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Effect of Drying Methods on the Mineral Content of Waterleaf (*Talinum Triangulare*), African Spinach (*Amaranthus Hybridus*) and African Garden Egg Leaves (*Solanum Marcrocarpan*)

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ABSTRACT:

Samples of waterleaf (*Talinum triangulare*), African spinach (*Amaranthus hybridus*) and African eggplant leaves (*Solanum marcrocarpan* were dried using different methods: oven drying, sun drying and air drying methods to determine the effect of the drying methods on the mineral composition of the selected vegetables. The dried vegetables and their respective freshly harvested vegetables were subjected to mineral evaluation using spectrophotometer method. Results obtained shows that values recorded for calcium for various samples ranged from 264.50±0.071 to 55.64±0.05, magnesium ranged from 124.50±50 mg/100g to7.64±0.02 mg/100g, iron ranged from 65.10±0.14 mg/100g to 3.81±0.03 mg/100g, phosphorus ranged from 204.00±1.41 mg/100g to 125.18±0.09 mg/100g, potassium ranged from 644.00±1.41 to 6.15±0.07, sodium ranged from 0.48±0.01 mg/100g to 313.88±0.12 mg/100g and zinc ranged from 0.46±0.01 to 2.41±0.01 mg/100g respectively. The samples were significantly different from each other at $p \leq 0.05$. The results demonstrated that air dried waterleaf contains more minerals than other samples that made use of higher temperatures. As a result, oven-dried, sun-dried African eggplant leaves and African spinach leaves recorded higher concentrations of all the minerals analyzed than air-dried leaves. It is possible to conclude that the suitability of any drying process is dependent on the type of vegetable. The air drying method is suitable for waterleaf, whereas the oven and sun drying methods are appropriate for drying African spinach leaves and African eggplant leaves.

Keywords: Waterleaf, African spinach leaves, egg plant leaves, minerals

1. Introduction:

Vegetables are edible parts of leaf, stem and roots of plant (Aburime, 2019). They are usually cooked or eaten raw. They include those plants part that are used in making soup which serves as an integral part of the people's meal (Ihekoronye & Ngoddy, 2007). As a food source, they supply fibre, minerals and vitamins to the diet of majority of people in developing countries like Nigeria, where they are frequently consumed as side dish or relish with staple food (Ihekoronye & Ngoddy, 2007). Vegetables are important protective foods for the maintenance of health and prevention of diseases. They contain valuable phyto-nutrients like carotenoids, polyphenolic compounds and dietary fibre that can be utilized for the physiological needs of the body.

Vegetables contribute to food security which adds variety to the starchy staples either as soups or porridge. Green leafy vegetables are good source of micro-nutrients, non-volatile acids, organic acids, mineral salts, volatile sulphur compounds and tannin which impart flavour in diets and antioxidants compounds like polyphenols, flavonoids and arrays of carotenoids and ascorbic acid which boost the body immunity (Oguntona *et al*., 1998). Vegetable also consist of carbohydrate mainly as indigestible fibrous materials such as cellulose, hermicillulose and lignin and small quantity of sugar such as glucose, fructose, sucrose and high moisture content that ranges from 75%-95%. Sub-Saharan Africa is said to have the world's lowest intake of micronutrient-rich in fruits and vegetables, with most countries consuming less than half of the World Health Organization's (WHO) recommended daily intake of 400g per capita per day (WHO, 2005). Micronutrient deficiencies are primarily caused by lack of consumption of fruits and vegetables, particularly in populations with low intake of nutrient-dense animal sources and dietary products.

Nutritional deficiencies particularly iron, iodine, and vitamin A deficiencies, has been identified as major issues for school-age children in low-income countries. Iron, vitamin A, iodine and zinc deficiencies, on the other hand, have far-reaching consequences for growth, development and health, thereby contributing to impaired immunity and cognitive function, growth failure, increased morbidity, and mortality.

One major problem inhibiting the production and consumption of indigenous leafy vegetable in most African countries like Nigeria is the high post-harvest losses due to inadequate storage facilities. Losses are exacerbated by loads of mixed leaves ripening, inefficient packaging system and inefficient transport systems due to poor road network which subject leaves to static and dynamic stress.

Vegetable products play an important role in West African diets. Some crops grown for one purpose may also be used for another, such as cowpea and cassava, which are grown for their protein-rich seeds and carbohydrate-rich leaves respectively, and the leaves are harvested for vegetables (Seidu *et al*., 2012).

Leafy vegetables have been linked to important nutritional value as a major source of vitamins and minerals to ensure a balanced diet (Rubaihayo, 1997). Vegetables are good source of roughages, they stimulate the intestinal muscles and keep them in working order by providing an indigestible matrix, as well as preventing constipation through their laxative effect. The fiber content of vegetables generally adds bulk to the food, preventing us from feeling hungry all the time (Rubaihayo, 1997).

Some indigenous leafy vegetables, such as okra and vegetable jute, add a glutinous component to stew and soup, making it easier to swallow foods like 'Banku,' 'Fufu,' and 'Gari.' It has also been discovered that vegetables are a good source of vitamins K, A, and C, as well as minerals like calcium, iron, phosphorus, thiamine, niacin, and riboflavin, carbohydrate, and crude protein when compared to exotic leafy vegetables (Schippers, 2000). The interest of this study is to look at the effect of different drying methods on the mineral composition of some selected green leafy vegetables. The drying methods include; sun drying, oven drying, and air drying method.

2. Methodology:

All the vegetables such as (Waterleaf, African Garden egg leaves and African Spinach leaves), were purchased from Eke market Afikpo L.G.A Ebonyi State, Nigeria.

2.1. Sample preparation:

All the leaves were destalked where necessary. They were then rinsed thoroughly with portable water and allowed to drain.

2.2. Drying of vegetable sample:

The selected vegetable leaves were prepared and dried according to the method described by Mbah *et al* (2012).

2.3. Determination of Minerals:

The calcium content was determined by using the atomic absorption spectrophotometric method as described by Pearson, (1976). The magnesium content was determined by using 1g of the sample digested in 20ml of acid mixture (650ml concentrated HNO_3; 80ml PCA and 20ml concentrated H_2SO_4) using the atomic absorption spectrophotometric method described by Onwuka, (2005). Potassium content was determined by adopting the method of AOAC, (2000). Sodium content was determined by photometry method of AOAC, (2000). Phosphorus content was determined on 0.5ml of mineral digest using the molybdate method described by Onwuka, (2005). The iron content was determined by using the spectrophotometric method described by Onwuka, (2005). Zinc content was determined on 1g of digested sample in 20ml of acid mixture (650ml concentrated HNO_3; 80ml PCA and 20ml concentrated H_2SO_4) using spectrophotometric method described by Onwuka, (2005).

2.4. Statistical analysis:

All data obtained in triplicates were subjected to analysis of variance (ANOVA) using the SPSS statistical package (Version 10.0), (2000 edition). Means were separated with Duncan multiple ranged test (DMRT).

3. Results

3.1 Result of the effect of drying methods on mineral composition of waterleaf

Results obtained from Table 1 shows that the amount of calcium in various samples recorded significant difference at ($p \leq 0.05$). Calcium (Ca) was found to be higher in the control sample compared to the dried samples. The amount of calcium in the dried samples ranged from 56.96 to 55.64 mg/100g. This result shows that air-drying method best preserved calcium compared to other drying methods used. This result is in agreement with the study of Ogunlakin *et al*. (2020), who reported that waterleaf samples dried at room temperature retains more calcium when compared to other high temperature drying methods. Calcium is crucial in maintaining various important physiological functions, such as controlling neuron excitability, required for the skeletal muscles to maintain their integrity, critical for maintaining cardiac tone and contractility, it helps rennin coagulate milk in the stomach (Pravina *et al*., 2013).

The magnesium (Mg) content of waterleaf for all the drying methods used recorded significant difference at ($p \leq 0.05$). There was a decrease in the magnesium content as the temperature increases during drying. Similar trend was observed by Tesleem *et al*. (2008) and Ogunlakin *et al*. (2020). Magnesium helps to maintain normal nerve and muscle function, supports healthy immune system, keeps the heartbeat steady, and helps bones remain strong. It also aids in the regulation of blood glucose levels (Ogunlakin *et al*., 2020).

The iron (Fe) content of the various waterleaf samples had significant difference at ($p \leq 0.05$). The fresh waterleaf (control) retained the highest amount of iron. The iron content ranged from 63.82 mg/100g (for control sample) to 63.71 mg/100g (for oven-dried) sample. There was also a gradual decrease in iron as the temperature increases. Tesleem *et al*. (2008) had earlier opined that the mineral content of vegetables decreases with increase in drying temperature. Iron is a key component of hemoglobin, a protein found in red blood cells that transport oxygen from the lungs to all areas of the body.

Phosphorus (P), potassium (K), sodium (Na) and zinc (Zn) content of the various waterleaf samples were significantly different at ($p \leq 0.05$). In this study, the fresh leaf (control) gave higher value of nutrients compared to the dried samples. Therefore, it was observed that drying decreases the mineral content of vegetables generally. Several volatile minerals and nutrients are lost to high temperature. Some soluble minerals are usually leached away during the drying process. The increase in some minerals in both oven-drying and sun-drying methods can be attributed to the fact that some antinutrients were destroyed due to the high temperature applied during drying thereby making more mineral and nutrients available (Oluwalana *et al*., 2011).

Table 1. Effect of different drying methods on the mineral composition of waterleaf

Sample	Ca (mg/100g)	Mg(mg/100g)	Fe(mg/100g)	P(mg/100g)	K(mg/100g)	Na(mg/100g)	Zn(mg/100g)
C-WL	58.27 ± 0.01^{d}	8.94 ± 0.06^{c}	65.10 ± 0.00^{d}	131.50 ± 0.01^{d}	8.10 ± 0.01^{d}	0.54 ± 0.01^{b}	0.63 ± 0.00^{c}
AD-WL	56.96 ± 0.01^{a}	7.64 ± 0.00^{a}	63.82 ± 0.01^{a}	125.18 ± 0.01^{a}	6.15 ± 0.00^{a}	0.48 ± 0.01^{a}	0.46 ± 0.01^{a}
SD-WL	56.12 ± 0.02^{b}	7.23 ± 0.01^{d}	63.81 ± 0.00^{b}	127.60 ± 0.00^{b}	7.22 ± 0.01^{b}	0.51 ± 0.00^{a}	0.55 ± 0.05^{a}
OD-WL	55.64 ± 0.01^{c}	7.56 ± 0.01^{c}	63.71 ± 0.00^{c}	127.94 ± 0.01^{c}	7.86 ± 0.00^{c}	0.53 ± 0.01^{b}	0.62 ± 0.01^{c}

Values are mean ± standard deviation. Means with the same letter(s) on the same row are not significantly different using the method of least significant difference (LSD) at 5% probability.

Keys

C-WL – control water leaf, AD-WL= Air-dried waterleaf, SD-WL= Sun-dried waterleaf, OD-WL= Oven-dried waterleaf.

3.2 Result of different drying methods on the mineral composition of African Spinach leaf

The calcium (Ca), magnesium (Mg) and iron (Fe) of the various African spinach leaf samples were significantly different at ($p \leq 0.05$) respectively. Among the dried samples, the oven dried African spinach leaf recorded higher concentration of the aforementioned minerals. Calcium (Ca) was found to be higher in the control sample compared to the dried samples. The amount of calcium in the dried samples ranged from 242.04 to 261.74mg/100g. This result shows that oven-drying method best preserved calcium compared to other drying methods used. While the magnesium (Mg) content of African spinach leaf ranged from 121.51 to 122.29mg/100g. The oven-drying method recorded the highest magnesium content compared to the other drying methods used. The iron (Fe) content of the African spinach leaf samples had significant difference at ($p \leq 0.05$). The oven drying method recorded the highest value of 4.86mg/100g, followed by the sun drying method. Oluwalana *et al*. (2011) suggested that increased drying temperature might lead to increased mineral composition of vegetables due to the destruction of antinutrients caused by high temperature processing. Similarly, phosphorus (P), potassium (K), sodium (Na) and zinc (Zn) were significantly different at ($p \leq 0.05$) respectively. Drying tends to cause a decrease in minerals in vegetables compared to the raw ones. Zinc is essential for immunological function, wound healing, blood clotting, thyroid function, and many other processes. It is also important for healthy vision and may have antiviral properties (Aletor and Abiodun 2013). Also, a small fraction of sodium is required by the human body to carry nerve impulses, contract and relax muscles, and maintain adequate water and mineral balance. In the same vein, the primary function of phosphorus in the body is to assist maintain normal amounts of fluid inside our cells.

Table 2. Effect of different drying methods on the mineral composition of African Spinach leaf

Sample	Ca (mg/100g)	Mg(mg/100g)	Fe(mg/100g)	P(mg/100g)	K(mg/100g)	Na(mg/100g)	Zn(mg/100g
C-ASP	264.05 ± 0.01^{d}	124.05 ± 0.01^{d}	4.95 ± 0.01^{d}	139.00 ± 0.00^{d}	88.50 ± 0.01^{d}	88.05±0.01	0.66±0.01
AD-ASP	242.04 ± 0.01^{a}	121.51 ± 0.00^{a}	3.81 ± 0.01^{a}	133.32 ± 0.01^{a}	78.50 ± 0.00^{a}	78.05±0.01	0.56±0.01
SD-ASP	250.54 ± 0.00^{b}	121.81 ± 0.01^{b}	4.13 ± 0.01^{b}	134.72 ± 0.01^{b}	85.35 ± 0.01^{b}	85.35±0.00	0.62±0.01
OD-ASP	261.74 ± 0.05^{c}	122.29 ± 0.01^{c}	4.86 ± 0.01^{c}	136.46 ± 0.01^{c}	86.95 ± 0.01^{c}	86.95±0.01	0.65±0.05

Values are means ± standard deviation. Means with the same letter(s) on the same row are not significantly different using the method of least significant difference (LSD) at 5% probability.

Keys: C-ASP – control African spinach, AD-ASP= Air-dried African spinach, SD-ASP= Sun-dried African spinach,

OD-ASP= Oven-dried African spinach.

3.3 Result of different drying methods on the mineral composition of African egg plant

The mineral content obtained in this result were significantly different at $p \leq 0.05$ for all the sample of the African egg plant leaf as shown in Table 3. The fresh African eggplant leaf (control) retained the highest amount of minerals in all the minerals tested. Meanwhile, the oven-dry method, followed by the sun dry method retained the minerals most compared to air dry method. Calcium (Ca) recorded the highest content in the control sample which was significantly different from the dried samples. The amount of calcium in the dried samples ranged from 208.28 to 210.11mg/100g. The result shows that sun-drying method best preserved calcium and recorded a value of 208.76mg/100g when compared to other drying methods used. While the magnesium (Mg) content of African egg plant leaf ranged from 10.97 to 12.19 mg/100g. The oven-drying method recorded the highest magnesium content in this study and was found best among the drying methods used. The iron (Fe) content of the African spinach leaf samples had significant difference at ($p \leq 0.05$). The oven drying method recorded the highest iron content of 7.30mg/100g, followed by the sun drying method which recorded 6.76mg/100g. Potassium content of African egg plant leaf ranged from 633.25 to 640.49 mg/100g. The oven-drying method recorded the highest potassium content which was significantly different from the other drying methods used. According to Combo *et al.* (2020), African eggplants have substantial quantities of anti-nutritional components (oxalate, tannin, flavonoid and phytate). These anti-nutritional components of the eggplant leaves are capable of inhibiting the bioavailability of minerals like calcium, iron, zinc and others. However, drying at temperatures above 50ºC is capable of destroying these anti-nutrients thereby making these minerals available for biological activities hence, the reason for increase in mineral content in those samples that are dried under high temperature.

Table 3. Effect of different drying methods on the mineral composition of African egg plant

Sample	Ca (mg/100g)	Mg(mg/100g)	Fe(mg/100g)	P(mg/100g)	K(mg/100g)	Na(mg/100g)	Zn(mg/100g)
C-AEP	213.25±0.05^{d}	14.10±0.00^{d}	7.93±0.00^{d}	204.0±0.00^{d}	644.00±0.01	313.88±0.00^{d}	2.41±0.01^{a}
AD-AEP	208.28±0.02^{a}	10.97±0.02^{a}	6.24±0.01^{a}	198.12±0.01^{a}	633.25±0.01	305.00±0.01^{a}	2.28±0.01^{a}
SD-AEP	208.76±0.01^{b}	11.55±0.01^{b}	6.76±0.01^{b}	199.56±0.01^{b}	634.95±0.01	311.05±0.01^{b}	2.30±0.01^{b}
OD-AEP	210.11±0.01^{c}	12.19±0.01^{c}	7.30±0.01^{c}	201.67±0.00^{c}	640.49±0.01	313.05±0.01^{c}	2.36±0.01^{c}

Values are means ± standard deviation. Means with the same letter(s) on the same row are not significantly different using the method of least significant difference (LSD) at 5% probability

Keys: C-AEP – control African eggplant, AD-AEP= Air-dried African eggplant, SD-AEP= Sun-dried African eggplant, OD-AEP= Oven-dried African egg plant.

Conclusion

The present study entails the effect of drying methods on the mineral composition of waterleaf, African eggplant leaves and African Spinach leaves. The methods used include air-drying method, sun-drying methods and oven-drying methods. As shown in the results obtained, calcium, iron, magnesium, phosphorus, potassium, sodium and zinc are influenced by the different drying methods. The results obtained shows that air dried waterleaf contained higher amount of minerals compared to the other drying methods that involved higher temperatures. Consequently, oven-dried and sun-dried African eggplant leaves and African spinach gave higher concentration in all minerals compared to the air-dried method. Therefore, it could be deduced that the suitability of any drying method depends on the type of vegetable. Air drying method is suitable for waterleaf drying while oven drying and sun drying methods are suitable for drying of African spinach leaves and African eggplant leaves.

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