Effects of Heating Temperature and time on the Nutrients and Antinutrients Composition of *Telfairia occidentalis* (Hook F.)

Imaobong Udousoro ¹ *, Bassey Etuk ²

¹ Chemistry Department, University of Uyo, Uyo, Akwa Ibom State, Nigeria
² Department of Science Technology, Akwa Ibom State Polytechnic, Ikot Osuru, Ikot Ekpene, Nigeria

* Author to whom correspondence should be addressed; E-Mail: imaobong2i@yahoo.com.

**Article history:** Received 6 September 2012, Received in revised form 5 October 2012, Accepted 6 October 2012, Published 7 October 2012.

**Abstract:** The effect of heat treatment and time on proximate and some antinutrient composition of *Telfairia occidentalis* (Hook F.) were investigated. Analyses were carried out on fresh samples of *Telfairia occidentalis* and samples were heated at 50 °C for 5 min, 50 °C for 15 min, 90 °C for 5 min and 90 °C for 15 min. The result of parameters studied ranged 1.29 - 1.78% (fibre), 6.65 - 12.60% (protein), 4.00 - 13.40% (crude fat), 0.27 - 4.28% (carbohydrate) and 103.52 - 148.28 kcal (caloric value) in the fresh samples. On heat treatment some parameters showed percentage reduction ranging 66.58 to 93.69%, 13.80 to 46.98%, 5.05 to 27.50%, and 6.71 to 27.90% for carbohydrate, protein, crude fibre, and ash respectively, while crude fat (110 to 235%) showed percentage increase. Values of antinutrients in fresh samples were 0.001 - 0.0114 mg/100 g (HCN), 13.20 - 105.60 mg/100 g (oxalate), 56.09 - 64.71 mg/100 g (phytate) and 0.95 - 3.1 mg/100 g (tannin). The percentage reduction on heating ranged 24.80 to 69.00% (tannin), 3.80 to 66.60% (oxalate), 56.66 to 91.00% (HCN), and 0.81 to 13.00% (phytate). HCN recorded the highest percentage reduction at 90 °C for 15 min and phytate showed the least reduction at same temperature. The result showed that increase in temperature decreased the carbohydrate, crude fibre, protein, and ash contents of *Telfairia occidentalis*, while the crude fat content increased. For the antinutrients, the levels generally reduced with raised temperature. Caution therefore should be exercised in cooking the vegetable (< 90 °C for 5 min advisable) to retain maximum amounts of nutrients.

**Keywords:** *Telfairia occidentalis*; heat treatment and time; proximate composition; antinutrients.
1. Introduction

*Telfairia occidentalis* is a vegetable which is an important food component in diets in the Niger Delta region of Nigeria. Vegetables contain nutrients which can be absorbed by the human system for body building, energy, and regulatory and protective functions. They are also sources of vitamins, minerals and phytochemicals like flavonoids, carotenoids and polyphenols [1-4]. The vitamin contents in fruits and vegetables are nutritionally superior when compared to many cereals and legumes [5].

Fluted pumpkin is a member of the Cucurbitae family and belongs to the genus *Telfairia occidentalis*. It is a vegetative shrub that creeps low across the ground with large lobed leaves and long twisting tendrils. *T. occidentalis* is commonly grown in the Niger Delta region of Nigeria for its nutritional leaves and seeds. Locally it is called *ubong* by the Efiks and Ibibios, *ugu* by the Igbos, and *eweroko* by the Yorubas [6].

Longe et al. [7] reported that the leaves of *T. occidentalis* are rich in minerals like iron, potassium, sodium and phosphorus. It is also rich in antioxidants and phytochemicals such as phenols, and vitamin C. Vegetables are believed to help reduce blood pressure, improve digestion and enhance healthy metabolism. Young leaves of *T. occidentalis* sliced and mixed with coconut water and salt are used to treat convulsion in ethnomedicine and the roots are used as a rodenticide [8]. The leaf extract is useful in the management of hypercholesterolemia, liver problems and impaired immune defence system [9]. Vegetables are also known as excellent sources of natural energy boosters.

Processing makes food safe for consumption and destroys pathogenic microorganisms. The effect of processing on food depends on the sensitivity of the nutrient to the various prevailing conditions such as heat, oxygen, pH and light [10]. However, it is necessary that vegetables are prepared in such a manner that retains maximum amounts of their nutrients, while losses through oxidation and leaching are highly minimized [1]. The aim of this research therefore, is to determine the effect of different heat treatments with time on proximate and antinutrient compositions of *Telfairia occidentalis*.

2. Materials and Method

*Telfairia occidentalis* was obtained from the botanical garden of Akwa Ibom State Polytechnic and identified in the Department of Botany, University of Uyo, Nigeria. Healthy green leaves were removed from the tendrils on reaching the laboratory, washed to remove dirt and dust particles and sliced into thin threadlike pieces with stainless steel knife as usually done during local cooking. The fresh sliced leaves were boiled with distilled deionised water in the ratio one part of vegetable: four parts of water at 50 °C for 5 min, 50 °C for 15 min, 90 °C for 5 min and 90 °C for 15 min. Fresh *T. occidentalis* leaves were used as the control. At the completion of the heating periods, the samples
were filtered and the residues obtained were oven dried at 60 °C to a constant weight and ground into powder using the mortar and pestle and stored in air-tight polythene bags until analysis. The analysis for nutrients and antinutrients compositions of the different samples was performed according to the standard methods specified by AOAC [11]. Statistical analysis was preformed with Microsoft Excel.

3. Results and Discussion

3.1. Effect of Heat Treatment on the Proximate Composition of Telfairia occidentalis

The effect of heat treatment on the proximate composition of Telfairia occidentalis is presented in Tables 1 and 2. It was observed that the ash, fibre, protein and carbohydrate contents of Telfairia occidentalis decreased with increasing temperature and heating period.

The level of ash ranged from 1.93% (at 90 °C/15 min) to 2.50% (50 °C/5 min). The mean ash content of the fresh vegetable was slightly higher (2.68%) than that reported by Saidu and Jideobi [1]. The ash content was found to decrease as the temperature and time of heating increases. The percentage reduction in ash with temperature ranged from 6.71% (50 °C/5 min) to 27.9% (90 °C/15 min), and the greatest reduction was observed at 90 °C for 15 min. Ash constitutes the total inorganic matter in a sample. The results showed that heating reduced the availability of the minerals in the vegetable, and this may be due to leaching into water during heating and volatilization of the minerals during ashing [12]. Although most minerals have low volatility at temperatures between 500 - 600 °C (ashing temperature), some are volatile and may be partially lost e.g. iron, lead, and mercury [13].

Table 1. The effect of heat treatment on the proximate compositions of Telfairia occidentalis

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ash (%)</th>
<th>Fibre (%)</th>
<th>Protein (%)</th>
<th>Crude fat (%)</th>
<th>Carbohydrate (%)</th>
<th>Caloric value (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No treatment</td>
<td>2.68 ± 0.31</td>
<td>7.78 ± 0.15</td>
<td>12.60 ± 0.01</td>
<td>4.00 ± 0.30</td>
<td>4.28 ± 0.05</td>
<td>103.52 ± 1.06</td>
</tr>
<tr>
<td>50 °C/5 min</td>
<td>2.50 ± 0.13</td>
<td>2.65 ± 0.20</td>
<td>10.85 ± 0.04</td>
<td>8.40 ± 0.25</td>
<td>1.43 ± 0.01</td>
<td>124.72 ± 0.05</td>
</tr>
<tr>
<td>50 °C/15 min</td>
<td>2.50 ± 0.15</td>
<td>1.67 ± 0.30</td>
<td>10.50 ± 0.05</td>
<td>8.50 ± 0.27</td>
<td>1.04 ± 0.04</td>
<td>122.30 ± 0.07</td>
</tr>
<tr>
<td>90 °C/5 min</td>
<td>2.03 ± 0.33</td>
<td>1.35 ± 0.35</td>
<td>7.70 ± 0.02</td>
<td>11.60 ± 0.20</td>
<td>0.63 ± 0.03</td>
<td>137.72 ± 0.12</td>
</tr>
<tr>
<td>90 °C/15 min</td>
<td>1.93 ± 0.34</td>
<td>1.29 ± 0.10</td>
<td>6.65 ± 0.01</td>
<td>13.40 ± 0.20</td>
<td>0.27 ± 0.01</td>
<td>148.28 ± 0.10</td>
</tr>
</tbody>
</table>

Note: Mean of three samples ± S.D.

Table 2. Percentage change in proximate compositions of Telfairia occidentalis after heat treatments

<table>
<thead>
<tr>
<th>Proximate composition</th>
<th>50 °C/5 min (%)</th>
<th>50 °C/15 min (%)</th>
<th>90 °C/5 min (%)</th>
<th>90 °C/15 min (%)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>6.71</td>
<td>6.71</td>
<td>24.20</td>
<td>27.90</td>
<td>Decrease</td>
</tr>
<tr>
<td>Crude Fibre</td>
<td>5.05</td>
<td>6.10</td>
<td>24.10</td>
<td>27.50</td>
<td>Decrease</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>13.80</td>
<td>16.60</td>
<td>38.88</td>
<td>46.98</td>
<td>Decrease</td>
</tr>
<tr>
<td>Crude Fat</td>
<td>110.00</td>
<td>112.50</td>
<td>190.00</td>
<td>235.00</td>
<td>Increase</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>66.58</td>
<td>75.70</td>
<td>85.28</td>
<td>93.69</td>
<td>Decrease</td>
</tr>
</tbody>
</table>
Crude fibre content reduced in the pattern: no treatment > sample treated at 50 °C/5 min > sample treated at 50 °C/15 min > sample treated at 90 °C/5 min > sample treated at 90 °C/15 min. The percentage reduction was 5.05% (at 50 °C/5 min) to 27.7% (at 90 °C/15 min). This decrease may be due to the dissolution of dietary fibre portions soluble in acids and alkali used during the analysis; also, hemicellulose components such as arabinogalactan are highly branched and water soluble, while pectins and hydrocolloids are easily solubilized by heat [14]. Bello et al. [15] reported that crude fibre consists mainly of cellulose, hemicellulose and lignin components whose compositions are affected during hydration of food. Hemicellulose, pectin and hydrocolloids are easily solubilized by heat and this may be the reason for the above reduction. Crude fibre has been linked with reduction of incidences of rectum-colon cancer, diabetes, and cardiovascular diseases [13]. The above result may imply that heat treatment could reduce the nutraceutical potentials of T. occidentalis.

The result for crude protein followed same trend as observed for crude fibre. The mean value of fresh protein in this study (Table 1) was higher than the range reported by Saidu and Jideobi [1] for T. occidentalis grown in Minna, Nigeria (2.4%). There was 13.80% (at 50 °C/5 min) to 46.98% (at 90 °C/15 min) reduction in protein as a result of heat treatment (Table 2). The RDI value of protein is (23 - 36 mg/100 g) for children, and (44 - 60 mg/100 g) for adults [16]. Rahama and Mustapha [12] reported that increase in temperature can cause severe protein damage in food ranging from destruction of amino acid to complete racemisation. Also, Komolafe and Obayanju [17] reported that during heating, cellular protein are denatured and chloroplyll which are bound to the protein, may be released. Such free chlorophyll is highly unstable and readily converted to pheophytin, which could enhance denaturation of protein when heated. Heat denatures two groups of the most abundant protein moiety, namely: myofibrillar and sarcoplasmic protein. Alais and Linden [18] reported that heat causes breakage in the myofibrillar protein bonds. As the heat increases, the moisture in the protein evaporates and the protein loses flexibility and mass. The reduction in solubility accompanied by coagulation affects the level or availability of crude protein. Onyeike et al. [19] reported reduction in protein level as the result of heat on some Nigerian selected staple food while Hassan et al. [14] reported reduction in the protein level of the leaves of Leptadenia hastate as a result of drying.

The crude fat values showed increase in trend as follows: no treatment < sample treated at 50 °C/5 min < sample treated at 50 °C/15 min < sample treated at 90 °C/5 min < sample treated at 90 °C/15 min. This may be due to the increase in the extraction efficiency of crude fat by organic solvents as the rate of heating increases [13]. 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 [20]. The percentage increases in crude fat after heat treatments are shown in Table 2.
A decreasing trend was observed at different heat temperature and time for carbohydrate just like ash, crude fibre, and crude protein as shown in Table 1. The percentage reduction of carbohydrate ranged from 66.58% (at 50 °C/5 min) to 93.89% (at 90 °C/15 min). Increased temperature reduced the carbohydrate content of the vegetable drastically and hence limits its possible usefulness as an energy source. Carbohydrate is made up of starches and sugars. Heating starches changes crystallized starch molecules into gels during which the starch granules swell and absorb water becoming soft and easier to dissolve [10]. The result obtained in this study is consistent with that reported by Onyeike et al. [2] that heat processing decreased the ash, protein, fibre and carbohydrate content of some vegetables consumed.

3.2. Effect of Heat Treatment on the Antinutrient Compositions of Telfairia occidentalis

The effect of heat treatment on antinutrient compositions and percentage reductions in *T. occidentalis* are presented in Tables 3 and 4, respectively.

### Table 3. The effect of heat treatments on some antinutrient compositions of *Telfairia occidentalis*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>HCN (mg/100 g)</th>
<th>Total oxalate (mg/100 g)</th>
<th>Soluble oxalate (mg/100 g)</th>
<th>Tannin (mg/100 g)</th>
<th>Phytate (mg/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Treatment</td>
<td>0.0114</td>
<td>105.60</td>
<td>39.60</td>
<td>3.104</td>
<td>64.706</td>
</tr>
<tr>
<td>50 °C/5 min</td>
<td>0.005</td>
<td>101.20</td>
<td>30.80</td>
<td>2.333</td>
<td>64.175</td>
</tr>
<tr>
<td>50 °C/15 min</td>
<td>0.0041</td>
<td>92.40</td>
<td>26.40</td>
<td>2.120</td>
<td>62.876</td>
</tr>
<tr>
<td>90 °C/5 min</td>
<td>0.0025</td>
<td>79.20</td>
<td>17.60</td>
<td>1.174</td>
<td>57.135</td>
</tr>
<tr>
<td>90 °C/15 min</td>
<td>&lt; 0.001</td>
<td>74.80</td>
<td>13.20</td>
<td>0.950</td>
<td>56.090</td>
</tr>
</tbody>
</table>

### Table 4. Percentage reduction in antinutrients after heat treatments

<table>
<thead>
<tr>
<th>Antinutrient composition</th>
<th>50 °C/5 min (%)</th>
<th>50 °C/15 min (%)</th>
<th>90 °C/5 min (%)</th>
<th>90 °C/15 min (%)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCN</td>
<td>56.60</td>
<td>64.00</td>
<td>78.00</td>
<td>91.00</td>
<td>High Decrease</td>
</tr>
<tr>
<td>Tannin</td>
<td>24.80</td>
<td>31.70</td>
<td>62.77</td>
<td>69.00</td>
<td>Decrease</td>
</tr>
<tr>
<td>Total oxalate</td>
<td>3.80</td>
<td>12.00</td>
<td>24.50</td>
<td>28.76</td>
<td>Decrease</td>
</tr>
<tr>
<td>Soluble oxalate</td>
<td>22.20</td>
<td>33.30</td>
<td>55.50</td>
<td>66.60</td>
<td>Decrease</td>
</tr>
<tr>
<td>Phytate</td>
<td>0.81</td>
<td>2.84</td>
<td>11.71</td>
<td>13.00</td>
<td>Slight Decrease</td>
</tr>
</tbody>
</table>

The values of HCN ranged from < 0.01 mg/100 g (90 °C/15 min) to 0.005 mg/100 g (50 °C/5 min) (Table 3). Heat treatment decreased the level of HCN by 56.60% at 50 °C/5 min to 91.00% at 90 °C/15 min (Table 4). This is similar to that reported by Ajala [21]. Since the release of HCN from
glycoside precursor is an enzymatic reaction, heat treatment affects the reaction, hence the observed reduction. HCN is known to inhibit cytochrome oxidase, a respiratory enzyme. Murray et al. [22] reported that small quantities of cyanide are necessary in the conversion of inactive vitamin B_{12} (hydroxycobalamine) to the active form (cyanocobalamine). Ogunka-Nnoka and Mepba [23] found that pretreatments such as soaking, boiling, and dehulling of spices caused significant reduction in cyanide content.

The value for total oxalate ranged from 74.80 mg/100 g (90 °C/15 min) to 101.20 mg/100 g (50 °C/5 min), while soluble oxalate ranged from 13.20 mg/100 g (90 °C/15 min) to 30.80 mg/100 g (50 °C/5 min) (Table 3). Treatment type correlated positively with total and soluble oxalate reduction (R^2 = 0.934 and 0.963, respectively) (Fig 1). In addition, percentage reduction ranged from 3.80% (50 °C/5 min) to 28.76 % (90 °C/15 min) for total oxalate and 22.20% (50 °C/5 min) to 66.60% (90 °C/15 min) for soluble oxalate. The results obtained are higher than 0.50 mg/100 g reported by Ajala [21] but lower than the lethal dose of 200 to 500 mg/100 g for humans and 200 to 250 mg/100 g for pigs [24,25]. Reduction in oxalic content of treated samples may be attributed to the leaching of the acid as a result of the solubility of the neutral salts such as for sodium and potassium in water. Dietary oxalate has been known to complex with Ca^{2+}, Mg^{2+}, Fe^{2+} and phosphate ions leading to the formation of insoluble oxalate and oxalate stone [23].

The value of tannin ranged from 0.950 mg/100 g (90 °C/15 min) to 2.33 mg/100 g (50 °C/5 min). The percentage reduction after heat treatment was in the range 24.8% at 50 °C/5 min to 69.00% at 90 °C/15 min. Treatment type correlated positively with tannin reduction (R^2 = 0.900) (Fig 1). Ajala [21] reported values of 0.92 mg/100 g for raw Solanecio biofrae and 0.65 mg/100 g for boiled samples. The lethal dose of tannin is 35 mg/Kg body weight. The reduction in tannin could be attributed to the fact that tannins are polyphenols and all polyphenolic compounds are water soluble and can be leached into the heated medium [26]. Tannins are known to inhibit the activities of digestive enzymes and their nutritional effects are mainly related to their interaction with protein. Tannin-protein complexes are insoluble and protein digestibility is decreased by combining with the digestive enzymes of the intestinal tract to form a precipitate. Tannin also reduces the catalytic and hydrolytic functions of enzyme [22].
Figure 1. Relationship heat treatments and antinutrients reduction. Treatment type: 0 = no treatment, 1 = sample treated at 50 °C/5 min, 2 = sample treated at 50 °C/15 min, 3 = sample treated at 90 °C/5 min, and 4 = sample treated at 90 °C/15 min.

The level of phytate observed was in the range 56.09 mg/100 g (90 °C/15 min) to 64.17 mg/100 g (50 °C/5 min), while the percentage reduction due to heat treatments ranged from 0.81% at 50 °C/5 min to 13.00% at 90 °C/15 min (Tables 3 and 4). Treatment type correlated positively with phytate reduction (R² = 0.800) (Fig. 1). Lower values were also reported by Ajala [21], and were lower than the lethal dose of 250 to 500 mg/100 g [24]. The reduction in phytate with heating could result from the heat labile nature of phytic acid and formation of insoluble phytic-protein and phytic-mineral complexes. Phytate plays a significant role in decreasing the bioavailability of multivalent cations such as Ca²⁺, Mg²⁺, Zn²⁺, Fe²⁺ and Fe³⁺ by forming insoluble metal complexes and rendering them unavailable to man and animals. Phytate may affect digestibility by binding with substrate, amylases and proteolytic enzymes [23]. Processes such as germination, soaking, dehulling, cooking, fermentation and other autolytic treatments are known to reduce or eliminate phytate in foods [27,28].

4. Conclusions

The study has revealed that Telfairia occidentalis contains an appreciable quantity of nutrients, but increase in heating temperature and time affected its ash, crude protein, crude fibre, crude fat and carbohydrate contents. Crude fat showed percentage increase as a result of heat treatment while ash, crude protein, crude fibre and carbohydrate showed percentage reduction. The antinutrients, tannin,
phytate, oxalate (total and soluble) and hydrocyanic acid (HCN) showed percentage reduction in varying degrees as a result of heat treatments. Caution therefore should be exercised in cooking the vegetable (< 90 °C/5 min advisable) to retain maximum amount of nutrients.

References


