the *L. taraxacifolia* leaves extract (TOLE) was investigated in ovalbumin (OA) sensitized guinea-pig trachea. The test drugs (TOLE or prednisolone) were

administered orally 1 hour before the aerosolized 2% ovalbumin challenge. After the leaves extract was administered, a significantly opposed outcome on the contraction of the trachea to both acetylcholine (35.10 ± 0.04) and OA (18.6 ± 1.5) was observed. In addition to that, the extract decreased monocytes (0.62 ± 0.23), lymphocytes (3.4 ± 0.59) and neutrophils (3.65 ± 0.20) counts in ovalbumin-sensitized guinea-pigs. Thus, *L. taraxacifolia* leaves extract possesses anticholinergic and reduces neutrophil, eosinophil and basophil counts in ovalbumin-sensitized guinea pigs [81]. Again, other several studies have ascribed the anti-proliferative, antimicrobial activities, antioxidant activity [90,110,113] of the plant. In one such study, 'anti-proliferative Phyto-compounds in *Launaea taraxacifolia* leaves manifested selectivity and minimal cytotoxicity against cancerous and non-cancerous cell lines' respectively [110]. Samples extracted with methylene chloride exhibited the greatest anti-proliferative activity thereby hindered the multiplication of the majority (97%) of SGT oral cancer cells whiles the highest antimicrobial activity in both disc diffusion and broth dilution assays were recorded by samples extracted with butanol [110]. Thus, *L. taraxacifolia* leaves in the various fractions (methylene chloride and butanoic) was further suggested by the researchers as a potential lead for the isolation of anticancer and antimicrobial bioactive. Similarly, *L. taraxacifolia* extracts shown anti-proliferative activity and induce apoptotic activity in human promyelocytic HL60 leukaemia cells [113]. Williams et al., [114] also reported the anti-helmintic activities of *Launaea taraxacifolia* leaves as part of twenty-nine indigenous medicinal plants utilised in Africa (Ghana) they examined. Though some of the plants were observed to be potent against the target parasite (*Ascaris suum*, a swine parasite that is very closely related to the human *A. lumbricoides*), *L. taraxacifolia* displayed a negligible antihelmintic effect [114]. Christensen et al., [115] also validated the anti-blastocystis activity of twenty-four [24] plant parts from twenty-one [21] medicinal plants used to remedy stomach ailments from Ghana. *L. taraxacifolia* was part of the medicinal plants evaluated but, unfortunately, its activity was very poor as reported by the authors [115]. Bello et al., [24] through their review also indicated other pharmacological activities (anti-ulcer, neuroprotective activity, antiviral activity, hypolipidemic and antidiabetics properties) which have been reported in other developing countries.

10. TRADITIONAL MEDICINAL PROPERTIES

In most traditional Ghanaian homes, these indigenous vegetables are exploited for consumption and treatment of diseases. Though *T. triangulare* is used in the preparation of soup, it used in the treatment of diabetes and other general body health [34]. Further traditional significance of these indigenous vegetables has also been reported (Table 2). Additionally, an overview of the chemical composition and properties of these vegetables can be found in Table 2.

11. EFFECT OF PROCESSING ON NUTRIENT CONSTITUENTS

Although these indigenous vegetables contain a high amount of nutrients, prolong cooking/boiling time has been implicated to decrease the mineral content. For instance, the beta carotene and vitamin C content of Ayoyo (*C. olitorius*), and Kontomire (*X. sagittifolium*) significantly decreased after boiling [85]. Similarly, [35] also indicated the significant loss of micronutrients from *C. olitorius, X. sagittifolium*, and *L. taraxacifolia* after boiling and microwave cooking. Then also, [94] assessed the effect of varied drying techniques (freeze-drying, oven drying and solar drying) on phenolic content and antioxidant activity. After the experiment, the antioxidant activity of the leaves reduced as a result of decreased phenolic constituent.

Watson [57] analyzed the ascorbic acid content of raw and processed *X. sagittifolium*, *T. triangulare* and *C. olitorius*. In the raw form, they were 80.6mg/100g, 23.8mg/100g, and 47.5mg/100g respectively in terms of composition but reduced to 12.5mg/100g, 14.7mg/100g, and 97mg/100g after boiling. Then also during storage, the ascorbic acid content in *X. sagittifolium* reduced from 80.6mg/100g to 73.8mg/100g after 24hrs. In a similar study in Nigeria, fresh *T. triangulare* harboured 20.00mg/ml vitamin C. However when subjected to different processing methods, vitamin C content in the leaf reduced with sun drying (for 48hrs) causing the least effect thereby retaining a high amount of vitamins. Blanching caused a reduction by 18% (2mg/ml), squeezing with salt water 14% (6.0mg/ml) and sun-drying 4% (16.0mg) [116]. Hence the adoption of improved cooking methods for more nutrient retention should be promoted.

Table 2. Summary of indigenous vegetables studied highlighting their chemical constituent, pharmacological activities and reported medicinal values

Plant Species	Mineral	Proximate	Phytochemical	Pharmacological Activities	Reported traditional medicinal values
Corchorus olitorius	Calcium, copper, iron, magnesium, manganese, molybdenum, zinc, potassium. Vitamins A (Beta Carotene), B2, B6, B12 and C, lutein total folate, zeaxanthin and total carotenoids	Proteins	Alkaloids, glycosides, tannins, terpenoids, phytosterol flavonoids, saponins, cardiac glycosides anthraquinones, Phenolic compounds and a-linolenic acid	The plant has antimutagenic, wound healing, analgesic, anticarcinogenic, antimicrobial, anti-inflammatory, antioxidant, Antilipidemic effects.	For treating fevers and free bowels. For the management of anaemic conditions and general malaise [34]. Treatment of fever, waist pain, stomach problem, loss of appetite [117].
Launaea taraxacifolia	Calcium, sodium, iron, magnesium, manganese, phosphorus, zinc, potassium, folate, lutein, Vitamin A and C	Carbohydrate crude proteins, fats total ash and crude fibre	cardiac glycosides, terpenoids tannins, flavonoids, steroids, polyphenols,	Anti-inflammatory properties, anticholinergic effect, Antioxidant, Free radical scavenging activity, anti-proliferative, antimicrobial activities,	Lowers blood pressure, immune system booster, reducing blood sugar; for treating liver, skin and gall bladder disease [61]. Treats hypertension [118,119]. Blood tonic, Fever, Ulcer [120].
Talinum. triangulare	Iron, calcium, sodium zinc, phosphorus, and potassium Vitamins A (B-Carotenoid), B6 and C contents	High moisture, carbohydrates proteins, fats, ash and crude fibre	Saponins, Polyphenols, Alkaloids, Phytosterols, flavonoids, glycosides and tannins	Reduction of oxidative stress offers angiotensin-I-converting enzyme (ACE) inhibitory effects	It is employed in treating diabetes and other general body health [34].
Xanthosoma sagittifolium	Calcium, copper, iron, phosphorus, magnesium, manganese, molybdenum and zinc, Vitamin A, Vitamin C, folate, thiamine, riboflavin	Proteins, carbohydrate, fibre	a-linolenic acid, phenolic compounds, Flavonoids	Antioxidant, and free radical scavenging activity.	It was reported as good for the management of anaemic conditions, immune system booster [34]. It is used in the management of diabetes mellitus [36].

12. CONCLUSION

Indigenous vegetables are crops that are widely distributed in different regions of Ghanaian communities. Majority of the populace use them to prepare a variety of delicacies in various homes. Furthermore, it appears traditional healers utilize these vegetables as medicine especially in rural homes to treat various ailments such as anaemia, hypertension, fever, ulcer, malaria, waist pain and others. This probably is as a result of the several phyto-compounds such as saponins, tannins, glycosides, terpenoids, sterols, flavonoids that have been identified from these indigenous vegetables. These compounds have also been documented to offer protection benefit, health-promoting and immune-strengthening properties by exhibiting a wide array of pharmacological effects such as antimicrobial, antioxidant, anti-inflammatory, free radical scavenging, erythropoiesis activities. However, seeing the malnourished diets consumed in rural households in Ghana, the nutritive value of these indigenous vegetables could be a major way to curb nutritional deficiencies as well as food security issues. Therefore, encouraging their consumption through scientific researches is deemed necessary.

13. RECOMMENDATION FOR FUTURE EXPLORATION

Mass production of these indigenous vegetables should be encouraged as they are not difficult to cultivate and are readily affordable. Awareness should be created by various stakeholders on the nutritious and health benefit of these indigenous vegetables as it will be the cheapest way of dealing with nutrient deficiencies (malnutrition). Then also more studies have to be conducted on the identification and isolation of bioactive ingredients of the plants and their health implications using animal models in Ghana.

DATA AVAILABILITY

All data used for the study have been included in the article.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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