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Influence of Pre-treatment methods on the nutritional and antioxidant potentials of sauces made from leaves of *Telfairia occidentalis*

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Abstract
The effect of pre-treatment and cooking on the nutritional potential and antioxidant capacity of *Telfairia occidentalis* (fluted pumpkin) was evaluated. A survey to find out the different treatment applied to the leaves before preparation and consumption in Cameroon. These leaves were divided into four groups: raw leaves (RL), leaves scrubbed with salt (SS), simple boiled leaves (SB), leaves boiled with limestone (BL). The three treated samples (SS, SB and BL) were then separated into two-, and one-part oven dried while the other was further cooked with the addition of *Cucumeropsis mannii* seeds and other ingredients (tomatoes, onion, ginger, garlic, salt). Scrubbed with salt cooked with egusi, simple boiled leaves cooked with egusi and boiled with limestone cooked with egusi (SBCE, SSCE and BLCE). The proximate analysis, minerals, antinutrients, bioactive compounds and antioxidant, were determined using standard methods. Results showed that the leaves had good levels of lipids, proteins, carbohydrates and ash no matter the pre-treatment and cooking method applied. The protein level however, decreased with boiling, but with the addition of ingredients, they increased while carbohydrates decreased. For minerals, the leaves had high levels of Ca, Mg, P and Fe which could cover the RDA (Recommended Dietary Allowances) for these minerals. However, the calcium and iron levels increased when boiled with limestone. Magnesium decreased while Phosphorus showed no significant increase.

Keywords: *Telfairia Occidentalis*, Nutritional Potential, Pretreatment Methods, Cooking, Antinutrients, Antioxidant Potential

1. Introduction

The nutritional importance of vegetables has long been recognized within the nutrition and medical communities (Yan Bai, *et al*., 2020) [60]. There is increasing awareness amongst the general public of the health advantages of diets high in vegetables (Bellary *et al*., 2011) [11]. They are made up of cellulose, hemicelluloses and pectin substances that give them their texture and firmness (Iniaghe *et al*., 2009) [35]. They contain valuable sources of food ingredients that can be utilized to build up the body (Otitoju *et al*., 2014) [48].

Leafy vegetables inclusion in diets has been shown to be protective against the incidence of chronic, degenerative and age-related disorder diseases, due to the presence of antioxidants (Erukainure *et al*., 2010) [26]. Antioxidants are compounds which quench molecular oxidation, and play a vital role in guarding the body's defence mechanism against free radicals and reactive oxygen species (ROS), which are generated continuously in the body due to both normal metabolism and certain diseases (Erukainure *et al*., 2010) [26]. As such, the relatively low cost and high nutritional potential vitamins (especially vitamins A and C, minerals, trace elements, fibres) of leafy vegetables (LV) are an asset for their use in daily diet for their portrayal as food for the poor (Yan Bai *et al*., 2020) [60]. Consumption of fruits and vegetables is associated with a low incidence of these oxidative stress related diseases and aging (Kinyi *et al.*, 2022) [38]. In fact, leafy vegetables contribute to the improvement of the nutritional status of the population of rural areas, peri-urban and urban areas (Ramya and Priya 2019) [51].

Despite the nutritional importance of local vegetables, many of them are still to be used because of the lack of knowledge on their nutritional potential. As a result, many efforts are been made in recent years in developing countries to raise the level of knowledge of wild leafy vegetables (Cappa *et al.*, 2020) [17]. In Cameroon, for example, several studies on the nutritional composition of leafy vegetables have been conducted. This is the case with works of (Ejoh *et al*., 2017) [24] on *Cucurbita maxima*; (Kidje, 2019) [37] on *Telfairia occidentalis.* However, transformation of some leafy vegetables remains to be exploited.

Generally, most vegetables are cooked before consumption. The purpose of preparing vegetables before consumption is to improve taste rather than retention of mineral nutrients, which serve as health promoting compounds (Yadang *et al*., 2009) [59]. Therefore, leafy vegetables require prior treatment (Yadang *et al*., 2009) [59]. However, cooking methods, such as boiling, steaming, can profoundly affect both the texture and the nutritional value of vegetables. Cooking methods have been shown to affect content of nutrients and health promoting compounds such as vitamin C, carotenoids, and polyphenols in broccoli vegetables (Ramya and Priya 2019; Craig *et al*., 2021) [51, 18]. The effect of processing on food depends on the sensitivity of the nutrient to the various processing conditions such as heat, oxygen, pH and light (Okibe *et al*., 2016) [46]. It is hence necessary that vegetables are prepared in such a manner that retains maximum amounts of their nutrients, that is minimizing losses through oxidation and leaching (Okibe *et al*., 2016) [46]. In Cameroon, some data exist on the nutritional composition of some dishes (Ponka *et al.,* 2016; Djuikwo *et al*., 2021; Nyangono *et al*., 2021) [49, 21, 44]. To our knowledge, no evaluation of the influence of pretreatment methods on the nutritional potential and antioxidant capacities of sauces made from *Telfairia occidentalis* leaves has been done. The aim of this work was to study the influence of pretreatment methods on the nutritional potential and antioxidant capacities of sauces made from *Telfairia occidentalis* from Cameroon.

2. Materials and methods

Collection and treatment of samples

Freshly harvested leaves of *Telfairia occidentalis* commonly called « *Okonghobong* » were bought from a local market (Mokolo) in Yaounde, the capital city of Cameroon, identified at the Cameroon National Herbarium Obili, then transported to the Laboratory for Food Science and Metabolism (LabSAM) of the Biochemistry Department University of Yaounde 1 Cameroon. Upon arrival, the leaves were cleaned, chopped, separated into three (BL, SB, SS) samples of 900g and one (RL) sample of 450g kept raw and oven dried for 12h. The three samples were later divided and 450g of each sample was further treated with the addition of egusi, onion, ginger, oil, tomatoes, garlic and salt, and cooked following traditional method of processing soups as described by the survey until three sauces ready for consumption were obtained. They were all oven dried for 44h at 45°C to eliminate moisture while preventing the destruction of nutritive elements contained in the samples. They were then blended and the obtained powders were kept at 4°C for analysis.

Assays

The moisture content was determined by drying in an oven at 105°C to constant weight (AOAC, 1980) [1]. The crude protein content was evaluated by digestion of the sample; nitrogen determination by a spectrophotometric method described by Devani *et al*. (1989) [20] and the crude protein content was obtained by multiplying the quantity of nitrogen by the coefficient 6.25. Total lipids were determined by continuous extraction in a Soxhlet apparatus for 12 h using hexane as solvent, ash by incinerating in a furnace at 550°C, crude fibres by sequential hot digestion of the defatted samples with dilute acid and alkaline solutions and total carbohydrates by difference (AOAC, 1980) [1]. Mineral contents (Ca, Fe, Mg, P): Atomic absorption spectrophotometry (Benton and Vernon, 1990) [12]; Phenolic compounds : (Vinson *et al*., 1998 [56]); Vitamin C : (Idah *et al*., 2010) [32]; antinutrients : oxalate contents by titration (Aina *et al.*, 2012) [5]; phytate contents: titration (Olayeye *et al.*, 2013) [47]; Tanin contents: spectrophotometry (Ndhlala *et al*., 2007) [43]; saponines contents: differential solubility Koziol (1990) [39]. Antioxidant potential analysis : Ferric Reducing antioxidant power (FRAP): Benzie and Strain (1996) [13]; DPPH (diphenyl-1-picryhydrazyl) radical scavenging activity assay: Lopes-Lutz *et al.,* (2008) [41].

Statistical Analysis

The results of the various test were presented as mean ± standard deviation, analyzed with the use of IBM/SPSS 20.0 software for Windows Analysis of Variance (ANOVA) 1 factor test coupled with a post *Hoc Tukey* test were used to compare averages at a threshold significance of 5%. Microsoft Excel 2016 software was used for calculations (means and standard deviations).

3. Results

The results of analysis are presented on the tables below. Table 1 shows the nutritive contents of Raw and pretreated leaves of *Telfairia occidentalis* expressed in grams per 100 grams of dry matter (g/100gDM).

Table 1: Influence of pretreatment on macronutrients of raw leaves, pretreatment and sauces made from *Telfairia occidentalis* leaves (g/100g DM)

Elements	Moisture	Ash	protein	Crude fat	Crude fibre	Carbohydrates
RL	12.15±0.37^{de}	6.61±0.33^{cd}	29.00±0.03^{c}	7.04±0.00^{a}	13.20±0.10^{e}	32.97±0.71^{c}
BL	11.51±0.08^{cd}	8.81±0.06^{a}	24.79±0.04^{b}	9.33±0.58^{b}	15.03±0.02^{f}	38.53±0.67^{e}
SB	9.06±0.33^{a}	6.30±0.21^{c}	24.77±0.04^{b}	12.96±0.15^{c}	12.64±0.04^{d}	34.48±0.41^{d}
SS	14.37±0.10^{f}	9.36±0.19^{e}	14.95±0.02^{a}	12.30±0.30^{c}	17.02±0.02^{g}	31.99±0.02^{c}
BLCE	11.04±0.81^{c}	7.78±0.17^{a}	32.96±0.06^{d}	34.18±0.10^{d}	11.75±0.03^{c}	9.38±0.15^{b}
SBCE	8.91±0.41^{a}	6.09±0.71^{c}	33.07±0.27^{d}	36.60±0.71^{e}	9.58±0.05^{b}	5.54±0.76^{a}
SSCE	10.15±0.12^{b}	4.27±0.03^{b}	32.86±0.06^{d}	35.12±0.02^{d}	9.20±0.02^{a}	8.36±0.15^{b}

Values with different superscripts in the same column are significantly different (p<0.05). RL: Raw Leaves; BL: Boiled with Limestone; SB: Simple boiled; S: Scrub with Salt; BLCE: Boiled with limestone cooked with egusi; SBCE: Simple boiled cooked with egusi; SSCE: Scrub with salt cooked with egusi

Table 2: Influence of pre-treatment on Bioactive compounds (mg/100g of DM) on leaves of *Telfairia occidentalis*

Elements	RL	BL	SB	SS	BLCE	SBCE	SSCE
Vitamin C	38.63±0.69^{e}	17.99±0.58^{b}	13.04±0.76^{a}	21.39±0.55^{c}	19.68±0.50^{bc}	21.39±0.55^{c}	39.18±0.05^{f}
Phenolic compound	499.75±0.17^{d}	321.28±0.38^{a}	356.27±0.47^{c}	353.03±0.44^{b}	406.91±0.86^{e}	388.70±0.17^{d}	450.00±0.12^{f}

Values with different superscripts in the same column are significantly different (p<0.05). RL: Raw Leaves; BL: Boiled with Limestone; SB : Simple boiled ; SS : Scrub with Salt; BLCE : Boiled with limestone cooked with egusi ; SBCE : Simple boiled cooked with egusi ; SSCE : Scrub with salt cooked with egusi.

Table 3 : Influences of Pre-treatment on minerals (mg /100g DM) on leaves of *Telfairia occidentalis*

Element	RL	BL	SB	SS	BLCE	SBCE	SSCE
Mg	524.67±0.58^{e}	402.38±0.13^{c}	305.13±0.6^{b}	295.90±0.10^{a}	623.90±1.25^{g}	526.17±0.06^{f}	516.90±0.10^{d}
P	295.15±0.01^{c}	299.90±0.26^{d}	215.25±0.01^{b}	196.97±0.00^{a}	408.39±0.01^{g}	396.50±0.25^{f}	310.89±0.01^{e}
Ca	984.00±1.00^{c}	1134.20±0.01^{d}	959.71±0.01^{a}	1333.80±0.01^{f}	1163.25±0.25^{e}	973.02±0.01^{b}	1377.85±0.01^{g}
Fe	24.45±0.06^{d}	24.61±0.10^{e}	20.82±0.06^{c}	14.97±0.01^{a}	28.39±0.01^{g}	25.66±0.06^{f}	16.68±0.01^{b}

Values with different superscripts in the same column are significantly different (p<0.05). RL: Raw Leaves; BL: Boiled with Limestone; SB: Simple boiled; SS: Scrub with Salt; BLCE: Boiled with limestone cooked with egusi; SBCE: Simple boiled cooked with egusi; SSCE: Scrub with salt cooked with egusi.

Table 4: Influence of pre-treatments on the antinutrients (mg/100g of DM) on leaves of *Telfairia occidentalis*

Elements	RL	BL	SB	SS	BLCE	SBCE	SSCE
Oxalates	44.98±0.02^{g}	37.71±0.74^{e}	27.02±0.76^{a}	33.34±0.04^{c}	29.69±0.01^{b}	36.13±0.11^{d}	39.18±0.05^{f}
Phytates	3.67±0.06^{d}	1.00±0.00^{a}	1.00±0.00^{a}	1.00±0.00^{a}	3.00±0.00^{c}	3.00±0.00^{c}	2.00±0.00^{b}
Saponines	11.00±0.05^{d}	4.74±0.56^{c}	3.34±0.54^{b}	1.62±0.60^{d}	1.12±0.57^{a}	0.90±0.24^{a}	0.69±0.56^{a}
Tannins	13.47±0.50^{a}	27.14±0.05^{d}	28.47±0.10^{e}	19.54±0.07^{c}	17.93±0.43^{b}	38.76±0.10^{g}	32.50±0.12^{f}

Values with different superscripts in the same column are significantly different (p<0.05). RL : Raw Leaves ; BL: Boiled with Limestone ; SB : Simple boiled ; SS : Scrub with Salt ; BLCE : Boiled with limestone cooked with egusi ; SBCE : Simple boiled cooked with egusi ; SSCE : Scrub with salt cooked with egusi.

Table 5: Influence of pre-treatments on the antioxidant capacities (mg/100g of DM) on leaves of *Telfairia occidentalis* (Ferric Reducing Antioxidant Power Assays and DPPH)

Samples		IC50 DPPH (µg/ml)	FRAP (mg EGA/g DM)
Pre-treatments	BL	44.38±0.28^{a}	**95.31±0.27^{f}**
	SB	50.00±0.00^{c}	62.02±0.12^{a}
	SS	51.97±0.66^{d}	73.55±0.18^{b}
	BLCE	48.98±0.17^{c}	93.00±0.22^{e}
	SBCE	45.82±0.29^{b}	86.56±0.14^{d}
	SSCE	43.25±0.28^{a}	77.24±0.08^{c}
	RL	77.24±0.86^{e}	101.61±0.50^{g}
Reference antioxidant	Gallic acid	**0.67±0.00**	**142.11±3.10**

Values with different superscripts in the same column are significantly different (p<0.05). RL: Raw Leaves; BL: Boiled with Limestone; SB: Simple boiled; SS: Scrub with Salt; BLCE: Boiled with limestone cooked with egusi; SBCE: Simple boiled cooked with egusi; SSCE: Scrub with salt cooked with egusi; EGA: Equivalent Gallic Acid

4. Discussion

T. occidentalis leaves are among the vegetables sparingly consumed in the North West, Southwest and West of Cameroon. The young leaves are cooked as green vegetables while the seeds are used as hardeners in sauces. The proximate composition of *T. occidentalis* shows that they have low moisture (water) contents like most other vegetables. Moisture content is a widely used parameter in the processing and testing of food. It is an index of water activity of many foods. The observed high values implies that these vegetables may have longer shelf life because microorganisms that cause spoilage thrive in foods having high moisture content and also is an indicative of low total solids Adepoju, (2006) [4]. Fruits and vegetables contain large quantities of water in proportion to their weight. When these foods are eaten, the water can be absorbed by the body Iheanacho (2009) [34].

The ash contents varied as seen on the table. The reduction in the ash content in some sample here could be due to the longer cooking duration and these were the same observations made by (Vodouhe *et al*., 2012) [57] on leaves of *Amaranthus hybridus*. We could then deduct that cooking facilitated the rupture of the cell membranes of the leaves thereby leading to the exposure of the elements found within them.

Telfairia occidentalis is also a good source of vegetable protein having a protein content of 29.00 %. This value was higher than that (3.3%) recorded by the USDA Nutrient Database for Standard Reference. Its protein content makes it suitable for consumption, as a necessity for body development. The protein value of *Telfairia occidentalis* as observed in this study confers on it the advantage as a rich source of vegetable protein over some vegetables such as raw *Curcubita maxima* leaves. Total Protein contents as presented in table 1 above varies with the type of treatment applied. Both the boiled leaves and those boiled with limestone possessed the high contents of 24.77±0.04 g/100g DM and 24.79±0.04 g/100g DM respectively, with no significant difference between them, while those SS were lower 14.95±0.02 g/100g DM. This low content in the scrubbed with salt samples might be because scrubbing might have weakened the cells thereby allowing the easy liberation of proteins from the leaves Kidje, (2019) [37]. Similarly, in the samples further treated with egusi, no significant difference was observed, but the protein contents greatly increased. These results are contradictory to those of (Vodouhe *et al*., 2012) [57] that boiling in water brings about a decrease in protein contents on leaves of *Amaranthus hybridus*. Incorporating *Telfairia occidentalis* in the diet can furnish it with sizeable amounts of protein which provides enormous benefits such as maintenance of fluid balance, formation of hormones and enzymes, contribution to immune function, to mention but a few.

For crude fibre, the existence of a significant difference between the values of *T. occidentalis* leaf powders that varied depending on the treatment applied ($p < 0.05$) as shown on Table 1. Fibre cleanses the digestive tract, by removing potential carcinogens from the body and prevents the absorption of excess cholesterol. Fibre also adds bulk to the food and prevents the intake of excess starchy food and may therefore guard against metabolic conditions such as hypercholesterolemia and diabetes mellitus. Fiber binds to cancer-causing chemicals, keeping them away from the cells lining the colon, providing yet another line of protection from colon cancer (Mensah *et al.,* 2008). This study showed that cooking increased the fibre content at the rate of 15.38%. These observations are in line with results obtained by (Vodouhe *et al*., 2012) [57] in Benin on the leaves of *Ocinum gratissimum* (11.55 g/100g DM) boiled for 15 minutes with a percentage increase of 51.41%. Equally Kidje (2019) [37] working on the leaves of *T. occidentalis* obtained 17.6±1.5 g/100g DM for leaves scrubbed with salt (38±0.4 g/100g DM) and (34.6±0.3 g/100g DM) respectively for simple boiled and boiled with limestone.

The crude fat obtained from the result was low which agrees with results of (Banerjee *et al.,* 2012) [10], that vegetables contains low amounts of fat and calories. The fat content of *Telfaria* may suggest that this vegetable may not be a high fat content vegetable. Individuals on weight reduction could therefore use it. An increasing trend of lipid content was observed in the samples BLCE, SBCE and SSCE, which can be attributed to the rupture of the plant cell walls as well as the addition of egusi rich in lipids and oils used for the preparation of the sauces. This shows that heating frees the crude lipid from the vegetable matrices. This may be due to the increase in the extraction efficiency of crude fat by water as the rate of heating increases. Some lipids in foods are in complex lipoprotein and liposaccharides, hence heat breaks the bond between them and the lipids are freed and solubilized in the extracting solvent (Okibe *et al.,* 2016) [46].

The carbohydrate content of *T. occidentalis* were about 32% (Raw leaves). According to Emebu and Anyika (2011), carbohydrates are pivotal nutrients required for adequate diet. *T. occidentalis* like most vegetables contains high-level carbohydrate but lower than that of other vegetables such as *Amaranthus hybridus* (52.18%). Investigations on the carbohydrate contents on *T. occidentalis* according to the treatment applied proved a decreasing trend in the contents for the different cooking methods as seen on Table 1 above this might have been because of carbohydrate dissolving in water during boiling. Increased temperature reduces the carbohydrate content of vegetable and hence limits its possible usefulness as an energy source.

Generally, vegetables are rich in vitamins, minerals, trace elements, dietary fibre and proteins [31-34]. The result of this study showed that *Telfairia occidentalis* is rich sources of vitamin C. This finding is in agreement with the result of Otitoju *et al.* (2014) [48] who reported that *Telfairia occidentalis* is a rich source of vitamin C. Statistical analysis of these samples showed significant differences for samples RL and SS while no significant difference was observed amongst samples BL and BLCE, BLCE and SSCE, SB and SBCE. These results were inferior to the samples, vitamin C and E concentrations were 420.86 ± 32.77 mg/100 g obtained by (Otitoju *et al.*, 2014) [48] working on these same fresh leaves and the 277.80 ± 22.98 mg/100 g on the dried leaves of the same plants. Ascorbic acid (vitamin C) is an antioxidant, which helps to protect the body against cancer and other degenerative diseases such as arthritis and type II diabetes mellitus (Adeniran *et al.*, 2013) [3]. It also strengthens the immune system. In fact, green vegetables with high ascorbic acid content, such as *T. occidentalis* may enhance the absorption of non-heme iron. Additionally, ascorbic acid may potentially act as an anticancer agent.

The obtained results showed that, all samples contained phenolic compounds; with the highest contents registered with SB (356.27±0.47 mg EGA/100 g DM), and the least was BL (321.28±0.38 mg EGA/100 g DM) for the samples without *Cucumeropsis mannii* seeds. It is to note that these seeds contain a negligeable amount of polyphenols reason for the slight increase in the samples containing them. Phenolic compounds are natural antioxidants with heart protecting properties (Achu *et al.*, 2013) [2].

T. occidentalis were high in Ca, Mg, P and Fe. Based on the findings on the mineral contents from this study, a significant percent of the daily calcium requirement for the average human can be met through judicious use of *T. occidentalis* for meal preparation. Calcium is a major factor sustaining strong bones and plays a part in muscle contraction and relaxation, blood clotting, synaptic transmission and absorption of vitamin B12. The relatively high content of calcium (984.00mg/100g) in *T. occidentalis* suggests that it may be of therapeutic value in hypocalcaemic state like osteoporosis.

Phosphorus contents in the leaves varied significantly ($P<0,05$) with the treatments applied. It is noted that scrubbing with salt and boiling without limestone caused a decrease in the contents, but with the addition of the seeds there was an increase in these contents. Scrubbing with salt provokes the rupture of plant cell walls permitted the releases of phosphorus (EFSA, 2014) [23]. On the otherhand boiling without limestone was favorable for the solubilisation of the mineral in the boiling water. Meanwhile the use of limestone rather brought an increase in the mineral contents of the samples from (295.15±0.01 mg/100g DM) to (299.90±0.26 mg/100g DM). Limestone might have fixed Phosphorus molecules thereby preventing it from being washed and solubilised in the cooking water. The mineral has a RDA of 1200 mg/100g (Idris, 2011) [33], proving that an intake of more that 100g of leaves is required to meet the organism's requirements in this mineral. It should be noted that in the organism, phosphorus permits calcium fixation in bones by limiting it urinary excretion and also acts in the mechanism of energy reserve and liberation (EFSA, 2014) [23]. A disequilibra between phosphorus and calcium leads to situations like rickets, osteoposis and dental decay (Asaolu *et al*., 2012) [8].

Contents in magnesium as observed in the leaves presented a significant difference ($P<0.05$) as shown on table 19. These contents varied from 295.90±0.10 mg/100g DM (SS) to 623.90±1.25 mg/100g DM (BLCE). The contents of leaves boiled with limestone 402.38±0.13 mg/100g is superior to the 303.1±0.6 mg/100g obtained by Kidje, (2019) [37] on the same leaves. It was observed a significant difference (P<0.05) amongst the samples not minding the treatment applied. As such the increase in the samples treated with the addition of *Cucmeropsis mannii* seeds would have been brought by the seeds which have a high mineral content in magnesium. Nevertheless heat affects the contents of magnesium present in the samples. These differencies could be explained by the genetic variability of samples, harvest season and age of plant before harvest (Kuhlein, 2000) [40]. This value nevertheless fits in the RDA range that lies between 30-410 mg/100 g (Danso *et al*., 2019) [19]. Magnesium is a necessary mineral for ATP enzymes that contributes in the synthesis of ADP and RNA during cellular proliferation. Its deficiencies causes convulsion (Wardlaw *et al*., 2004) [58]. These leaves could be vital to limit deficiencies as 100g is enough to reach the RNI (Reference Nutritional In-take).

The iron contents in the powders of *T. occidentalis* leaves varied from 14.97±0.01 mg/100g DM (SS) to 28.39±0.01mg/100g DM (BLCE) and presented significant difference (P < 0.05) between samples. The increase in the samples containing egusi was brought by egusi which is equally a good source of iron. Iron level of *T. occidentalis* was also high (24.45 mg/100 g) but lies in the FAO/ WHO (FAO (1988) [27] recommended dietary allowance for Iron which has been reported as an essential trace metal and plays numerous biochemical roles in the body, including oxygen binding in haemoglobin and acting as an important catalytic center in many enzymes, for example, the cytochrome system Geissler, (2005) [29]. As such, the consumption of these leaves could help balance the iron requirements of the organism. Iron is important for the human body as it helps in the formation of haemoglobin and myoglobine important proteins for oxygen transport (Idris, 2011) [33]. Iron deficiencies causes anaemia which is the most abundant alimentary deficiency in the world (Trowbridge and Marlorell, 2002) [54].

The oxalate contents of *T. occidentalis* leaf powder witnessed a significant difference (p<0.05) between the samples not minding the pretreatment method applied. The oxalate contents of raw leaves (44.98±0.02 mg/100g DM) is the highest while those of leaves boiled without limestone recorded the least content (27.02±0.76 mg/100g DM). Contrarily, those srubbed with salt and cooked with egusi for the samples that were further treated with the addition of egusi recorded the highest contents 39.18±0.05 mg/100g DM in oxalate, while samples boiled with limestone and cooked with egusi recorded the least values 29.69±0.01mg/100g DM in oxalates. Oxalates in nutrients contain a soluble fraction and a non-soluble fraction (Bhandari and Kawabata, 2004) [15]. According to Albihn and Savage (2001) [6], oxalates contained in samples are drained in water during cooking. The reduction in these contents is therefore due to their solubility of these components and their drainage during cooking. Oxalic acid is an antagonist for calcium utilisation. From its toxicity rate in humans which is between 200 to 500mg (Hassan and Umar, 2004) [30], the low contents in oxalates obtained both in treated and non-treated samples confirms the fact that oxalates in these leaves are of little or no danger to the body if consummed. As such, the quantity of oxalates in this study is relatively low and cannot be detrimental to the organism. Note should be taken that regular consumption of oxalates can induce kidney diseases (Hassan *et al*., 2007) [31].

Phytate contents of treated leaves were the smallest compared to those containing egusi but both were smaller than the raw leaves. For the BL, SB and SS samples, there existed no significant difference (P<0.05). Similarly, the BLCE and SBCE had no significant difference compared to SSCE. After boiling with and without limestone and scrubbing with salt, leaves of *T. occidentalis* had respective values of 1.00±0.0 mg/100g DM, while the BLCE and SBCE had contents of 3.00±0.0 mg/100g DM, but SSCE had 2.00±0.0 mg/100g DM reason for the difference on ANOVA analysis. Raw *T. occidentalis* leaves had (3.67±0.058 mg/100g DM). From reports, (Ejoh *et al.*, 2017) [24] working on leaves of *Cucurbita maxima* obtained a reduction percentage of 33.3%, this plant is of same family as *Telfairia occidentalis*. As such, heat might have been favorable for the solubilisation of the phytates contained in these leaves during boiling as well as scrubbing might have ruptured cells thereby facilitating the liberation of phytates into the water from scrubbing. It is known that phytates reduces the bioavailability of Ca, Mg, Fe and Zn (Anyum *et al*., 2002) [7]. Low phytates concentrations helps in the management of diabetes and obesity (Sanchis *et al*., 2018).

Table 4 shows that treatment had a positive effect on saponin contents. As raw leaves and scrub with salt powders had a high saponine contents 11.00±0.05 mg/100g DM and 11.62±0.60 mg/100g DM respectively compared to the boiled samples, as analysis showed no significant difference (P<0.05) amongst these samples. Similarly, samples further treated with egusi (BLCE, SBCE and SSCE) had contents of 1.12±0.57 mg/100g DM 0.90±0.24 mg/100g DM and 0.69±0.56 mg/100g DM, respectively showed no significant difference (P< 0.05). These differences could be explained by factors such as age of the plant before harvest, genetic diversity, harvesting season as reported (Kajihausa *et al*., 2010) [36]. The leaves in contact with hot water might have favored the rupture of cell membranes. As such, saponines would have been liberated and drained into boiling water. (Ejoh *et al.*, 2017) [24] working *Cucurbita maxima* leaves made the same observations where they recorded losses upto 60.08% after bleaching and 81,5% after bleaching in the presence of limestone. A high saponin content has been shown to provoke gastro-enteritis manifested by diarrhoea and dysentery (Marrelli *et al*., 2016) [42]. Saponins have also been observed to kill protozoans and molluscs and act as antifungal and antiviral agents (Rahal *et al.*, 2014) [50]. This implies that *T. occidentalis* might have higher potential in fighting against microorganisms such as fungi and viruses, as well as exhibits greater antioxidant activity and prevents liver damage.

There was a significant difference (P< 0.05) observed in all the samples as concerns tanin. With the highest values 28.47±0.10 mg/100g DM reported in the boiled leaves followed by the boiled with limestone 27.14±0.05 mg/100g DM, then 19.54±0.07 mg/100g DM for the scrub with salt samples. This same trend is noticed in the samples that were further treated with the addition of egusi. All these were more than the 13.47±0.50 mg/100g DM reported in the raw leaves. Tanins are components soluble in water and can significantly be reduced during bleaching (Adepoju and Karim, 2004). Meanwhile, it is to note that the biological properties of tanins are principally linked to their capacities to form complexes with macromolecules, particularly proteins, as their phenolic groups are good hydrogen donnors. As such, they form solid hydrogen bonds with the carboxylic groups of proteins that present a higher affinity with them (Rira, 2006) [52]. In the presence of heat, there is the hydrolysis of this complex that might have been formed between tanins and proteins thereby facilitating the liberation of tanin molecules making them more available in the reaction medium. This phenomenon might be the reason for the increase in tanin contents of the treated samples. It should be noted that the RDA value for tanins is 150 to 200 mg/100g as reported (Schiavone *et al*., 2008) [53]. This proves that tanin contents of *Telfairia occidentalis* obtained in this study are relatively low and therefore present no hindrance to the bioavailability of proteins. In medicine, especially in Asia (Japanese and Chinese) tanin-containing plant extracts are used as astringents, against diarrhoea, as diuretics, against stomach and duodenal tumors, and as anti-inflammatory, antiseptic, antioxidant and hemostatic pharmaceuticals (Dolara *et al*., 2005) [22]. This implies that this plant might have high potential in natural healing and prevention of inflammation.

Results from analysis expressed in mg of Fe II/100g of DM as seen on the table above. It can be noticed that extracts obtained all contained a reducing power activity with values significantly different ($p<0.05$) to that of gallic acid (142.11±3.10mg of Fe II/100g DM).

DPPH• antiradical activity realised in this study was represented by the inhibitory concentration 50 (IC_{50}) of extracts, which represents the antioxidant concentration necessary to reduce the initial DPPH• concentration by 50%. The IC_{50} values obtained from the percentage inhibition regression were expressed in µg/ml and presented in the above table. The IC_{50} are inversely proportional to the scavenging effects and the low values reflect an important antiradical activity (Fadili *et al*., 2017) [28]. The IC_{50} of the ethanolic extracts tested were respectively 43.25±0.28 µg/mL; 44.38±0.28µg/mL; 45.82±0.29µg/mL; 48.98±0.17 µg/mL; 50.00±0.00 µg/mL; 51.97±0.66 µg/mL; and 77.24±0.86 µg/mL for SSCE, BL, SBCE, BLCE, SB, SS and RL respectively. These activities significantly different ($p < 0.05$), amongst samples were largely inferior to that of gallic acid (0.67±0.00 µg/mL) used as reference antioxidant in this study.

5. Conclusion

In conclusion, the findings of this research work showed that the Lesser-Known Vegetables (LKVs) *Telfairia occidentalis* are good sources of macro and micronutrients in respect to high protein content, vitamin C, Calcium, and Iron as well as antioxidants. They could be useful as possible sources for combating mineral or macronutrient deficiencies.

The pretreatment methods used by households ameliorate the protein contents, while awaiting studies on its bioavailability, they give the leaves of *Telfairia occidentalis,* and the dishes cooked from these leaves a benefit as a good source of macronutrients, micronutrients and antioxidants. Despite the treatment, method used there was a significant reduction of 81% in antinutrients.

6. References

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