Effect of Drying Methods on the Vitamins, Minerals and Phytochemical Contents of Waterleaf (*Talinum triangulare*)

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ABSTRACT

Waterleaf (*Talinum triangulare*) as a vegetable is susceptible to deterioration due to its high moisture content which leads to considered amount of waste due to lack of efficient preservation techniques. It is high in vitamin, mineral and phytochemical contents which may be affected during drying process. Therefore, this study investigated on the effect of drying methods on the vitamin, mineral, phytochemical and antioxidant content of dried waterleaf vegetable. Four drying methods (air, sun, solar, and cabinet at 45 °C) were used to dry freshly harvested waterleaf. Minerals, vitamins and phytochemical contents of the dried waterleaf were determined. The range of results of vitamin contents of the dried waterleaf vegetable are 0.71-1.38, 0.05-0.27, 1.70-2.39, 14.27-28.62, and 2.78-3.82% for vitamins B_1, B_2, B_3, C and β-carotene, respectively. The results of mineral contents of the dried waterleaf samples are 0.018-0.034, 0.327 - 0.599, 0.168 - 0.222, and 0.016 - 0.059, 12.000 - 23.450% for sodium, potassium, calcium and magnesium, respectively. Phytochemical contents of the dried vegetables ranged from 0.207 to 0.274, 0.011 to 0.017, 0.002 to 0.013%, 0.002 to 0.006, 0.002 to 0.004 and 0.294 to 0.329 for saponin, phytate, oxalate, tannins, flavonoids and alkaloid, respectively. Results of this study shows that sample that was dried using air at ambient temperature retain more vitamin, mineral and phytochemical content of dried waterleaf vegetable.

Keywords: Waterleaf, drying, vitamins, minerals, phytochemicals

INTRODUCTION

Vegetable is important item of the diet in many Nigeria homes and they are valuable sources of nutrients especially in rural area where they contribute substantially to protein, minerals, vitamins, fibre and other nutrients which are usually in short supply in the daily diets [1]. They have the cheapest and most abundant sources of protein [2] and add flavour, taste, colour and aesthetic appeal to the diet [3]. Consumption of vegetable ensures the intake of various essential vitamins and minerals element thus avoiding the problem of malnutrition. However, they contain anti-nutritional which reduce the bioavailability of some nutrients [4].

Waterleaf *(Talinum triangulare)* is an herbaceous perennial plant widely grown in tropical regions as a leaf vegetable [5]. It is consumed as a vegetable and constituent of a sauce in Nigeria. Nutritionally, waterleaf has been shown to possess the essential nutrients like β-carotene, minerals (calcium, potassium and magnesium), pectin, protein and vitamins [5]. Waterleaf has been also discovered for the management of cardiovascular diseases like stroke, obesity, etc [1] and it is used traditionally as softener of other vegetable species. Waterleaf is a highly perishable vegetable and it is susceptible to deterioration due to its high moisture content which consequently leads to waste as a result of lack of efficient preservation techniques. Therefore, drying is one of the processing methods that give products to have increased shelf lives [6], which is achieved by reducing the moisture content present in the food product, such as fruit and vegetable to a level where microbial growth will be inhibited. Several works has been conducted on drying of vegetables and the effects of drying methods on their quality [7] [8] [9] [10], but there is limited information in the literature on the effect of different drying methods on some quality parameters of waterleaf. Though, Oluwalana *et al*. [11] investigated the effect of drying methods on proximate composition, mineral contents and sensory attributes of waterleaf but sun drying and varying drying temperatures using oven were considered. Hence, there is need to study the effect of different drying methods on quality parameters of dried waterleaf using drying methods at relatively low temperatures. This research is therefore aimed at studying the effect of drying methods on the vitamins, minerals and phytochemical contents of the dried waterleaf and to establish the most effective drying method that retains the quality attributes.

MATERIALS AND METHODS

Materials

Freshly harvested waterleaf was obtained from Ladoke Akintola University of Technology (LAUTECH) Teaching and Research Farm, Ogbomoso. Other materials and equipments used were obtained at Owodunni of Food Processing Laboratory of Food Science and Engineering, LAUTECH, Ogbomoso, Oyo State.

Sample Preparation

The fresh leaves of harvested waterleaf were removed from the main stalk and were sorted to remove the bruised ones. The good shape leaves were thoroughly washed in water and drained using plastic sieve. The drained leaves were divided into four equal portions of 500 g each to be dried using air (at ambient temperature), sun, solar and cabinet (hot-air at 45 °C) drying methods.

Drying of the Samples

The first portion was spread on a stainless tray, and air dried at ambient temperature in well-ventilated room. The weight was measured at 24 h interval until constant weight was reached. For sun and solar drying methods, the samples were spread on a stainless tray and placed under direct sun and solar dryer, respectively between 10 am and 6 pm and weighed at 1 h interval until constant weight was reached. The fourth part was spread on a stainless tray, placed in cabinet dryer at 45 °C and weighed at 1 h until constant weight was obtained.

Determination of vitamin contents

Vitamins B_1, B_2, B_3, C (which are thiamine, riboflavin, niacin and ascorbic acid, respectively) and β-carotene contents of waterleaf were determined in the dried waterleaf using [12] standard method.

Determination of mineral contents

The method of [12] was used determine sodium and potassium contents of the dried waterleaf samples by flame photometry. The calcium, magnesium and iron contents were determined after wet digestion with a mixture of nitric, sulphuric and hydrochloric acid using Atomic Absorption Spectrophotometer (AAS ZA3000).

Determination of phytochemical contents

Saponins: The method of [13] was used to determine the saponin content of the dried samples. The ground samples (10 g) of dried waterleaf were extracted in 20 ml of 20% with constant stirring for 12 h at 55 °C. The resultant solution was filtered and the residue was re-extracted in 200 ml 20% ethanol. The solvent was then evaporated under vacuum to a volume of 40 ml and 20 ml of diethyl ether was added in a separating funnel and the mixture was vigorously shaken. The aqueous layer was recovered and the pH was adjusted to 4.5 by adding NaOH. The solution was shaken with 60 ml n-butanol, washed twice with 10 ml of 5% aqueous NaCl and then evaporated to dryness in a fume cupboard to give crude saponins and the content was calculated as follows:

$$\%\ \text{Saponins} = \frac{\text{Weight of saponin extract}}{\text{Weight of sample used}} \text{ x } 100 \qquad (1)$$

Phytates: Phytate content of the dried waterleaf sample was determined using phytic acid determination as described by [13]. Sample (2 g) was weighed into a 250 ml conical flask. Sample was soaked in 100 ml of 2% conc. HCl for 3 h and then filtered through a double layer Whatman number 1 filter paper. The filtrate (50 ml) was placed in a 250 ml beaker and 100 ml of distilled water was added. To each sample, 10 ml of 0.3% ammonium thiocyanate indicator solution was added, titrated and followed with standard iron chloride solution which contained 0.00195 g iron/ml. The end point was identified by a brownish-yellow coloration appearance which persisted for 5 min and the percentage phytic acid was calculated as follows:

$$\% \text{ Phytic acid } = \chi \times 1.19 \times 100 \quad (2)$$

where, χ = titre value × 0.00195 g

Oxalates: Oxalate content was determined by adopting the methods of [14]. The dried waterleaf sample (2 g) was suspended in distilled water (190 ml), the solution (10 ml 6M HCl) was added it and digested at 100 °C for 1 h. The sample was cooled and adjusted to have 250 ml with distilled water. The sample was filtered with number 1 Whatman filter paper and then divided into two portions. Four drops of methyl red indicator were added to the samples, followed by the drop wise addition of concentrated NH_4OH solution until the solution colour changed from pink to a yellow. The samples were heated to 90 °C, cooled and then filtered. The filtrates were heated to 90 °C and 10 ml of 5% $CaCl_2$ solution was added with continuous stirring. The cooled samples were centrifuged at 2500 rpm for 5 min and the supernatant was then decanted. The precipitates were dissolved in 10 ml 20% H_2SO_4 and the filtrates of the sample were composited and adjusted to have a volume of 200 ml. The measure of 125 ml of the filtrates was heated to near boiling and titrated against 0.05 M standardized $KMnO_4$ solutions until a faint pint colour persisted for 30 s. The oxalate content was then calculated as follows:

$$1 \text{ ml } 0.05 \text{ M } KMnO^4 = 2.2 \text{ mg oxalate} \quad (3)$$

Tannins: The method of [15] was used to determine the tannin content. The methanolic extract (1.0 ml) was mixed with vanillin-HCl reagent which was prepared by mixing equal volumes of 8% (v/v) hydrochloric acid and 4% (w/v) vanillin, in methanol. The mixture was allowed to stand for 20 min at room temperature and the absorbance was measured at 500 nm, on a UV/Vis spectrophotometer. Absolute methanol was used as a blank and the tannin content in the sample was deduced from the calibration curve plotted for a gallic acid standard.

Flavonoids: The method of [16] was used to determine the flavonoid content. Each extract (500 µl) was mixed with 1.50 ml of 95% ethanol, 0.10 ml of 10% aluminium chloride ($AlCl_3.6H_2O$), 0.10 ml of 1 M sodium acetate ($NaC_2H_3O_2.3H_2O$) and 2.80 ml of distilled water. After incubation for 40 min, absorbance was measured at 415 nm using a spectrophotometer. To calculate the concentration of flavonoids, a calibration curve was prepared using quercetin as standard. The flavonoid concentration is expressed as quercetin equivalents in mg per gram of extract and all assays were carried out in triplicate.

Alkaloids: Alkaloid content was determined using the method by [17]. Five grams (5 g) of the ground waterleaf sample was extracted in 200 ml of 10% acetic acid in ethanol in a 250 ml beaker. Sample was incubated for 4 h at ambient temperature, filtered and then the filtrate concentrated on a water bath to one-quarter of the original volume. The extract was precipitated

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by adding the drops of conc. HN_4OH and was allowed to settle. The precipitate was washed with dilute HN_4OH and then filtered. The residue which contained the alkaloids was dried and weighed. The alkaloid content was determined using:

$$\text{alkaloids (\%)} = \frac{\text{final weight of sample}}{\text{initial weight of extract}} x100 \qquad (4)$$

Statistical Analysis

The data generated were subjected to Analysis of Variance (ANOVA) using the procedure of Statistical Package for Social Sciences (SPSS, Version 16) to determine significance difference at 95% confidence level among the means. The means was separated with Duncan Multiple Range Test (DMRT) as described by Lyocks [18].

RESULTS AND DISCUSSION

Vitamin Content of Dried Waterleaf

The results of vitamin contents of dried waterleaf vegetable are as presented in Table 1. There are significant differences ($p<0.05$) in the vitamins B_1, B_2, B_3, C and β-carotene of the samples. Vitamin B_1 ranged from 0.71 to 1.38%, vitamin B_2 ranged from 0.05 to 0.27%, and vitamin B_3 ranged 1.70 to 2.39% with the raw samples having the highest value while the samples that dried with solar have the lowest value, respectively. The vitamin C ranged 14.27 to 28.62 % and β-carotene from 2.78 to 3.82%. There was a significant difference ($p<0.05$) in the all vitamin contents for all the drying methods used. There were reductions in all vitamin contents of the dried vegetable samples determined. The reduction is as a result of the samples been exposed to heat. This agreed with Negi and Roy [19] who said the loss of vitamins in green leafy vegetables is a function of the processing method, drying temperatures and drying procedure. The loss is attributed to the thermo-sensitive, labile and hydro-soluble nature of that vitamin which is easily leached into the heating medium. Samples air-dried at ambient temperature, though reduced significantly but retained vitamins in the dried samples compared to other samples dried with other drying methods. This is similar to observation of Vyankatrao [9] who studied the effect of drying methods on nutritional value of some vegetables. The loss of carotenoid contents in the processed vegetable is also attributed to the softening of the plant tissue leading to the release of the carotenoids according to Rodriguez-Amaya and Kimura [20].

Mineral Contents

The mineral contents (sodium, potassium, calcium, magnesium and iron) of the dried waterleaf are as presented in Table 2. The sodium values of the dried vegetables ranged from 0.018 to 0.034 mg/100 g with sample dried at room temperature having the highest value and the sample in solar dryer having the lowest value. There was no significant difference ($p<0.05$) between raw sample and the sample dried at room temperature. Also, there was no significant difference ($p<0.05$) in cabinet and sun dried sample. There was little reduction in the sodium value when compare to the raw samples. It was also observed that as temperature increased in each drying methods, the sodium content reduced. This is because higher temperature has effect on sodium content. This result was in line with the observation of Tesleem *et al*. [7] who use sun drying, steam blanching and combination of the two methods on waterleaf and deduced that sun drying sample retained more mineral than all other methods.

The potassium content of the samples ranged from 0.327 to 0.599 mg/100 g with the raw sample having the highest value and the solar dried sample with the lowest value. There was a significant difference ($p<0.05$) in the values of potassium for all the drying methods used. There was a reduction in the value of potassium as temperature increased. This result was in harmony with the finding of Akubugwo *et al*. [21] who work on *Amaranthus hybridus* L. and *Solanum nigrum* L. There was reduction of potassium content in the raw sample as it got dried, also the sample dried at ambient temperature retain more potassium among the dried samples (0.4870%) and the solar dried have the lowest value (0.3270 mg/100 g). Calcium is a mineral important in teeth, bone and muscle metabolism [22]. The value for calcium content in the dried vegetable ranged from 0.168 to 0.222 mg/100 g with the fresh sample having the highest value while the solar dried sample having the lowest value. Though, significant differences ($p<0.05$) were observed in the values of calcium for all the drying methods but sample dried at room temperature retain more calcium among the dried samples (0.214 mg/100 g). It was observed that there was a reduction in the values of calcium with increase in temperature. This result obtained was similar to that of Tesleem *et al*. [7] who subjected waterleaf to different processing methods.

Magnesium is an important mineral element in connection with circulatory disease such as heart disease [21]. The magnesium content of the dried vegetable ranged from 0.016 to 0.059 mg/100 g with the raw sample having the highest value, while the solar dried sample has the lowest value. There was a significant difference ($p<0.05$) in the values of magnesium for all the drying methods used. Also, the samples dried at room temperature retain more mineral among the dried samples (0.0490 mg/100 g). The same trend was observed by Tesleem *et al.* [7] during the drying of waterleaf using sun drying, steam blanching and combination of the two methods. Iron is an essential trace element for hemoglobin formation, normal function for central nervous system and energy metabolism [23]. The iron content for dried vegetable ranged from 12.000 to 23.450 mg/100 g. There was significant difference ($p<0.05$) in all the samples. There was a decrease in the value of dried vegetable with increase in drying temperature, with the dried sample at room temperature having the highest value (20.500 mg/100 g) and the solar dried sample have the lowest value (12.000 mg/100 g). Generally, room temperature drying method retained more mineral than other drying methods used. This result conformed to the work of Akubugwo *et al*. [21] on drying of *Amaranthus hybridus L*. and *Solarium nigrum L.*

Phytochemical Contents

The results of phytochemical contents (saponin, phytate, oxalate, tannin, flavonoid and alkaloid) of the dried vegetable are as presented in Table 3. The saponin content of the dried vegetable ranged from 0.207 to 0.274%, with fresh sample having the highest value (0.274%) while the solar dried sample has the least value of saponin content (0.207%). This might be as result of high temperature observed in the solar dryer during this experiment because the range of temperature observed in solar dryer was between 45 – 60 °C, depending on the intensity of the sun. Though, there was reduction of saponin as samples got dried but no significant difference ($p>0.05$) was observed among the three drying methods (room temperature, sun, solar and cabinet) used. It was observed that higher temperature reduced the saponin content of the dried vegetable; this is as result of the fact that structures of saponin get destroyed as temperature increased from room temperature [24], [25].

The phytate content of the dried samples ranged from 0.011 in solar-dried sample to 0.017% in fresh vegetable sample. There was a notable reduction in the value of phytate in the vegetable as it was exposed to drying air. There was a significant ($p<0.05$) reduction in the values of phytate content of sample in all the drying method used. This was confirmed by Udousoro and Akpan [26] when it was reported that the phytate in vegetables decreased with increase in temperature. The oxalate content of the vegetable ranged from 0.002 to 0.013% with fresh sample having the highest value (0.013%) and the sample that was dried with the cabinet dryer having the lowest samples (0.001%). A notable reduction in the value of oxalate in the dried vegetable when processed was observed. There were significant differences ($p<0.05$) in all the drying methods. Oxalate in food binds to calcium and form an insoluble salt which prevents the absorption of calcium as well as iron and zinc and their utilization by the body forming kidney stones. The reduction of oxalates in drying of vegetables was reported by Muchoki *et al*. [27], Mwanri *et al*. [28], which is similar to the observation in this study.

Tannins which are anti-nutrients of plant foods that hinder enzymes for digestion, and also decrease the use of vitamins and minerals were reported to be health-promoting components in plant foods [29]. They were found in this study to range between 0.002 and 0.006% with the raw sample have the highest value while the sample that was solar dried have the lowest value. There were no significant difference between the raw sample and the sample that was dried with ambient temperature, also there was no significant difference between the sun, solar and cabinet dried samples. Though, the content of tannins in waterleaf is very low, their presence in the dried samples is of benefit as reported by Ghosh [30] that inclusion foods containing tannins in one's daily diet helps in preventing and combating various types of health ailments due to their radical scavenging and antioxidant potential.

The flavonoids ranged from 0.002 to 0.004% with the raw sample have the highest value while the sample that was solar dried have the lowest value. The lower value obtained in solar dried sample might be as a result of high temperature which leads to loss of macromolecules (flavonoids) during drying. The result in this study agree with the finding of Rwubatse *et al*. [8] who reported a low value of flavonoids during oven drying of sweat orange fruit mixed with flour in making biscuit. The same trend of significant differences was observed in the results of alkanoids which ranged from 0.294 to 0.329 with solar dried sample having the lowest value.

Rickman *et al.* [31] reported that drying, as one of the processing methods used in preparing vegetables before consumption reduces the components such as alkaloids which may affect the nutritional content of vegetables. Ebuehi *et al*. [32] also reported that there is relative stability of alkaloids when food is subjected to heat treatment. The insignificant difference (p>0.05) observed in the three drying methods (sun, solar and cabinet) of this study agreed with the findings of Manzano *et al*. [33] which may actually be as a result of the fact that drying was not done at a very high temperature.

Table 1: **Vitamin contents of waterleaf (%)**

Drying Method	B_1	B_2	B_3	C	β-Carotene
Fresh	1.38^{a}	0.27^{a}	2.39^{a}	28.62^{a}	3.82^{a}
Room temperature	1.24^{b}	0.17^{b}	2.24^{b}	26.81^{b}	3.71^{b}
Cabinet	1.12^{cd}	0.12^{c}	2.10^{c}	22.93^{c}	3.58^{c}
Sun	0.97^{c}	0.10^{cd}	1.94^{d}	17.68^{d}	3.02^{d}
Solar	0.71^{d}	0.05^{d}	1.70^{e}	14.27^{e}	2.78^{e}

Means values (n=3) with the different superscripts within the same column are significantly different ($p<0.05$).

Table 2: Mineral contents of waterleaf (mg/100 g)

Drying Method	Sodium	Potassium	Calcium	Magnesium	Iron
Fresh	0.034^{a}	0.599^{a}	0.222^{a}	0.059^{a}	23.450^{a}
Room Temperature	0.030^{a}	0.487^{b}	0.214^{b}	0.049^{b}	20.500^{b}
Cabinet	0.024^{b}	0.476^{b}	0.199^{c}	0.039^{c}	17.500^{c}
Sun	0.024^{b}	0.465^{b}	0.188^{d}	0.044^{c}	14.050^{d}
Solar	0.018^{c}	0.327^{c}	0.168^{e}	0.016^{d}	12.000^{e}

Means values (n=3) with the different superscripts within the same column are significantly different ($p<0.05$).

Table 3: Phytochemical contents of waterleaf (%)

Drying Method	Saponin	Phytate	Oxalate	Tannin	Flavonoid	Alkaloid
Fresh	0.274^{a}	0.017^{a}	0.013^{a}	0.006^{a}	0.004^{a}	0.329^{a}
Room Temperature	0.247^{ab}	0.015^{b}	0.012^{ab}	0.006^{a}	0.004^{a}	0.318^{a}
Cabinet	0.265^{ab}	0.013^{c}	0.001^{b}	0.004^{b}	0.003^{b}	0.302^{b}
Sun	0.215^{ab}	0.012^{cd}	0.006^{c}	0.002^{c}	0.002^{b}	0.298^{b}
Solar	0.207^{b}	0.011^{d}	0.002^{d}	0.002^{c}	0.002^{b}	0.294^{b}

Means values (n=3) with the different superscripts within the same column are significantly different ($p<0.05$).

CONCLUSION

The vitamin, mineral and phytochemical content of the waterleaf (*T. triangulare*) has proved that it is good for medicinal purposes. All the drying methods showed a considerable reduction in the minerals, vitamin and phytochemical content of the vegetable but drying at ambient temperature is the most preferred processing method to retain the best of the vitamin, minerals and phytochemical contents of the vegetable. Results of analysis revealed that waterleaf dried at lower temperatures adopted in the study contain an appreciable amount of vitamin, minerals and phytochemical contents of the vegetable can still be of benefit to human health. It can therefore be concluded that the waterleaf sample dried at ambient temperature retains nutritional quality of the sample which may be needed in our daily nutritional need.

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