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Effect of different drying methods and storage on proximate and mineral composition of fluted pumpkin leaf, *Telfairia occidentalis* Hook f.

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ABSTRACT

Purpose: The leaves of *Telfairia occidentalis* is affected by the various methods of drying and storage employed after harvest. This research work is therefore designed to determining the best drying method for the preservation of *Telfairia occidentalis* using the mineral and proximate constituents as indices. **Research method:** The cleaned, fresh leaves were then divided into three portions. The first portion was sundried, the second portion was air-dried and the third portion was oven-dried. Each sample was analyzed for proximate composition and mineral content. **Findings:** The results of the various analysis generally showed that the oven-dried samples have the highest mineral content followed by sun-dried and then the air-dried. The ash content was most top (12.78%) in the oven-dried example, sample followed by air-dried, sun-dried, and then fresh samples while the moisture content was most top (82.62%) in the clean example followed by sun-dried, air-dried and oven-dried with 11.40, 9.18%, and 6.33% moisture respectively. The carbohydrate content was most top (32.62%) in the sun-dried sample followed by air-dried, oven-dried and then fresh ones with 30.10, 29.58, and 4.44% respectively. The protein content was highest (32.69%) in the oven-dried sample followed by air-dried, clean, and then sun-dried examples with 30.16, 5.92, and 2.70%, respectively. The fat content was highest (7.50%) in the air-dried and oven-dried examples followed by sun-dried, and the fresh ones with 6.85 and 1.85%, respectively. The fiber content was most top (11.16%) in the oven-dried example followed by air-dried, sun-dried, and the fresh ones with 10.69, 9.16, and 2.94% respectively. **Limitations:** The proximate and mineral compositions of the leaves were investigated after drying and storage. **Originality/Value:** The results showed that the oven-dried samples in most cases, have the highest proximate and mineral composition. So, oven-drying is the most nutritionally viable method in the preservation and storage of *Telfairia occidentalis*.

INTRODUCTION

The importance of plant foods to the human body cannot be underestimated. There are a lot of health benefits that can be obtained through the consumption of these plant foods, these health benefits are mostly connected to their physiological actions as a result of their phytochemicals and nutritional value on the human body (Orole et al., 2020). Hart et al. (2005) observed that the consumption of vegetables in Nigeria has been on the increase; he estimated the cost or value to be about 22-47.58 kg/person/year. Green leafy vegetables help in promoting good health because they are rich in nutrients (Oboh & Aigbe, 2011). Leafy vegetables are easy to prepare, low in price, and contain right a good amount of nutrients such as vitamins, minerals, proteins of higher biological value than some other food stuffs (Oyenuga, 1968; Oke, 1968).

Telfairia occidentalis (Hook) F. (Fluted Pumpkin) is a green vegetable commonly known as ugwu belonging to the family Cucurbitaceae. It is grown in most parts of West Africa where edible seeds occur mostly in cultivated forms in various parts of Southern Nigeria. It is a creeping vegetable that spread across the ground with lobed leaves and thrives best in soil rich in organic matter (Mohd et al., 2016). *T. occidentalis* can be described as a dark green leafy vegetable that contains the following nutrients in abundance, vitamins, minerals, and carotenoids, which act as antioxidants in the body. It has also been reported that certain compounds present can prevent the growth of certain types of cancer (Adams, 2013). *T. occidentalis* leaf is widely consumed by humans and livestock due to its high constituent protein, fat, oil, mineral salts, and vitamins. The tender shoots, succulent leaves, and immature seeds are cooked and consumed as vegetables (Asiegbu, 1998). The different species of *Telfairia* are also grown in other tropical regions of the world, including India, Bangladesh, Sri Lanka, and the Caribbean. The various species are also known to be a primary source of iron and essential fatty acid making it desirable as cooking oil. The essential amino acids contents compared favorably with those of essential legumes (Asiegbu, 1998) and the high content of mineral and vitamin nutrients, especially Fe, Mg and K, carotene, and vitamin C is remarkable making the leaves potentially useful as food supplements. The stem waste can produce activated carbon. According to Agbugba and Thompson (2015), *T. occidentalis* has the highest value among the notable and common tropical leafy vegetables grown in South-eastern Nigeria in terms of income to local farmers. Recent researchers have reported that the leaf of *T. occidentalis* is a good source of a significant number of minerals among them are iron, potassium, sodium, phosphorus, calcium and magnesium, antioxidants, vitamins, such as thiamine, riboflavin, nicotinamide, and ascorbic acid, phytochemicals such as phenols. Matured fluted pumpkins are harvested 4-5 months after planting (Akoroda, 1990).

The simplest method for preserving green leafy vegetables, especially when they are in surplus, is drying. Many authors have worked on drying as a means to preserve foods, such as vegetables and other perishable foods. Over the years, different methods of drying green leafy vegetables have been put in place, and currently, newer techniques are being investigated (Akoroda, 1990). Some of these techniques include the use of different drying systems, and cold storage. Drying of vegetables is done for two main reasons, to preserve the perishable raw commodity against agents of deterioration, and to reduce the cost of processing like packaging, handling, storing and transporting (Ansah et al., 2020). Despite the high nutritional, medicinal and economic value of *T. occidentalis*, its production in Nigeria has failed to meet the domestic demand for its consumption (Opabode & Adeboye, 2005). This is as a result of its high perishability, which can be linked to its high moisture content, resulting in substantial postharvest losses. Losses up to 30-40% have been recorded on the vegetables after harvest in developing countries, like Nigeria. This is mainly due to poverty, inferior postharvest handling methods, inadequate processing technology, storage facilities, poor infrastructure, as well, and inadequate marketing systems (Kayode & Kayode, 2011). Drying of leaves and vegetables remains an essential method of preserving food. The moisture content of food is reduced to a level that is safe for storage over a long period. The growth of mold and fungi are also prevented, thereby reducing microbial degradation (Kayode & Kayode, 2011).

This research work is designed to evaluate the effects of different methods and storage of fluted pumpkin leaf, *T. occidentalis* using the mineral and proximate constituents as indices.

MATERIALS AND METHODS

This research work was conducted in a Laboratory of Crop Science, Faculty of Agricultural Science, Ekiti State University, Ado Ekiti, and Nigeria.

Source of *Telfaria occidentalis* samples and their drying methods

Fresh leaves of *T. occidentalis* were obtained from Iworoko market, Ado-Ekiti, Ekiti State, Nigeria. The leaves were thoroughly rinsed with clean water to remove adhering dirt. After washing, the leaves were sliced into pieces. They were then divided into three portions. The first portion was sundried for 8 days, while the second portion was air-dried for 14 days at a temperature of 28±2 ^oC and relative humidity of 75±5% the third portion oven- dried at 60 ^oC for 48 h. All the samples were dried to constant weight. After drying, they were stored in baskets for two months in the Laboratory under an ambient temperature of 28±2^o C and 75±5% relative humidity. After that, the samples were pulverized and stored in an air-tight container. Each sample was replicated three times. Then, after that, the three dry samples together with the fresh sample used as control were taken to the Laboratory for proximate (moisture content, fat, crude protein, crude fiber ash, and carbohydrate) and mineral analysis.

Proximate analysis

Crude protein (P) content determination

The method of AOAC (1990) was used**.** Exactly 2 g of the powdered samples were accurately weighed and placed in the Kjeldahl flask. Exactly 10 g of anhydrous sodium tetraoxosulphate (vi) (Na_2SO_4) and 0.5 g of Copper (ii) tetraoxosulphate (vi) was added, followed by 25 mL concentrated tetraoxosulphate (vi) acid (H_2SO_4) in the Kjeldahl flask. The flask was heated by inclining it over the hot plate. The digestion was washed into a 250 mL standard flask, and distilled water was added. Exactly 5 mL of each digested sample was pipetted into the Buchi distillation unit, and 5 mL of sodium hydroxide (NaOH) was added until the solution became dark. The ammonia gas (NH_3) liberated was distilled into a 15 mL 2% boric acid solution containing the mixed indicator, which later turned green. The distillation process was stopped when the volume of distillate reached 150 mL, and the distillate titrated with 0.01 M hydrochloric acid (HCl), which generated blue color. The percentage of protein can be calculated as follows (1):

$$\% \text{ P} = \frac{\text{Con.of Hcl} \times \text{titre value} - \text{blank} \times 0.014 \times 100 \times 6.25}{\text{Weight of sample}} \quad \text{(the protein conversion factor)} \tag{1}$$

Moisture content determination

The standard method of AOAC (1990) was adopted in determining the moisture content. Exactly 5 g of each sample was weighed into aluminum foil W_1, the weight of the foil, and the example before oven drying W_2 and after drying W_3 was also noted. Oven drying of the example was conducted at 60 °C for 24 h. The leaves were then removed and cooled. Percentage moisture content was calculated as follows (2):

Weight of empty foil = W_1

Weight of foil + sample before drying = W_2

Weight of foil + sample after drying = W_3

$$\% \text{ Moisture content} = \frac{W2-W3}{W2-W1} \quad (2)$$

Fat content determination

The standard method of AOAC (1990) was used to determine the fat content. Exactly 2 g of the sample was weighed into a 100 mL beaker, and 2 mL of 96% ethanol was added together with 7 mL of concentrated Hydrochloric acid (HCl) and 3mL of water (H_2O). This was heated on a water bath for about 15 minutes. After cooling it was transferred into a separating funnel, and the beaker was washed with 100 mL ethanol and transfer into the separating flask. This was extracted three times with 30 mL of diethyl ether and once with 30 mL of light petroleum ether (40-60 °C). The solvent extracts were combined and filtered through cotton plug into a clean and dried pre-weighed 100 mL beaker. The solvent was removed by evaporating it on a water bath, and the glass, and its residue transferred into an oven and dry for about one hour. This was later moved into desiccators for cooling, and the residue weight as fat. The percentage of fat content was determined as follows (3):

$$\% \text{ Fat} = \frac{\text{Weight of residue}}{\text{Weght of sample}} \times 100 \quad (3)$$

Ash content determination

The crucible was prepared by igniting in a muffle furnace at 550 °C for 12 h, and later transferred into a desiccator containing active desiccant while still hot to cool. After cooling the crucible was weighed and about 5 g of sample added into the cauldron. The cauldron was then placed in the muffle furnace and ignited until all the organic components have burnt off remaining the Ash. The cauldron was transferred into a desiccator when the furnace temperature reduced to about 200 °C and allowed to cool. It was weighed after cooling to get the weight of the ash. The percentage of ash was calculated as follows (4):

$$\% \text{ Ash} = \frac{\text{Ash}}{\text{Weight of Sample}} \times 100 \quad (4)$$

Crude fiber determination

The standard method of AOAC (1990) was used to determine the crude fiber. Exactly 2 g of the sample was weighed and the fat extracted with hexane. The sample was later transferred into an oven and dry at 70 °C overnight. After drying, the sample was ground and passed through a 0.3-0.5 mm mesh screen. The sample was transferred into the flask of the reflux apparatus and digested with 200 mL of 1.25% H_2SO_4 for 30 minutes after that, it was filtered and washed with distilled water. After washing, the sample was again transferred into the flask and digested with 200 mL of 1.25% NaOH for 30 minutes. Thereafter, it was filtered and washed using clean water. This was later transferred into a pre-weighed crucible and dried in the oven at 105 ^{o}C until a constant weight was achieved. The crucible was then put in the muffle furnace and ignited until it turns full ash. The percentage of fiber was calculated as follows (5):

$$\% \text{ Fibre} = \frac{\text{Fibre} - \text{ash}}{\text{Sample weight}} \times 100 \quad (5)$$

Carbohydrate content determination

This was determined using the standard method of AOAC (1990). Carbohydrate in food by difference = 100% - (% Moisture + % Protein + % Fat + % Ash + Fiber)

Mineral content determination

The minerals were determined using Atomic absorption spectrophotometer (Buck Scientific Model 210).

Data analysis

Results were expressed as the mean ± standard error of three replicates. The data obtained were subjected to analysis of variance (ANOVA) using the statistical analysis system. The means were then separated using Duncan's Multiple Range Test (DMRT) at a 5% level of significance.

RESULTS AND DISCUSSION

Generally, the proximate composition of the dried samples of *T. occidentalis* (Table 1) revealed that the proximate content of the dry samples was significantly affected ($P<0.05$) by the different drying methods. The moisture content was highest (82.62%) in the fresh *T occidentalis* leaf sample followed by sun-dried, air-dried, and oven-dried with 11.40, 9.18 %, and 6.33% moisture respectively. The moisture content of the dry samples was significantly different ($P<0.05$) from that of the fresh sample. Drying remains an essential method of preserving food. The moisture content of food is reduced to a safe level in which it can be stored for an extended period. Also, the growth of mold and fungi are prevented, thereby reducing biodegradation. The proximate composition of *T. occidentalis* subjected to different drying methods revealed variations in their proximate and mineral composition. Observed increases in the nutritional form of dried *T. occidentalis* could be explained by the elimination of moisture. The decrease in food moisture content leads to the increased concentration of constituent elements (Morris et al., 2004). The result obtained from this research work also revealed that the protein content was highest (32.69%) in the oven-dried sample of *T. occidentalis* leaf followed by air-dried, fresh, and then sun-dried samples with 30.16, 5.92 and 2.70% respectively. There was no significant difference in the amount of protein present in air-dried and oven-dried examples. The protein content of the fresh sample was significantly different ($P<0.05$) from that of the dried samples. This is in agreement with the work of Elegbeleye (1998), who reported that the increase in protein content of dried vegetables is due to the decrease in moisture content. Generally, removal of moisture, according to Morris et al. (2004), leads to an increase in the concentration of the nutrients. Therefore, for *T. occidentalis* to be preserved for an extended period before use, the moisture content has to be reduced to the minimum (Hussein et al., 2018). The ash content was highest (12.78%) in the oven-dried sample of *T. occidentalis* leaf followed by air-dried, sun-dried and then fresh examples with 11.22, 10.51, and 2.22% respectively. The ash content of the dry sample was significantly lower ($P<0.05$) than that of the fresh sample. There was no significant difference ($P<0.05$) in the amount of ash in air-dried and the oven-dried samples. The higher ash content obtained in the oven-dried samples was similar to that reported in other literatures, (Onwuka et al., 2002). Ash content indicates the availability of mineral content of food substances (Onwuka et al., 2002). Hence, *T. occidentalis* contains a high proportion of mineral salts. The fat content was most top (7.50%) in the air-dried, and oven-dried samples of *T. occidentalis* leaf followed by sun-dried, and the new ones with 6.85 and 1.85% respectively. The fat content of the fresh sample was significantly different (P<0.05) from that of the dried samples.

The fiber content was highest (11.16%) in the oven-dried sample of *T. occidentalis* leaf followed by air-dried, sun-dried, and the fresh ones with 10.69, 9.16 and 2.94% respectively. The fiber content of the new sample was significantly different (P<0.05) from that of the dried samples. Dietary fiber in vegetable aids in increase bulk and reduces food transit time in the alimentary canal, and the incidence of constipation, and other related diseases (Hassan et al., 2007). Fiber is useful for maintaining bulk, motility, and increasing intestinal tract. It is also necessary for health conditions, curing of nutritional disorders and food digestion.

The carbohydrate content was highest (32.62%) in the sun-dried sample of *T. occidentalis* leaf followed by air-dried, oven-dried and then new ones with 30.10, 29.58 and 4.44% respectively. The carbohydrate content of the fresh sample was significantly different (P<0.05) from that of the dried samples. There was no significant difference in the carbohydrate content of the air-dried and oven-dried samples. The study showed that the sun-dried and air-dried samples have the highest carbohydrate contents. Carbohydrate content of vegetable increases after drying (Kolawole et al., 2011). Generally, the mineral composition of the dried example of *T. occidentalis* leaf (Table 2) revealed that the mineral salt content in the dried samples was significantly affected (P<0.05) by the various drying methods**.** Sodium was highest (775.30 $mg.100g^{-1}$) in the oven-dried sample, followed by sun-dried and air-dried samples with 583.30 and 553.30 $mg.100g^{-1}$ respectively. The amount of sodium (158.40 $mg.100g^{-1}$) is significantly lower in the fresh leaf sample. Potassium was highest (2845.15 $mg.100g^{-1}$) in the oven-dried example, followed by a sun-dried and air-dried sample with 2268.20 and 2158.30 $mg.100g^{-1}$, respectively. The amount of potassium (680.20 $mg.100g^{-1}$) is significantly lower in the fresh leaf examples compared to the dried samples. The result obtained in the present study shows that the oven-dried examples contain the highest mineral content, followed by sun-dried and then the air-dried. The amount of the mineral content was generally lowest in fresh leaf examples.

Table 1. Proximate composition of *Telfairia occidentalis* leaf sample

Samples	% Moisture	% Fat	% Crude protein	% Crude fiber	% Ash	% Carbohydrate
Fresh	82.62±1.30^{a}	1.85± 1.22^{c}	5.92± 1.24^{c}	2.94± 1.33^{d}	2.22± 1.24^{d}	4.44 ±1.40^{d}
Sun-dried	9.18± 1.51^{c}	6.85± 1.22^{b}	2.70± 1.30^{d}	9.16 ±1.50^{c}	10.51± 1.12^{c}	32.62 ±1.33^{a}
Air-dried	11.40± 0.25^{b}	7.50± 0.34^{a}	30.16± 1.40^{b}	10.69± 1.30^{b}	11.22± 1.33^{b}	30.10± 1.40^{b}
Oven-dried	6.33± 1.24^{d}	7.50± 1.29^{a}	32.69± 1.22^{a}	11.16 ±1.40^{a}	12.78± 1.60^{a}	29.58± 1.44^{c}

Each value is the mean ± standard error of three replicates. Means in the same column, followed by the same letter(s) are not significantly different at $p \geq 0.05$.

Table 2. Mineral composition of *Telfairia occidentalis* leaf

Sample	Na	K	Mn	Mg	P
Fresh	158.40± 1.30^{d}	680.20 ±1.70^{d}	42.50± 1.20^{d}	865.10 ±1.22^{d}	60.50± 1.50^{d}
Sun-dried	583.30± 1.30^{b}	2268.20± 1.40^{b}	211.20 ±1.10^{b}	3365.20 ±1.20^{b}	611.20± 1.34^{c}
Air-dried	533.30± 1.13^{c}	2158.30 ±2.30^{c}	207.20 ±3.30^{c}	3025.10± 2.10^{c}	631.50 ±1.20^{b}
Oven-dried	775.30 ±2.30^{a}	2845.15± 1.22^{a}	226.50 ±1.20^{a}	3555.20 ±1.33^{a}	633.60 ±1.20^{a}
Sample	Fe	Ca	Zn	Cu	Pb
Fresh	41.20± 1.45^{d}	80.00± 1.60^{d}	6.04± 1.15^{d}	4.08 ±1.30^{d}	ND
Sun-dried	242.50± 1.40^{b}	1803.50± 1.22^{b}	35.10± 1.55^{c}	20.30± 1.35^{c}	ND
Air-dried	231.20± 1.33^{c}	1777.10± 2.30^{c}	37.00± 1.23^{b}	22.25± 1.20^{b}	ND
Oven-dried	312.40± 1.10^{a}	2215.30± 1.30^{a}	39.25± 2.24^{a}	28.50± 1.18^{a}	ND

Each value is the mean ± standard error of three replicates. Means in the same column followed by the same letter(s) are not significantly different at $p \geq 0.05$. ND: Not discovered.

Manganese was highest (226.50 mg.100g^{-1}) in the oven-dried examples, followed by air-dried and sun-dried samples with 211.20 and 207.20 mg/100g respectively. The amount of Manganese (42.50 mg.100g^{-1}) is significantly lower in the fresh *Telfairia occidentalis* leaf sample compared to the dried samples. Magnesium was highest (3555.20 mg.100g^{-1}) in the oven-dried sample, followed by sun-dried and air-dried samples 365.20 and 3025.10 mg.100g^{-1}, respectively. The amount of Magnesium (865.10 mg.100g^{-1}) is significantly lower in the fresh *T. occidentalis* leaf sample compared to the dried samples. Phosphorus was highest (633.60 mg.100g^{-1}) in the oven-dried sample, followed by air-dried and sun-dried samples with 631.60 and 611.20 mg.100g^{-1}, respectively. The amount of Phosphorus (60.50 mg.100g^{-1}) is significantly lower in the fresh *T. occidentalis* leaf sample compared to the dried samples. Iron was highest (312.40 mg.100g^{-1}) in the oven-dried sample, followed by sun-dried and air-dried examples with 242.50 and 231.20 mg.100g^{-1} respectively. The amount of iron (41.20 mg.100g^{-1}) is significantly lower in the fresh *T. occidentalis* leaf sample compared to the dried samples.

Calcium was highest (2215.30 mg.100g^{-1}) in the oven-dried sample, followed by sun-dried and air-dried samples with 1803.50 and 1770 mg.100g^{-1} respectively. The amount of Calcium (80.20 mg.100g^{-1}) is significantly lower in the fresh *T occidentalis* leaf sample compared to the dried samples. Zinc was highest (39.25 mg.100g^{-1}) in the oven-dried example, followed by air-dried and sun-dried examples with 37.20 and 35.10 mg.100g^{-1}, respectively. The amount of Zinc (6.40 mg.100g^{-1}) is significantly lower in the fresh *Telfairia occidentalis* leaf sample compared to the dried samples. Copper was highest (28.50 mg.100g^{-1}) in the oven-dried example, followed by air-dried and sun-dried example with 22.25 and 20.30 mg.100g^{-1}, respectively. The amount of copper (4.08 mg.100g^{-1}) is significantly lower in the fresh *T. occidentalis* leaf sample compared to the dried samples. There was no trace of lead discovered in all the samples. The oven-dried example recorded the highest mineral content across the elements. Similar results were reported by Ukegbu and Okereke (2013), where oven-dried vegetables had higher values of mineral salts content.

CONCLUSION

The production of *T. occidentalis* in Nigeria has been negatively affected as a result of its high level of perishability, which has resulted in huge losses after harvest. These losses can be linked to its high moisture content. The simplest and most popular method of preserving leafy vegetables over time is drying. This research work was therefore designed to determine the best drying method for the preservation of *T. occidentalis* using the mineral and proximate constituents as indices. The results obtained from this research work showed that the oven-dried samples, in most cases, have the highest proximate and mineral composition. So, oven-drying is the most nutritionally viable method in the preservation and storage of *T. occidentalis.*

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Conflict of interest
The authors at this moment hereby declare that there is no conflict of interest.

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