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Effect of the Different Drying Methods on the Chemical Composition of Fluted Pumpkin Leaves (*Telfairia occidentalis*)

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Abstract

Vegetables, primarily the leafy parts of edible plants, are vital sources of essential vitamins and minerals necessary for maintaining good health. *Telfairia occidentalis* (fluted pumpkin leaves), widely consumed among various ethnic groups in Nigeria, is a green leafy vegetable often subjected to drying for preservation and flavor enhancement. This study aimed to evaluate the impact of drying methods on the chemical composition of *T. occidentalis* leaves. Approximately 2.5 kg of fresh leaves were procured from Watt Market, Calabar (South-South Nigeria), sorted, and divided into three equal portions: a fresh (untreated) control, a sun-dried sample, and an oven-dried sample. After one month of drying, the samples were pulverized into flour, packaged in airtight containers, and stored in a cool, dry place. Proximate, elemental, and phytochemical analyses were conducted using standard methods. Results revealed a substantial reduction in moisture content from 83.01 ± 0.1% in the fresh sample to 22.60 ± 0.1% and 10.50 ± 0.2% in sun- and oven-dried samples, respectively, leading to increased dry matter. Enhanced concentrations of ash, crude protein, fat, fiber, and carbohydrates were observed, particularly in oven-dried samples (e.g., crude protein increased from 2.80 ± 0.02% to 5.13 ± 0.01%). However, mineral content declined with drying, more significantly in oven-dried samples; sodium levels, for instance, decreased from 9.30 mg/100g (control) to 7.71 mg/100g (sun-dried) and 4.34 mg/100g (oven-dried). Additionally, anti-nutritional factors and food toxicants were significantly reduced, especially in oven-dried leaves. The findings suggest that while drying enhances certain nutritional attributes, it also compromises some mineral content. Nevertheless, drying remains a viable strategy to extend shelf life and reduce waste in the absence of refrigeration.

Keywords: *Telfairia occidentalis*; Nutritional Value; Sun-Drying; Oven-Drying; Leafy Vegetables; Food Preservation

INTRODUCTION

Fluted Pumpkin-leaves (*Telfairia occidentalis*) popularly known as Pumpkin leaves are example of edible plants/vegetables used as food. This plant food has embedded in it; vitamins, minerals and fibres needed for good health (Obembe *et* al., 2021, Orole *et al.*, 2020, Oboh and Aigbe, 2011, and Sobowale *et* al., 2010). Omimakinde *et al.* (2019) documented that they belong to *Cucurbita* genus and the Cucurbitaceae family. They consist of three species; *Cucurbita pepo, Cucurbita moshata*, and *Cucurbita maxima.* They possess wide leaves, tendrils, fleshy fruits with many seeds (when mature), fibrous root, and are known to be among the creeping/climbing plants.

Telfairia occidentalis is amongst the most popularly grown green-leafy-vegetables in many parts of Africa. This vegetable grow very well during light rains, and they begin to grow poorly during very heavy consistent rainfalls or during the dry seasons. Its leaves and seeds are often used as vegetables/food in many parts of Africa (Grubben and Denton, 2004), especially in the southern parts of Nigeria. It accounts for 60-70% of the total vegetables consumption in Nigeria. In Nigeria, leafy vegetables are one of the important and affordable food items in many homes, and they add variety and valuable nutrients to diet. Nutrients embedded in vegetables are proteins, carbohydrates, minerals, vitamins and fibers, which are often not enough in many other daily consumed diets in many homes (Mosha and Gaga, 1999, Udofia and Obizoba, 2005, and AOAC, 2000).

Fluted pumpkin plant has leaves that are very succulent and tender (when young), and seeds (when the vegetable plant matures). Its tender leaves and immature seeds can be cooked and eaten. Fluted pumpkin leaves are usually cooked with other type(s) of vegetables. Vegetable such as water leaves (*Talinum triangulare*), and some food ingredients like salt, pepper, dry fish, crayfish, meat, palm oil, among others, are usually used with sliced or chopped pumpkin leaves to make soup. This soup is mostly used for swallowing garri (eba), pounded yam, amala, among others. It could also be prepared with grounded melon seeds (*Citullus lanatus*) for soup (Schippers, 2002, and Jacob *et al*., 2015).

Pumpkin leaves can also be taken alone, as freshly chopped vegetable, or its juice freshly extracted and swallowed, especially among people that believe that consuming it fresh serves as blood tonic. Martinez *et* al., (2008) reported that Pumpkins are used in some countries like Argentina, Brazil, and China as traditional medicine. Omimakinde *et* al., (2019), on the other hand documented that pumpkin leaves and its seeds were widely believed to be enriched with proteins and amino acids. They further stated how a researcher claimed that many traditionalists prefer to consume it often instead of taking blood tonic supplement tablets. Just as stated earlier, several green leafy vegetables (example, pumpkin-leaves) may be consumed raw (fresh), some may be taken as cooked food complements to major staples like; millet, maize, yam, cassava and rice. Mepha *et al.* (2007), documented that leafy vegetables get spoilt easily, hence needed special processing treatments to ensure that post-harvest losses are reduced.

The first form of food preservation technique 'drying', which is also a form of food processing came by accident. In the olden days peasant farmers and consumers noticed that vegetables that were spread outside dried under the sun, and did not spoil quickly, due to drying. They also noted that some dried vegetables added desirable taste to the leaves. Drying is now widely used for food processing/preservation. It was also noted that the decaying/perishable nature of most vegetables reduced more, when vegetables were subjected to another form of drying (oven-drying). Ansah *et al*., (2020), added that drying of vegetables helped in reducing the cost of processing such as handling, packaging, storing and even transporting.

Although several drying-techniques has continuously evolved, especially in the last decade to help process/preserve vegetables. It has often been reported that there was less competitive advantage of green-leafy-vegetables production among other agricultural products. Hence, they tend to be less attractive to many farmers. Thereby leading to less production practices, processing and marketing of most of these vegetables, especially the commonly consumed ones, such as pumpkin leaves (Oguche, 2011). Kiremire *et al.* (2010) stated that some traditional method of vegetable preservation or processing such as sun drying decreased nutrient content.

According to many researchers (Sobowale *et al.*, 2010, Oboh and Aigbe, 2011, Omimakinde *et al.,* 2019, Obembe *et al.*, 2021), the nutrient content left after drying reduced, but the nutritional value of the dried vegetables still remained relatively high in most cases. On the other hand, several food toxicants and anti-nutrients are greatly reduced, which is good for good health and vitality. This is due to the fact that anti-nutrients reduces the availability of some important food nutrients. Therefore reduction or elimination of anti-nutrients ensures better absorption and utilisation of nutrients. On the other hand, food-toxicants when present in food in very high amount may be lethal, as they have the potential to act as poisons. Example of such food-toxicants is oxalates. When they are found in very high amount in food can lead to health decline, or even death (Dye, 1956).

The amount and frequency of consumption of pumpkin-leaves, just like other vegetables accounts for the overall presence of certain food nutrients. Therefore high consumption of this vegetable and other edible green-leafy-vegetables help in the supply and quick replenishment of essential minerals in the body. Hence, help in good blood formation and transport. That is perhaps the reason that pumpkin-leaves are often called blood tonic by many. It is also known that the drying methods used for pumpkin leaves processing and/or preservation, will also determine the quantity and quality of food nutrients present in the processed vegetable.

MATERIALS AND METHODS

Different materials and methods were used based on the requirement of the different analyses carried out. Below are the various steps and analyses carried out:

Collection and identification of plant materials

Disease-free plant material (*Telfairia occidentalis* leaves) was purchased from Watt-Market in Calabar, Cross River State, Nigeria.

Study area and design

This study was carried out mostly in the Biochemistry Department, University of Calabar, Calabar, Cross River State, Nigeria. It was carried out to investigate the effect of different commonly used drying methods on the chemical composition of *Telfairia occidentalis* leaves vegetable.

Preparation of plant materials

The pumpkin leaves were washed to remove dirt and sand which may act as contaminants. The leaves were then divided into three parts. Two parts were treated (sun-dried and oven- dried for one month), while one part of the leaves was not treated (serves as control). The dried samples were pulverized with electric blender and fine powder from dried leaves were obtained. The different pulverized samples were then put into different an airtight container until it was required for different analysis.

Laboratory analysis of samples

The *Telfairia occidentalis* leaves were subjected to three (3) different laboratory analyses; proximate composition, elemental composition and phytochemical composition screening using the different standard analytical methods.

Proximate composition analysis

The proximate composition of the respective samples (sun-dried and oven-dried) were carried out following the standard methods as documented by the AOAC (Association of the Official Analytical Chemists).

Summary of analyses done:

i.***Moisture content determination*** (AOAC, 2000)

The two grams of each pulverised samples were scaled into a dried measured moisture dish and placed in an air oven at 70^0C and dried to a constant weight. The loss in weight after cooling in a desiccator for 65 minutes is equated as the moisture content.

ii.***Ash determination*** (AOAC, 2000)

Two grams of each pulverised samples were weighed accurately and put into a porcelain-crucible of known weight. The porcelain-crucible with its contents were covered and then ignited for 24-hours at 525^{0}C.The ash content were estimated by weighing the ash in the crucible. The estimation was done in triplicate for each sample.

Calculation

Ash (% dry weight) = <u>Weight of ash in grams</u> × 100

Weight of sample

iii. ***Crude-Protein content estimation through total Nitrogen (Macro Kjeldahl method)*** (AOAC, 2000)

One gram of each pulverised samples was placed in different digestion flasks in triplicate. A 96% anhydrous sodium sulphate and 3.5% copper sulphate catalyst mixture were added to the samples. The samples were then digested using concentrated sulphuric acid. The flasks were then cooled, and their sides rinsed with de-ionized water. Digestion was afterwards continued for an additional one hour. The digestions were then transferred into distillation apparatus. Approximately 10ml of de-ionized water with 15ml of 45% sodium hydroxide were used for their distillation. The ammonia that was released, were steam-distilled into 10ml of 5% boric acid solution containing 4 drops of methyl-red-methylene blue indicator. The distillation was further done until the receiving flask reached a volume of 20ml. The ammonium borate complex which was produced was then diluted to 50ml and titrated with 0.02N HCl to a pink end point. A blank distillation determination was carried out in a manner similar to the one described above, but sample in the digestion flask was omitted.

The percentage (D/W) of nitrogen in sample was then calculated as follows:

<u>ml of HCl (sample) – ml of HCl (blank) × 14 ×100</u>

Wt. of sample in gm × 1000

1g = 1000mg (to offset the titre values which are in millilitres)

The crude protein was obtained by multiplying the percentage nitrogen by the factor 6.25.

Crude-Protein = Percentage of nitrogen × 6.25

iv. ***Crude-Fat content (Petroleum ether extract)*** (AOAC, 2000)

Five grams of each of the pulverised samples were weighed accurately, and in a continuous Soxhlet extractor were treated with petroleum ether extraction. After the defatting period, the fat content was obtained through the evaporation of the ether, while the lipid extract was left, and was determined by weight. Determination was carried out in triplicate.

Calculation

Petroleum ether extract (% dry weight) = Weight of extract (g) × 100

Weight of dry sample

v. ***Crude-Fibre content***

The fat-free material (3.50g) of each pulverised samples for crude-fibre determination were subjected to 1.25% sulphuric acid and 1.25% sodium hydroxide extraction digestion in a known sequence. The residue after digestion were dried at 105^{0}C and then the weight were noted. Incineration at 550^{0}C to ash followed.

The loss in weight was taken as the crude-fibre content. The tests were done in triplicate.

% Crude-fibre content = Weight of ash in crucible after ignition × 100

Weight of sample

vii. ***Carbohydrate content***

Carbohydrate content of each pulverised samples was determined by adding the values obtained for moisture content, crude-protein, crude-fat, total ash and crude-fibre, then the value obtained was subtracted from 100g.

2. ***Estimation of Mineral Elements***

i. ***Estimation of Calcium*** (AOAC, 2000)

Calcium was converted to an acidic state by digesting 2.0g of each pulverised sample in a mixture of 25ml concentrated sulphuric acid and 5ml per-chloric acid. Dilutions for each pulverised samples were made as aliquots, which were then subjected to flame photometry. The calcium content of each sample, was then measured at 626nm on the photometry. The concentration of calcium was obtained from a prepared calibration curve of standard solutions of calcium carbonate.

ii. ***Estimation of Phosphorus (Molybdovanadate Method)*** (AOAC, 2000)

A portion from the acidic digest obtained from the calcium determination were used for phosphorus determination. Aliquots that were suitable were taken and reacted with molybdovanadate reagent to give a pink-colour complex of phosphor-molybdovanadate. The colour that had developed was quantified using a colorimeter at 400nm. Phosphorus concentration was then obtained using standard curve prepared with potassium hydrogen phosphate (KH_2PO_4).

3. ***Estimation of Antinutrients***

i. ***Estimation of Phytates*** (McCance and Widdonson, 1953)

Approximately 5g of each sample was extracted for phytic acid with 0.5N hydrochloric acid. The phytic acid extracted for each case were precipitated to ferric phytate, with the help of ferric chloride. Ferric phytate was reacted further with sodium hydroxide to transform it to sodium phytate. Phosphorus content of each sample was then quantified colorimetrically at 620nm after the addition of molybdate colour development solution.

ii. ***Estimation of Hydrogen Cyanide content*** **(**AOAC, 2000**)**

Cyanide content of 8g of each sample were liberated after soaking in water for approximately 4 hours. The cyanide liberated in the water were extracted using steam distillation into 20ml 2.5% NaOH, which 8ml 6N ammonium hydroxide and 2ml 5% potassium iodine were added. Then titrating with 0.02N silver nitrate to a faint but permanent turbidity followed.

(1.0ml of 0.02N $AgNO_3$ = 1.08mg HCN)

iii. ***Estimation of Total Oxalates*** **(**Dye, 1956**)**

Five grams of each sample were digested in a 200ml distilled water and 6N hydrogen chloride at 37^0C. The oxalate was then precipitated with calcium chloride as calcium oxalate. The oxalate were washed with 25% sulphuric acid and dissolved in 100ml water, before it was titrated against 0.05N potassium permanganate until a purple end point was reached, which persisted for about 15 seconds.

(1.0ml $KMnO_4$ = 2.20mg oxalate)

iv. ***Estimation of Soluble Oxalates*** **(**Dye, 1956**)**

Five grams of each sample were weighed and digested in 200ml distilled water and 6N hydrogen chloride at 90^0C for about 4-hours. The digest was further subjected to the same process found in total oxalate.

(1.00ml $KMnO_4$ = 2.20mg oxalate)

Data/Statistical analysis

All data obtained were expressed as the mean ± standard error of the three replicates carried out. The data obtained were subjected to analysis of variance (ANOVA) using the statistical analysis system (SPSS version 22.0, Chicago, IL, USA). The means were then separated using Duncan's Multiple Range Test (DMRT) at a 5% level of significance (associations between variables were considered statistically significant at p-values less than, or equal to 0.05, $p \leq 0.05$).

RESULTS

Results obtain from the various analyses; proximate composition, elemental composition and phytochemical analysis of the three samples (Fresh, Sun-dried and Oven-dried *Telfairia occidentalis* leaves), are presented in Tables 1 to 5. The result of proximate composition/analyses of Fresh, Sun-dried and Oven-dried *Telfairia occidentalis* leaves samples analysed, are shown in Table 1. Moisture content removed from some food by heat generally improve the digestibility of such foods. This further help increase the concentration of nutrients, and could also make some nutrients more available (Morris and Burrows, 2004). The moisture content was high in the fresh sample, and was then significantly reduced with the application of different drying methods.

The ash content was significantly high in all the drying methods, compared to the fresh leaves. Ash content although an index of total mineral-element, it can be used to test the extent of product contamination with sand from the surroundings (Gallali *et al.*, 2000). In this study, ash content ranged from 2.80 ± 0.02 to 5.13 ± 0.02, and was found to be higher in oven-dried sample. This observation was contrary to the other results obtained from a similar study we did using bitter leaves and Amaranthus leaves, which had higher ash content for sun-dried samples than oven-dried ones. Also noted, was that lipid content were in significantly higher value ($P<0.05$) in all the drying methods. Protein which is usually known to decrease upon drying, especially during heat application (Morris and Burrows, 2004), in this study, protein content rather increased remarkably upon drying which range from 4.62% to 5.54 ± 0.02 in oven-dried samples. The fibre content was significantly higher ($p<0.05$) in sun dried samples as compare to the oven samples.

In the elemental composition of fresh, sun-dried and oven-dried *Telfairia occidentalis* leaves (Table 2), the mineral analysis indicated losses in mineral composition in the treated samples as compared with its fresh sample. This accounts to the facts that heat treatment generally do not improve the availability of mineral contents in vegetables. The percentage loss for each element as presented in Table 3, recorded more than 50% loss in mineral contents, especially in oven-dried samples. For Phytochemical screening/analysis of Fresh, Sun-dried and Oven-dried *Telfairia occidentalis* leaves samples (Table 4), result showed that most anti-nutrients found in food are reduced during heat application. Intense heat application like in oven-drying removes a great percentage of available anti-nutrients in food much more than mild heat treatment (sun drying), but nutrient losses are more severe in oven-dried foods than sun-dried ones.

Further quantitative analysis of phytochemicals that were present in excess in Fresh, Sun-dried and Oven-dried *Telfairia occidentalis* leaves samples, showed that phytic acid was the most abundant phytochemical present in the *Telfairia occidentalis* leaves in this study, with value ranging from 1.69±0.02 to 1.87±0.02. Comprehensive result of phytochemicals analysis of *Telfairia occidentalis* leaves samples are presented in Table 5.

Table 1: Proximate Composition of Fresh, Sun dried and Oven dried *Telfairia occidentalis* leaves (%)

S/N	Name of sample	Moisture	Ash	Crude-Protein	Crude-Fat	Fibre	Carbohydrate
1	Fresh *Telfairia occidentalis* leaves	83.01 ± 0.1	2.80 ± 0.02	4.62 ± 0.01	0.64 ± 0.2	0.98 ± 0.01	7.95 ± 0.02
2	Sun-dried *Telfairia occidentalis* leaves	22.60 ± 0.1	4.10 ± 0.02	5.36 ± 0.02	2.41 ± 0.2	1.78 ± 0.02	63.75 ± 0.02
3	Oven-dried *Telfairia occidentalis* leaves	10.50 ± 0.2	5.13 ± 0.01	5.54 ± 0.01	2.31 ± 0.1	1.61 ± 0.01	74.91 ± 0.02

Each value represents mean of 3 determinants ± SD

Table 2: Elemental Composition of Fresh, Sun-dried and Oven-dried *Telfairia occidentalis* Leaves (mg/100g dry matter)

S/N	Name of sample	Na	P	K	Ca	Mg	Fe	Cu	Zn
1	Fresh *Telfairia occidentalis* leaves	9.30	2.09	6.31	5.36	2.75	0.11	0.53	0.10
2	Sun-dried *Telfairia occidentalis* leaves	7.71	1.01	5.53	1.70	1.46	0.08	0.41	0.07
3	Oven-dried *Telfairia occidentalis* leaves	4.34	0.33	3.97	1.05	0.66	0.02	0.17	0.01

Table 3: Percentage Loss in Elemental Composition of Processed Sample (Sun-dried and Oven-dried) *Telfairia occidentalis* leaves (%)

S/N	Name of sample	Na	P	K	Ca	Mg	Fe	Cu	Zn
1	Sun-dried *Telfairia occidentalis* leaves	17.10	51.67	12.36	68.28	46.91	27.27	22.64	30.00
2	Oven-dried *Telfairia occidentalis* leaves	53.33	84.21	37.08	80.41	76.00	81.82	67.92	90.00

Table 4: Results of Phytochemical Screening of Fresh, Sun dried and Oven dried *Telfairia occidentalis* leaves

S/N	Chemical constituents	Fresh *Telfairia occidentalis* leaves		Sun-dried *Telfairia occidentalis* leaves		Oven-dried *Telfairia occidentalis* leaves	
		Ethanol extract	Aqueous extract	Ethanol extract	Aqueous extract	Ethanol extract	Aqueous extract
1	Alkaloids	+	+	-	-	-	-
2	Cyanogenic Glycosides (Hydrocyanic acid)	+	+	+	+	+	+
3	Saponins	-	++	+	+	-	+
4	Tannins	+	-	-	-	+	-
5	Flavonoids	+	-	-	-	-	-
6	Oxalates	+	+	+	++	+	+

7	Phytic acid	++	+	+	+	+	+
8	Phlobatanins	-	-	-	-	-	-
9	Anthroquinons	-	-	-	-	-	-
10	Hydroxymethyl anthraquinons	-	-	-	-	-	-

Key

Presence	+
Presence in excess	++
Presence in much excess	+++
Absent	-

Table 5: Results of Quantitative Analysis of Prominent Phytochemicals in Fresh, Sun-dried and Oven-dried *Telfairia occidentalis* leaves

Sample	Phytic acid (mg/g)	Hydrocyanic acid (mg/g)	Saponins (mg/g)	Total Oxalates (mg/g)	Soluble Oxalates (mg/g)
Fresh *Telfairia occidentalis* leaves	1.87±0.01	0.13±0.01	1.81±0.02	1.73±0.01	0.41±0.02
Sun-dried *Telfairia occidentalis* leaves	1.73±0.02	0.11±0.01	1.77±0.01	1.60±0.02	0.39±0.02
Oven-dried *Telfairia occidentalis* leaves	1.69±0.01	0.09±0.02	1.68±0.01	1.56±0.02	0.35±0.01

DISCUSSION

Fluted pumpkin leaves (*Telfairia occidentalis* leaves), generally known as pumpkin-leaves is also called *ugwu* in many parts of Nigeria (Raji *et* al., 2016). It is known that many kinds of fresh fruits, vegetables, herbs, meat and fish can be dried. Vegetables are good sources of minerals when consumed in sufficient quantities. Eusebio (2009), confirmed the importance of vegetables by stating its tremendous potential in nutritional security and poverty alleviation. Eusebio (2009) further added that vegetables are easy to grow, require minimum production inputs, easily available, affordable, and rich in micronutrients. Vegetables are known to be highly perishable farm product. Vegetable spoilage is often due to enzymatic reactions and microbial activities in the vegetable. To ensure that there is sufficient quantity of vegetables for regular consumption, it entails drying the surplus, or the portion that would not be consumed immediately. The portion of the vegetable that won't be consumed immediately when dried prevents spoilage.

Drying, which is a form of food processing and preservation has effect on the chemical composition of vegetables, as shown in this study. In this study, drying led to the moisture and mineral values of dried pumpkin-leaves (*Telfairia occidentalis* leaves) vegetable being lower than that of its fresh vegetable (Tables 1, 2 and 3). It was also observed that the phytochemicals and anti-nutrients were greatly reduced (which is recommendable), as shown in Tables 4 and 5. This confirms the report made by Oguche (2011) that drying increases nutrient loss, while at the same time decreases phytochemicals, compared to the fresh vegetables. The researcher further stated that tannin and flavonoids values of dried vegetables were lower than those of fresh vegetables.

Chweya and Eyzaguirre (1999), also documented that elemental composition such as Sodium, Phosphorus, Potassium, Calcium, Magnesium, Iron, Copper and Zinc had higher values in the control (fresh vegetable) than dried *Telfairia occidentalis* leaves. This present study confirms some of the observations earlier stated, due to the fact that only some minerals such as Calcium, Phosphorus, Iron and Zinc registered great losses. The minerals losses experienced in the listed minerals exceeded 50%. The high amount of micronutrient losses was due to prolong heat treatment. It further showed that many vegetables are not very good sources of minerals. This is because most vegetables are not consumed raw (fresh). Therefore, it is essential to consume vegetables in very large quantities, so as to get sufficient quantity of their embedded nutrients. Nutrients such as calcium and potassium help facilitate physiological development of the teeth, bone, and muscles. It is also known that both elements are associated with Vitamin D metabolism (Ladan *et al.,* 1996).

Nahapetian and Bassir (1975), added that potassium found in the form of K^+ is the most important cation of the cell. This study documented potassium content in the samples analysed as ranging from 3.97mg/100g to 6.31mg/100g, and sodium content ranging from 4.34mg/100g to 9.30mg/100g. This amount is not enough for good bone formation and maintenance, unless the stated vegetable is consumed in very large quantity. Similarly, the fresh samples had the highest concentration of zinc with 0.10 mg/100g. The relatively low content of zinc upon drying (0.07mg/100g and 0.01mg/100g for sun-drying and oven-drying respectively) is not appealing.

Zinc is very important in the body, due to its nutritional roles in immune system (Bhaskaram, 2002), as well as insulin secretion (Chausmer, 1998), and it is also vital in vitamin A release from the liver (Hwang *et al.,* 2002). Boron *et al.,* (1988), had also documented its role as an enzyme. Zinc is also known to facilitate quick wound healing. Hence, there is need for this mineral to be present in food in substantial amount for utmost good health. Food-toxicants and phytonutrients were reduced with extended drying in this study, especially when intense heat was applied, as shown in oven-dried samples (Tables 4 and 5). This development is rather a good one, as high amount of food-toxicants and phytonutrients when consumed, have the capacity to cause several health challenges, or even death as documented by many researchers.

In Nigeria, despite the high medicinal, nutritional and economic value that has continually been documented of *T. occidentalis* (pumpkin-leaves), its production still remains short of demand. This was also observed by Opabode and Adeboye (2005). This trend to a high extent is due to the vegetable high perishable nature, which leads to substantial postharvest losses.

CONCLUSION

Of the two drying methods (sun-drying and oven-drying), sun-drying is better with regard to moisture retention. Although it is noted that sun-drying involves exposure of the vegetable to solar radiation for a prolong period without protection against the sun's ultra-violet (UV) rays, thereby subjecting nutrients that are very sensitive to UV rays to encounter great losses. It still manages to retain more nutrients than oven-dried samples in most cases. In traditional setting, sun-drying vegetables that have high amount of moisture content, are usually dried at low temperatures, but are exposed for a long time. This causes leaching, which is another vital reason for great soluble minerals loss. On the other hand, the high heat application experienced in oven-drying, reduces anti-nutrients in the vegetables greatly, compared to those of milder heat application, such as sun-drying. In communities with limited alternative sources of essential micronutrients, drying of fruits and vegetables should be promoted. This will ensure all year supply of these food embedded micronutrients in communities at risk, especially among young children that are at risk of malnutrition.

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Authors' Roles/Participation in the Authorship of the Manuscript:

1. Mary Athanasius Udoh (Corresponding Author): substantial contributions to the conception and design of the work, acquisition of data, analysis and interpretation of data, drafting the work, final approval of the version to be published.

2. Abimbola Gbenga Olayemi: acquisition of data, analysis and interpretation of data, final approval of the version to be published.

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