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(RESEARCH ARTICLE)

Influence of cooking methods on the nutritional composition of *Telfairia occidentalis* leaves

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Abstract

The present study was conducted to determine the influence of cooking methods on the nutritional potential of *Telfairia occidentalis* leaves. Standard methods were used for the analysis of nutrient and anti-nutrient contents. The analyses were carried out in triplicate and the results showed that raw *T. occidentalis* leaves contain interesting levels of crude fibre (25.3 g), carbohydrates (24.3 g), protein (24 g), fat (8.2 g) and ash (8.3 g). The descending order of mineral content obtained in this study is as follows: K> Ca>Mg>P>Fe>Mn>Na>Zn>Cu. The boiled samples without kanwa (rock salt) had the highest contents of crude fibre, calcium, zinc and copper. However, these leaves contained antinutrients such as oxalates (31.3 mg), phytates (1.3 mg), saponins (23.6 mg). These antinutrients were considerably reduced by cooking. In the boiled samples without kanwa (rock salt), we observed the highest reduction rates: 70.4% for oxalates and 53.8% for phytates. It would therefore be very beneficial to consume *Telfairia occidentalis* leaves boiled without kanwa (rock salt).

Keywords: *Telfairia occidentalis*; Cooking; Kanwa; Nutritional potential; Antinutrients

1. Introduction

Called 'ugu' in Nigeria and 'okonghobong' in Cameroon [3], *Telfairia occidentalis* is a perennial, dioecious, climbing herbaceous plant. This vegetable, from the Cucurbitaceae family, is widespread in the forest regions of West and Central Africa, particularly in Nigeria, Benin and Cameroon [34]. *Telfairia occidentalis has been the* subject of numerous investigations. The leaves of this vegetable contain essential oils and vitamins, while its roots contain cucurbitacin, sesquiterpenes and lactones. As a result, it has lactating properties and is used by lactating women [42]. The work of Kajihausa *et al.* [24] and Idris [23] in Nigeria has focused on the nutritional potential of the leaves of this plant. Ehiagbonare [15], showed that young leaves of *T. occidentalis* are used for the treatment of convulsions. These leaves are rich in iron and play a key role in the treatment of anaemia. In Cameroon, work by Leslie *et al.* [27] has shown that *Telfairia occidentalis* plays an important role in the management of anaemia. *T. occidentalis* is used in soups and in herbal medicine. Generally, the cooked leaves are staple vegetables in soups and stews in various cultures across equatorial Africa [13]. Lawal *et al.* [26] have shown that fresh vegetables have a high content of certain nutrients compared to vegetables that have undergone any processing. This is because vegetables are highly perishable and require careful processing to preserve nutrients, especially water-soluble vitamins [37, 22].

In Cameroon, housewives usually cook leafy vegetables with or without kanwa [18]. The nutritional value of leafy vegetables therefore depends on the method of preparation [22]. This work therefore proposes to study the influence

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of cooking with and without *kanwa* on the nutrient and anti-nutrient content of *Telfairia occidentalis* leaves*, in* order to provide information on the best preparation method to conserve nutrients for food security and health of the populations.

2. Material and methods

2.1. Sampling

The young leaves of *Telfairia occidentalis were* collected from a family garden in the city of Yaoundé, Centre region of Cameroon during the rainy season of july. They were put in a clean bag and taken to the laboratory of Food Science and Metabolism of the University of Yaoundé 1. The leaves were trimmed, stalks removed, washed with distilled water and cut into small pieces of about 1cm. They were divided into three batches of 500 g and treated differently as indicated in Table 1. At the end of each treatment, the samples were oven dried at 45°C for 24 hours. They were then ground to powder using a *XANFORD* electric grinder and sieved with a 2 mm sieve. The powders obtained were stored in hermetically sealed glass jars and then used for the various analyses in the laboratory.

Table 1 Treatment methods of *T. occidentalis* leaves

Lots	Batch 1	Batch 3	Batch 4
Treatments applied to the leaves of *T. occidentalis*	500 g of raw vegetable (control)	500 g of vegetables cooked in 3,5L of boiling water for 25minutes	500 g of vegetable cooked in 3,5L of boiling water, with 20g of kanwa for 10 minutes

2.1.1. Rock salt (kanwa)

Kanwa is a fossil salt extracted from mines composed of other minerals. It is very rich in sodium carbonate, (NaCO3, NaHCO3, 2H2 O) [30] and can contain up to 99% depending on the deposit. In cooking, Cameroonian women use rock salt to soften foods that are difficult to cook and to reduce the effects of flatulence (beans, cowpeas), to wash vegetables in order to better preserve their green colour and to make okra less sticky [30, 18].

2.2. Analysis of the chemical composition of the leaves of *Telfaira occidentalis*

The ash content was obtained after incineration at 550 °C for 24 hours. The determination of the mineral content of *Telfaira occidentalis* leaf powders was carried out by the method described by Benton and Vernon [8]. Minerals such as calcium, magnesium, iron, zinc, manganese, and copper were determined by the spectrophotometric method [5]. The potassium and sodium contents of the samples were determined by flame photometry. The total lipid and protein contents of the samples were determined by the Bourely method [10] and the Kjeldahl method [11] respectively. Total carbohydrates were determined by the difference method described by A.O.A.C [4]. Crude fibre was determined by the method described by A.O.A.C [5].

The oxalate content of *Telfairia occidentalis* leaves was determined by the titration method [1]. The determination of phytic acid content was carried out by the method of Olayeye *et al* [36]. The determination of saponins was carried out by the method of Obadoni et *al* [32]. For condensed tannin content, the method described by Ndhlala *et al* [30] was used. The results were processed by analysis of variances at a threshold of 5% with SPSS 20.0 software and Duncan's multiple comparison test.

3. Results and discussion

3.1. Influence of the type of cooking on the proximal composition of *T. occidentalis* leaves

The ash content varied with the type of cooking applied. Indeed, the ash content of the samples ranged from 6.21±0.04 g/100 g DM for leaves boiled simply in water (FB) to 8.95±0.29 g/100g DM for leaves boiled with kanwa (FBN). A value of 8.35±0.01 g/100g DM is noted in the raw leaves. Compared to the raw vegetables, those boiled simply in water showed a reduction of 25.63%. The decrease in ash content observed in this study was also found in boiled leaves of *Amaranthus hybridus* [43]. Boiling opened the cell membrane of the leaves, exposing the elements contained therein to leaching. The minerals in the leafy vegetables diffuse into the cooking water [27]. This explains the low ash content recorded in boiled leaves. The ash content of 8.35±0.01g/100g DM found for raw leaves of *Telfairia occidentalis* is not far from that obtained by Kajihausa *et al* [24] in Nigeria for the same leaf vegetable. This shows that these leaves contain significant amounts of mineral elements. Therefore, they are considered sufficiently high compared to the crude ash contents reported by Salazar *et al* [38] in commonly consumed leafy vegetables such as lettuce (*Lactuca sativa*) (0.4% DM), spinach (*Spinacia oleracea*) (0.7% DM). After cooking *T. occidentalis* leaves with kanwa, we observed an increase in ash content, which is in line with the observation made in Niger after cooking cowpea grains with various masses of rock salt [6]. Indeed, it has been shown that kanwa consists mainly of minerals [39, 31], and its addition to the feed can only increase the mineral content.

The different lipid contents of *Telfairia occidentalis* leaf powders ranged from 8.2±0.03g/100g DM (FC) to 10.9±0.12g/100g DM (FBN). The boiled leaf samples without kanwa gave a value of 10.3±0.3g/100g DM. The analysis of variance showed that there was no significant difference ($p > 0.05$) between the boiled samples with and without kanwa. Compared to the raw samples, there was an increase of 32.9% for the boiled leaf samples with kanwa and 25.6% for those boiled without kanwa. The increase would also be due to water loss and dry matter concentration observed after cooking and drying [43]. The lipid content obtained in this study is similar to that obtained (8.19 g/100g DM) in Nigeria on the same leafy vegetable [24]. Lipids promote the utilisation of fat-soluble vitamins such as β-carotene. However, the dietary importance of these lipids depends much more on their fatty acid composition.

The raw leaves of *T. occidentalis* analysed gave a protein content of 24.0±0.8 g/100g DM and those boiled just 21.7±0.7 g/100g DM. This content becomes low when these leaves are boiled with kanwa, (17.2±0.7 g/100g DM.) This corroborates the results of researchers in Benin [24] who observed a decrease in protein content after boiling of *Amaranthus hybridus* leaves. The decrease in protein content after cooking with kanwa is thought to be due to the alkalinity of this salt, which promotes protein solubility [19, 31].

The results of the protein content found in this study are similar to those from Nigeria [19] who obtained a value of 25.2±0.1 g/100g DM for raw leaves. For a series of eight leafy vegetables in the Adamaoua savannah of Cameroon, Tchiégang and Kitikil [40], found protein contents ranging from 18.39 to 26.48 g/100g DM. The significant protein content of *T. occidentalis* indicates that it could be a potential source of cheaper protein available to consumers. Tropical leafy vegetables can therefore contribute to food security for poor populations [12]. Boiling the leaves of T. *occidentalis* without kanwa considerably reduced the carbohydrate content. The raw leaves were reduced from 24.8 g/100 g DM to 1.2 g/100g DM. This represents a reduction of 95%. Those boiled with kanwa have a content of 14.1 g/100 g DM. The carbohydrates, known as water-soluble molecules, would have been solubilized in the cooking water [9, 17]. The mean values of crude fibre content of *T. occidentalis* leaf powders raw and cooked with or without kanwa were 25.3 g/100 g DM, 34.6±0.3 g/100 g DM and 38±0.4 g/100 g DM respectively. Statistical analysis showed a significant difference ($p < 0.05$) between these samples.

This value of 25.3 g/100g DM is higher than that obtained in Nigeria (15.4±0.01 g/100g DM) on powders of the same leaves [3]. This difference can be explained by genetic diversity, seasonality and the stage of maturity of the plant [25]. The lowest fibre value is recorded in raw leaves (25.3 g/100g DM). The fibre value of simply boiled *T. occidentalis* leaves and those boiled with kanwa were higher.

Table 2 Influence of cooking on macronutrients (g/100g DM) of *T. occidentalis* leaves

Elements	**FC**	**FB**	**FBN**
Dry matter	96±0.1^{a}	90.6±0.3^{a}	90.2±0.5^{a}
Total ash	8.3±0.01^{b}	6±0.04^{a}	8.9±0.3^{b}
Total fat	8.2±0.03^{a}	10.3±0.3^{b}	10.9±0.1^{b}
Total protein	20±0.9^{c}	21.7±0.7^{b}	17.2±0.7^{a}
Total carbohydrates	24.8±0.1^{c}	12±0.0^{a}	14.1±0.0^{b}
Crudes fibres	25.3±0.7^{a}	38±0.4^{c}	34.6±0.3^{b}

Means assigned different letters in the same rows are significantly different ($p<0.05$). FC: Raw leaves; FB: Boiled leaves; FBN: Boiled leaves with Kanwa.

Cooking in this study increased the fibre content to 75%. In Benin, Ocinum *gratissimum* leaves boiled in water for 15 minutes had a value of 11.55 g/100g DM with an increase of 51.41%. During cooking, some nutrients would have been solubilized in the cooking water making the fibre contained in the plant material more available. Fibre is important for the body because it acts in the digestive tract and prevents the absorption of excess nutrients [28]. Fibre also slows down the absorption of carbohydrates and thus slows down the rise in blood sugar [13]. Therefore, boiled *T. occidentalis* leaves, especially those boiled without kanwa, could be used as a source of fibre for blood glucose control.

3.2. Influence of cooking on minerals.

From the results presented in Table 3, potassium was the most abundant mineral (1983 mg/100g DM) in raw leaves of *T. occidentalis*, followed by calcium (982±0.57 mg/100g DM) and magnesium (519.2±0.47 mg/100g DM). Sodium showed a lower content (15.5 mg/100g DM) compared to iron (24.2 mg/100g DM) and manganese (21.18 mg/100g DM). Copper, present in very small quantities (1.2 mg/100g DM) comes after zinc (3.36 mg/100g DM). Cooking reduced the K, P, Mg and Fe contents. While an increase in Mn and Zn content was observed in the samples cooked with kanwa. With the same type of cooking, a very large increase in sodium content was recorded. Indeed, the sodium content increased from 15.5/100g DM in the raw samples to 223.7 mg/100g DM in the samples boiled with kanwa.

The very high potassium content shows that these leaves are a good source of potassium. Potassium is nutritionally important for PH regulation and the proper functioning of carbohydrate and protein metabolism. It should be noted that deficiency of this macroelement causes effects such as palpitation, abdominal restriction, nausea and constipation [2].

Calcium and magnesium levels in *T. occidentalis* leaves are higher than those reported in Nigeria [7]. Zinc and copper levels are lower than those found by Kajihausa *et al* [23] on the same leaves. These observed differences could be explained by factors such as harvesting season, age of the plant before harvesting, soil type, genetic diversity and other environmental factors [24, 23].

Table 3 Influences of cooking on minerals (mg /100g DM) of *T. occidentalis* leaves

Elements	FC	FB	FBN
K	1283.1±0.6^{c}	437.1±0.6^{a}	589±0.6^{b}
Na	15.5±0.0^{a}	18±0.0^{b}	223.7±0.1^{c}
Ca	982±0.6^{a}	1333.6±0.7^{c}	1140.37±0.6^{b}
P	293.2±0.9^{b}	210.3±1.4^{a}	291.1±1.2^{b}
Mg	519.2±0.5^{c}	303.1±0.6^{a}	399.2±0.6^{b}
Cu	1.2±0.0^{b}	1.3±0.01^{c}	1±0.0^{a}
Fe	24.2±0.5^{b}	20.8±0.7^{a}	21.3±0.5^{a}
Mn	21.18 ±0.0^{a}	21.04±0.02^{a}	30.29±0.05^{b}
Zn	3.36±0.0^{a}	8.34±0.0^{c}	3.79±0.02^{b}

Means assigned different letters in the same rows are significantly different (p<0.05). FC: Raw leaves; FB: Boiled leaves; FBN: Boiled leaves with Kanwa.

In general, the analysis of variance performed on the mineral contents of *Telfairia occidentalis* leaves shows a significant difference (p<0.05) between raw and cooked samples. There was a significant reduction in mineral content in the boiled leaf samples. This reduction could be explained by the fact that the minerals released during cooking would have diffused into the cooking water. In the case of iron, the boiled samples with and without kanwa showed no significant difference at the 5% significance level, with values of 20.8±0.7 mg/100g DM and 21.3±0.5 mg/100g DM respectively. Cooking caused a reduction in iron content with 12% and 14% respectively after cooking with kanwa and cooking without kanwa. This reduction in iron content is in line with the results of Bamidele *et al* [7] and Ejoh *et al* [18] after simple cooking of leafy vegetables and cooking with kanwa respectively. During cooking, there would have been Solubilisation of iron and its drainage into the cooking water.

Iron is required for the formation of haemoglobin and myoglobin, which are important proteins for oxygen transport [21]. Iron deficiency causes the anaemia described as the most common nutritional deficiency in the world [40]. Leslie *et al* [26] have shown in a study in Cameroon that *T. occidentalis* leaves are highly effective in combating anaemia.

The significant increase in Na after cooking with kanwa would be due to the kanwa used. Indeed, kanwa, due to its composition, is said to contain a high sodium content (812.38 ± 38.73mg/100gMS) [18]. From the known composition of traditional salts like kanwa, sodium is the most important cation. Since the consumption of sodium in edible salt is implicated in non-communicable diseases, kanwa could therefore have negative health effects if consumed in excess [30]. For example, excessive consumption of sodium in food promotes high blood pressure or oedema in some people [16].

Telfairia occidentalis, as observed earlier, have good nutritional potential. Leafy vegetables contain natural compounds that act as anti-nutritional factors interfering with the utilization of certain nutrients. These include phytates, oxalates and saponins [22].

3.3. Influence of cooking methods on antinutrients in *T. occidentalis* leaves.

The low oxalate content (31.3±0.1 mg/100g DM) in raw *T. occidentalis* leaves was further reduced with cooking (Table 4). For the boiled samples with and without kanwa, 13±0.01 mg/100g DM and 9.3±0.01 mg/100g DM respectively were recorded, i.e. a reduction of 58% and 70%. The same reduction trend was found by Ejoh *et al* [18] who showed respective reduction rates of 41% and 54%for *Hibiscus canabinum* leaves boiled with and without kanwa. The soluble oxalates in the leafy vegetables are drained into the water during cooking [34]. It is known that regular consumption of oxalates can induce kidney disease. Oxalic acid is an antagonist of calcium utilization [21]. The oxalate/calcium ratios (0.007- 0.01) obtained in this study are well below the critical value of 2.5 (Table 5), thus predicting better Ca bioavailability.

The phytate content (1.34±0.02 mg/100g DM) was significantly reduced with cooking. Indeed, in the leaves boiled with and without kanwa, a reduction of38.4% and 53.8% respectively was observed. The observed reduction would be due to their degradation by heat or to the formation of insoluble phytic acid-protein or phytic acid-protein-mineral salt complexes [34]. A high phytate content reduces the bioavailability of minerals. The phytate/Ca, phytate/iron, phytate/Zn ratios obtained in this study are very low (0.001; 0.055 and 0.399) compared to the critical values (Table 5) outlined by Obah and Amusan [32]. Thus, a low content of this substance would allow a better utilisation of proteins and minerals such as iron, calcium and zinc by the body [18].

The saponin content (23.6 mg/100g DM) followed the same logic but with a lower reduction rate. The reduction observed in the saponin content after the different cookings shows that they would have been leached and drained in the cooking water. High saponin levels cause gastroenteritis manifested by diarrhea and dysentery [20].

Table 4 Influence of cooking on anti-nutritional factors (mg/100g DM) of *T. occidentalis* leaves

Elements	**FC**	**FB**	**FBN**
Oxalates	31.4±0.1^{c}	9.3±0.01^{a}	13±0.01^{b}
Phytates	1.3±0.0^{c}	0.6±0.0^{a}	0.8±0.0^{b}
Saponins	23.7±1.0^{b}	1.0±0.8^{a}	18.3±0.4^{a}

Means assigned different letters in the same rows are significantly different ($p < 0.05$). FC: raw leaves; FB: boiled leaves; FBN: leaves boiled with Kanwa

Table 5 Antinutrient/mineral ratios of *T. occidentalis* leaves

	Oxalates/Ca	**Oxal/(Ca+Mg)**	**Phy/Zn**	**Phy/Fe**	**Phy/Ca**
Critical values	**2.5**	**2.5**	**10-15**	**1**	**0.4**
FC	0.03	0.02	0.40	0.06	0.00
FB	0.01	0.06	0.07	0.03	0.00
FBN	0.01	0.01	0.20	0.04	0.00

FC: Raw leaves; FB: Boiled leaves; FBN: Boiled leaves with Kanwa.

4. Conclusion

From the above results, it appears that *T. occidentalis* has an interesting source of protein, fibre and minerals such as K, Ca, Mg, Fe, Mn, Zn. Also, a low level of Na and the presence of trace amounts of Cu were noted. Both types of cooking influenced the nutritional potential of *T. occidentalis*. Indeed, the use of kanwa during cooking brought a very high amount of sodium, a slight amount of other minerals and a decrease in the amount of protein. Cooking without kanwa considerably reduced the antinutrient content and increased the fibre content. Studying the bioavailability of the nutrients in this leafy vegetable and optimizing its cooking method would lead to more effective use in population health.

Compliance with ethical standards

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Author's contribution

Elie FOKOU and Mercy ACHU LOH BIH designed the study, Ruth Viviane DJUIKWO NKONGA wrote the manuscript Germaine YADANG analyzed the data, Mathurin KIDJE NEGUEM carried-out the experimentations and biochemical analyses.

Disclosure of conflict of interest

The authors in this paper have no of conflict of interest.

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