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The Effect of Different Drying Methods on Some Common Nigerian Edible Botanicals

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Abstract: *The study was conducted to evaluate the effects of different drying methods on some common Nigerian leafy vegetables.The vegetable tested include T. occidentalis, B. alba, A. hybridus, T. triangulare, C. biafrae and C. rubens. All the vegetables were separately subjected to oven-drying, sun-drying, air-drying and freeze-drying and fresh samples was used as control. The proximate composition, anti-nutritional components and the mineral content of the dried samples was tested with each sample having five replicates. T. occidentale was found with highest content of Na and K regardless of the drying method used while the value of Mg, Zn, Mn and Fe decreases in relation to the drying method used, thus Oven drying < Sun drying<Air drying< freeze drying<fresh.T. occidentalis of 4.54g/100gDM and 0.67 g/100gDM of tannin and saponin respectively while B. alba recorded 6.05 g/100gDM of oxalate. Salkowski and Favonoid were both absent from all the vegetables regardless of the drying method used while Phlobatannin was found absent in oven dried and sun dried vegetables. Comparing the result obtained from the different drying methods, freeze drying method appeared more promising than other drying methods since it appears to maintain mineral content, anti nutritional components and proximate composition of the dried vegetables when compared to the control (fresh sample).*

Keywords: *anti-nutritional factors, drying methods, freeze drying, leafy vegetables*

1. INTRODUCTION

For ages, botanicals have been the major backbone of human and animal source of food and their importance cannot be over emphasis. Plants generally because of their autotrophic nature contain almost if not all the nutritional components required for growth in human and animals as well as insects. In order to make botanical source foods to be more appealing and to increase their shelf life, human have been processing different botanicals ranging from fruits, grains, vegetables andtubers. Morris *et al.*(2004) as well as Abiodun *et al.* (2012) reported that botanical source foods are safer and free of microorganisms especially when they are processed. Because of the high production of many edible botanicals such as vegetables and fruits during the rainy season, processing has been suggested to be the only way-out to reduce or prevent waste especially in the developing countries where the level of preservation is still low (Idah *et al.*, 2010).

Leafy vegetables are one of the highly consumable botanical foods which contain digestible carbohydrates, minerals and vitamins which are highly required for normal healthy digestion (Studman, 1999). Vegetables are generally regarded as perishables because of their high water content which aid their quick deterioration. Processing has therefore played a great deal in the preservation of these high valued plant resources. Hassan *et al.* (2007) suggested that because of the high water content in perishables, special processing techniques are required to reduce or prevent post harvest losses and as well kill microorganisms that can haste deterioration of the perishables. In Nigeria, preservation and processing of leafy vegetables takes different dimension from one social-ethnic groups to another but sun drying and salting is the common processing techniques adopted by many of the ethnic groups (Adeboye and Babajide, 2007). Drying has been noted to be one of the major processing techniques that could increase the shelf life of vegetables and reduce waste. Freeze drying, sun drying and oven drying have been the major type of drying methods involve in preservation of vegetables (Abiodun *et al.*, 2012).

However, plants generally respond differently to drying and different drying techniques have different effect on the components in plants. Furthermore, effect of processing (drying) on nutritional component of plant depends on the sensitivity of the nutrients in the plant to the various conditions including oxygen, heat, pH and light (Morris *et al.,* 2004). High level of illiteracy, low government intervention to agriculture and high level of interrupted power supply have been noted to contribute to the use of sun drying methods for preservation of many farm produces among Nigeria farmers. Nevertheless, sun drying method has been reported by different researchers to be effective in reducing moisture content (a factor believed to aid microbial growth) but because of the high illiteracy level among the Nigeria farmers, less concern has been given to the effects of this processing technique on the nutritional component of the vegetables. Therefore, in order to prevent the loss of nutritional components of vegetables and to increase their shelf life, there is a need to search for appropriate drying method that is not expensive but highly effective in preserving different vegetables. This work for that reason, investigated the effect of different drying methods on some common Nigerian leafy vegetables.

2. MATERIALS AND METHODS

2.1. Collection of Vegetables

The leafy vegetables used in this work include*T. occidentalis, B. alba, A. hybridus, T. triangulare, C. biafrae* and *C. rubens*. These vegetables were collected fresh from an open farm inside Army barrack, Akure, Ondo State, Nigeria. Sorting was carried out on all vegetables in order to remove those that were injured either by insect or during the period of collection, those that were decayed or wilted and those that were discoloured.

2.2. Preparation of the Vegetables

The stalks of all the vegetables were removed from the main branches and the leaves were washed to remove all stones, dirts and dusts. However, during the washing the leaves of each vegetable were handled with care to avoid any mechanical injury. After washing, each vegetable was tied and place in cool area to allow the water on their surface to drain away. The residue moisture was evaporated at a room temperature before the real drying process on a clean paper with constant turning over to avert fungal growth. After air drying, the leaves of the vegetables were weighed and were divided equally to five equal portions in order to have replicates. Also, each vegetable was grouped into three so as to have those that will be freeze dry, oven dry and sundry.

2.3. Dry Techniques

For sun drying, the method of Mbah *et al.* (2012) was employed with little modification. The leaves which have been air dried were placed on cotton sheets and then covered with the cheesecloth to keep off dust and insects. The cotton sheets were placed in a direct sunlight on a roof out of reach of animals. The leaves were occasionally mixed to allow even drying. All the sun dried vegetables were brought inside in the evening to avoid re-absorption of moisture. The dried samples were kept inside different air tight container before anaylsis.

For oven drying, the method of Mbah *et al.*(2012) was engaged with little modification. The leaves of each vegetable were placed inside different trays and were dried using force air. The oven was pre-heated to 60^0C and this temperature was maintained for 1hr to allow the leaves to dry. The leaves were left for 4h to allow complete drying and each dried samples were placed inside air dried container before analysis. However, the samples were allowed to cool before they were packed inside container to avoid heat which could lead to caking.

For air drying, the air-dried leaves were placed on cotton sheets and then covered with the cheesecloth to keep off dust and insects. The cotton sheets were placed in a well ventilated room at a temperature of 25±2°C for days. Natural current of air was used for shade-drying the vegetables. The leaves were left until they become crisp and brittle to touch.

For freeze drying, all the vegetables were washed and air dried under rotating fan for few minutes. After little drying the vegetables were cut into smaller sizes and were spread on a perforated tray to avoid clumping. The trays containing the vegetables were placed inside clean freezer at temperature of -20°C. After some minutes a piece of the freeze dried vegetable was removed and placed on a clean plate to test whether it is fully dried or not. The vegetables were placed inside different Ziploc bags after which they have been completely freeze dried and the bags were sealed up and were stored until further use.

2.4. Determination of the Proximate Composition and Mineral Contents

All the vegetables were dried before they were being analyzed for protein, fat, fibre, ash and carbohydrate content. The protein content was determined using micro-kjedahl procedure which was modified by Pearson (1976) while fat content was determined by the method of Peaerson (1976) using petroleum ether as solvent for extraction. Crude fibre of each of the vegetables was determined by Weende method with little modification. The ash content was determined by dry ashing in a furnace at 600°C for 2h. The carbohydrate content of the vegetables were obtained AOAC 1990 method and the moisture content of each of the vegetable was determined with the method of TCA. The mineral content analysis was carried out by abducting the methods of peaerson (1976) as well as Latta and Eskin (1980).

2.5. Determination of the Anti-Nutrient Composition of the Vegetables

The anti nutrient composition of vegetables was carried out using different methods. Tannins, Phloba tannin, Saponin and Salkowski were determined using spedtrophotometric procedures while flavonoid composition was determined by the method described Dye and modified by Iwuoha and Kalu (1995).

2.6. Data Analysis

All the data obtained were subjected to one way analysis of variance (ANOVA)and means were separated using New Duncan's Multiple Range Test in Statistical Package for Social Sciences (SPSS) version 17.

3. RESULTS

3.1. Effect of Drying Methods on Mineral Contents of Vegetables

Table 1 presented the effect of drying methods on the mineral contents of six vegetables. The effect of the drying methods on the mineral contents varies among the vegetables. Na, K, Ca, Mg, Zn, Mn, Fe, Cu, N and P were found in all the six vegetables while *T. occidentale* was found with highest content of Na and K regardless of the drying method used. Also, the amount of K was found to be significantly reduced in vegetables that were oven dried compared to those that were dried by other methods. Moreover, the highest amount ofK of 1.93 was found in fresh *T. occidentale*and was significantly ($p<0.05$) different from oven dried and sun dried vegetables. However, no significant ($p>0.05$) difference exist in Mg and Cu content among all the vegetables examined regardless of the drying method used. *C. rubens* was found to recorded highest Ca content among the vegetable in spite of the drying methods used. However, the value of Mg, Zn, Mn and Fe decreases in relation to the drying method used thus Oven drying < Sun drying<Air drying< freeze drying<fresh.

Table1. *Effect of drying methods on mineral content of different leafy vegetables*

Drying methods	Plant materials	Na	K	Ca	Mg	Zn	Mn	Fe	Cu	N	P
Oven	*T. occidentalis*	0.63±0.02^{a}	0.19±14.51^{a}	1.43±0.92^{a}	1.15±0.01^{a}	0.16±0.08^{a}	0.21±0.02^{a}	0.44±0.01^{a}	0.10±0.01^{a}	1.95±0.03^{c}	0.16±0.16^{a}
	B. alba	0.47±0.15^{a}	0.11±18.09^{a}	1.32±0.36^{a}	1.12±0.01^{a}	0.14±0.01^{a}	0.12±0.01^{a}	0.56±0.02^{a}	0.01±0.01^{a}	1.32±0.04^{c}	0.43±0.04^{a}
	A. hybridus	0.43±0.33^{a}	0.13±46.40^{a}	1.67±2.43^{a}	1.12±0.01^{a}	0.19±0.01^{a}	0.10±0.01^{a}	0.58±0.01^{a}	0.00±0.00^{a}	1.51±0.02^{ab}	0.87±0.09^{d}
	T. triangulare	0.18±0.05^{a}	0.10±44.80^{a}	1.60±2.45^{a}	1.31±0.01^{a}	0.21±0.01^{a}	0.13±0.01^{a}	0.73±0.01^{a}	0.03±0.01^{a}	1.30±0.01^{ab}	0.61±0.12^{b}
	C. biafrae	0.55±0.01^{a}	0.11±22.00^{a}	1.62±2.03^{a}	1.11±0.01^{a}	0.22±0.11^{a}	0.13±0.01^{a}	0.68±0.01^{a}	0.06±0.01^{a}	1.49±0.16^{c}	0.33±0.21^{a}
	C. rubens	0.54±0.03^{a}	0.12±38.29^{a}	1.69±0.97^{a}	1.09±1.70^{a}	0.14±0.01^{a}	0.14±0.01^{a}	0.72±0.01^{a}	0.09±0.01^{a}	1.84±0.01^{c}	0.43±0.05^{a}
Sun	*T. occidentalis*	0.67±0.11^{a}	0.83±0.09^{b}	1.58±0.16^{a}	1.19±0.01^{a}	0.40±0.01^{b}	0.23±0.01^{a}	0.99±0.06^{a}	0.00±0.00^{a}	1.46±0.01^{a}	0.85±0.03^{a}
	B. alba	0.61±0.02^{a}	0.30±0.27^{b}	1.49±0.40^{a}	1.13±0.01^{a}	0.23±0.01^{a}	0.25±0.01^{a}	0.83±0.01^{a}	0.00±0.00^{a}	1.48±0.01^{a}	0.38±0.02^{bc}
	A. hybridus	0.49±0.13^{a}	0.67±1.20^{b}	1.33±1.40^{a}	1.22±0.01^{a}	0.43±0.01^{b}	0.19±0.01^{a}	0.86±0.33^{a}	0.10±0.01^{a}	1.47±0.02^{c}	0.30±0.09^{b}
	T. triangular	0.21±0.07^{a}	0.33±0.27^{b}	1.23±0.42^{a}	1.31±0.01^{a}	0.27±0.02^{a}	0.18±0.01^{a}	0.76±0.02^{a}	0.10±0.00^{a}	1.26±0.03^{c}	0.46±0.01^{b}

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	C. biafrae	0.60±0.11^{a}	0.80±0.12^{b}	1.37±0.32^{a}	1.13±0.01^{a}	0.28±0.01^{a}	0.17±0.01^{a}	0.79±0.01^{a}	0.00±0.00^{a}	1.22±0.01^{ab}	0.81±0.20^{bc}
	C. rubens	0.56±0.02^{a}	0.22±0.01^{b}	1.62±1.70^{a}	1.06±1.70^{a}	0.24±0.01^{a}	0.23±0.02^{a}	0.80±0.01^{a}	0.02±0.01^{a}	1.36±0.03^{ab}	0.62±0.01^{b}
Air	*T. occidentalis*	1.92±1.27^{b}	1.77±0.12^{c}	1.63±0.92^{a}	1.63±0.02^{b}	0.29±0.01^{a}	0.33±0.09^{b}	1.13±0.91^{b}	0.00±0.00^{a}	1.40±0.01^{b}	0.83±0.09^{b}
	B. alba	1.40±0.02^{b}	1.47±0.05^{c}	1.34±0.36^{a}	1.56±0.02^{b}	0.32±0.01^{a}	0.30±0.27^{b}	1.38±0.03^{b}	0.01±0.00^{a}	1.23±0.01^{a}	0.30±0.27^{b}
	A. hybridus	1.61±0.01^{b}	1.57±0.23^{c}	1.57±2.43^{a}	1.85±0.02^{b}	0.31±0.02^{b}	0.37±1.20^{b}	1.32±0.01^{b}	0.10±0.01^{a}	1.43±0.01^{b}	0.67±1.20^{b}
	T. triangulare	1.81±0.02^{b}	1.66±0.14^{c}	1.63±2.45^{a}	1.77±0.01^{b}	0.33±0.01^{b}	0.31±0.27^{b}	1.34±0.01^{b}	0.10±0.00^{a}	1.27±0.02^{a}	0.33±0.27^{b}
	C. biafrae	1.06±0.07^{b}	1.75±0.01^{c}	1.32±2.03^{a}	1.57±0.01^{b}	0.34±0.01^{a}	0.30±0.12^{b}	1.41±0.01^{b}	0.00±0.00^{a}	1.28±0.01^{a}	0.80±0.12^{b}
	C. rubens	1.59±0.21^{b}	1.41±0.33^{c}	1.69±0.97^{a}	1.53±0.01^{b}	0.31±0.01^{a}	0.32±0.01^{b}	1.11±0.01^{b}	0.02±0.01^{a}	1.24±0.01^{a}	0.22±0.01^{b}
Freeze	*T. occidentalis*	1.72±0.01^{b}	1.79±0.22^{c}	1.27±0.31^{a}	1.80±0.10^{b}	0.30±0.01^{b}	0.37±0.01^{b}	1.17±0.91^{b}	0.00±0.00^{a}	1.72±0.01^{a}	0.55±0.01^{b}
	B. alba	1.17±0.01^{a}	1.57±0.15^{c}	1.32±0.09^{a}	1.78±0.01^{b}	0.33±0.01^{a}	0.35±0.01^{b}	1.68±0.03^{b}	0.05±0.01^{a}	1.92±0.01^{a}	0.67±0.01^{b}
	A. hybridus	1.70±0.05^{b}	1.37±0.45^{c}	1.37±0.07^{a}	1.36±0.07^{b}	0.32±0.01^{b}	0.40±0.02^{b}	1.92±0.01^{b}	0.10±0.01^{a}	1.28±0.04^{c}	0.54±0.04^{a}
	T. triangulare	1.42±0.03^{b}	1.26±0.41^{c}	1.31±0.06^{a}	1.80±0.02^{b}	0.37±0.02^{a}	0.35±0.03^{b}	1.41±0.01^{b}	0.04±0.01^{a}	1.08±0.03^{c}	0.84±0.11^{a}
	C. biafrae	1.60±0.01^{a}	1.55±0.06^{c}	1.41±0.01^{a}	1.87±0.01^{b}	0.38±0.01^{a}	0.37±0.04^{b}	1.42±0.01^{b}	0.00±0.00^{a}	1.58±0.01^{a}	0.35±0.10^{b}
	C. rubens	1.05±0.03^{a}	1.23±0.02^{c}	1.39±0.12^{a}	1.72±0.01^{b}	0.34±0.01^{a}	0.36±0.01^{b}	1.16±0.01^{b}	0.05±0.01^{a}	1.03±0.02^{ab}	0.12±0.01^{b}
Fresh	*T. occidentalis*	1.94±0.94^{b}	1.93±0.16^{c}	1.34±0.13^{a}	1.81±0.07^{b}	0.43±0.01^{b}	0.41±0.01^{b}	1.19±0.01^{b}	0.14±0.01^{a}	1.86±0.01^{c}	0.75±0.12^{a}
	B. alba	1.80±0.12^{b}	1.87±0.57^{c}	1.55±0.09^{a}	1.86±0.01^{b}	0.44±0.01^{b}	0.40±0.01^{b}	1.69±0.12^{b}	0.12±0.01^{a}	1.25±0.01^{c}	0.88±0.06^{a}
	A. hybridus	1.82±0.01^{b}	1.49±0.31^{c}	1.41±0.09^{a}	1.82±0.01^{b}	0.42±0.01^{a}	0.42±0.00^{a}	1.94±0.01^{b}	0.00±0.00^{a}	1.46±0.02^{a}	0.82±0.09^{d}
	T. triangulare	1.87±0.01^{b}	1.70±0.14^{c}	1.31±0.02^{a}	1.84±0.03^{b}	0.41±0.01^{a}	0.37±0.01^{b}	1.96±0.03^{b}	0.00±0.00^{a}	1.81±0.01^{a}	0.34±0.01^{b}
	C. biafrae	1.71±0.17^{b}	1.91±0.09^{c}	1.37±0.05^{a}	1.89±0.01^{b}	0.45±0.01^{b}	0.38±0.01^{b}	1.78±0.01^{b}	0.43±0.01^{a}	1.53±0.03^{c}	0.16±0.35^{a}
	C. rubens	1.80±0.12^{b}	1.46±0.94^{c}	1.47±0.61^{a}	1.91±0.02^{b}	0.44±0.01^{b}	0.39±0.01^{b}	1.42±0.01^{b}	0.62±0.01^{a}	1.46±0.01^{c}	0.96±0.23^{ab}

Each value is a mean of five replicates ± standard error of each sample. Values having the same alphabet as superscript in the same column are not significantly different at 0.05 significant levels

3.2. Effect of Different Drying Techniques on the Proximate Composition of Different Vegetables

The effect of different drying methods on the proximate composition of each of the vegetable tested was presented in Table 2. There was variation in the values of the proximate composition of the vegetables and significant differences exist between them. All the vegetables they were air dried recorded highest values of moisture content while those that were oven dry recorded the lowest moisture content. *T. occidentalis* recorded the highest value of moisture and fat content regardless of the drying method used while *C. rubens* recorded the highest value of ash content in spite of the different drying method used. However, it was observed that all the vegetables that were freeze dried and air dried were not significantly ($p>0.05$) different from each other in term of their moisture, fat and ash content while they were significantly ($p<0.05$) different from those that were oven dried and sun dried. All the vegetables that were air dried and freeze dried were rich in protein and fibre than those that were sun dried and oven dried. *T. occidentalis* recorded the highest value of 30.87g/100gDM and 13.52g/100gDM ofprotein and fibre respectively.*A. hybridus* that was oven dried recorded the lowest value of fibre and carbohydrate content of 0.50 g/100gDM and 0.22 g/100gDM respectively.

Table2. *Proximate composition of different vegetables dried with different methods*

DRYING METHODS	PLANT MATERIALS	MOISTURE	FAT	ASH	PROTEIN	FIBRE	CHO
Oven	*T. occidentalis*	16.11±0.20^{a}	2.41 ± 0.11^{a}	1.94 ± 0.01^{a}	9.63±0.01^{b}	6.93±0.01^{ab}	1.62 ± 0.02^{a}
	B. alba	12.35±0.12^{a}	2.25 ± 1.03^{a}	0.98 ± 0.01^{a}	2.83±0.01^{a}	2.58 ± 0.01^{a}	7.13 ± 1.00^{b}

	A. hybridus	15.93±0.23^{a}	1.92 ± 0.11^{a}	0.98 ± 0.01^{a}	7.57±0.02^{b}	0.50±0.00^{a}	0.22 ± 0.01^{a}
	T. triangulare	13.49±0.06^{a}	0.53 ± 0.01^{a}	2.91 ± 0.01^{a}	2.90±0.12^{a}	2.48±0.01^{a}	0.32±0.02^{a}
	C. biafrae	14.94±0.22^{a}	1.35 ± 0.23^{a}	0.96 ± 0.01^{a}	4.50±0.02^{a}	3.94±0.01^{a}	3.62 ± 0.01^{a}
	C. rubens	15.10±0.18^{a}	1.25 ± 1.02^{a}	1.92 ± 0.01^{a}	3.51±0.00^{a}	4.43±0.01^{ab}	1.19±0.01^{a}
Sun	*T. occidentalis*	19.84±0.23^{a}	3.21 ± 1.02^{a}	1.94 ±0.01^{a}	8.15±0.02^{b}	2.94±0.01^{a}	1.26±0.01^{a}
	B. alba	14.94±0.22^{a}	1.08 ± 0.01^{a}	0.99 ±0.01^{a}	2.94±1.10^{a}	0.98±0.01^{a}	6.39±0.01^{b}
	A. hybridus	15.71±0.17^{a}	1.89 ± 1.11^{a}	0.98 ±0.01^{a}	8.14±0.02^{b}	2.92±0.01^{a}	2.57±0.01^{a}
	T. triangulare	15.89±0.21^{a}	1.41 ± 1.14^{a}	1.96 ±0.10^{a}	5.15±0.01^{ab}	0.93 ± 0.01^{a}	2.14±0.01^{a}
	C. biafrae	17.3±0.11^{a}	0.84 ± 0.11^{a}	0.98 ±0.01^{a}	5.75±1.21^{ab}	2.90±0.01^{a}	0.32±0.01^{a}
	C. rubens	17.09±0.12^{a}	1.21 ± 0.12^{a}	1.94 ±1.01^{a}	6.54±0.10^{b}	0.96±0.02^{a}	5.62±0.01^{ab}
Air	*T. occidentalis*	38.93±0.26^{c}	10.98±0.11^{bc}	13.46±0.06^{b}	30.87±0.12^{e}	13.52±0.06^{c}	18.82±1.21^{cd}
	B. alba	31.82±1.22^{c}	13.20±0.12^{cd}	13.20±0.05^{b}	27.35±0.24^{de}	7.47 ± 0.01^{b}	27.95±0.24^{de}
	A. hybridus	33.88±1.24^{c}	13.46±0.21^{cd}	19.23±0.23^{cd}	27.81±1.20^{de}	11.66±0.11^{c}	22.85±0.36^{d}
	T. triangulare	31.50±1.33^{c}	14.23±1.11^{d}	27.77±1.02^{e}	24.14±0.24^{d}	4.35 ± 0.13^{ab}	14.35±1.22^{c}
	C. biafrae	33.04±024^{c}	13.15±1.01^{cd}	18.07±0.01^{cd}	22.23±0.24^{cd}	8.15 ± 0.01^{b}	14.57±0.14^{c}
	C. rubens	37.70±1.03^{c}	9.07 ± 0.03^{b}	20.75±0.12^{d}	20.09±1.21^{c}	6.03 ± 0.02^{ab}	23.30±0.12^{d}
Freeze	*T. occidentalis*	29.63±1.06^{b}	7.69 ± 0.03^{b}	13.20±0.01^{b}	26.80±1.12^{d}	10.39±0.21^{bc}	26.98±1.02^{de}
	B. alba	22.50±0.16^{b}	11.89±1.01^{c}	12.92±0.01^{b}	24.04±0.02^{d}	9.61± 0.01^{b}	27.74±0.22^{de}
	A. hybridus	27.62±0.33^{b}	10.66±1.01^{bc}	12.96±0.01^{b}	20.23±0.12^{c}	12.5 ±0.01^{c}	25.83±0.16^{d}
	T. triangulare	23.50±1.23^{b}	11.68±1.02^{c}	19.23±1.00^{cd}	20.22±1.02^{c}	4.56±0.01^{ab}	35.74±0.13^{e}
	C. biafrae	29.10±1.66^{b}	9.77± 0.03^{b}	16.07±0.11^{c}	21.51±0.01^{c}	8.51±1.00^{b}	29.70±0.24^{de}
	C. rubens	28.33±1.22^{b}	9.11± 0.03^{b}	13.21±0.01^{b}	19.29±1.12^{c}	6.33±0.01^{ab}	28.95±1.23^{de}
Fresh	*T. occidentalis*	42.41±0.21^{c}	12.92±0.01^{bc}	13.49±0.05^{b}	32.87±0.22^{e}	14.52±0.01^{c}	20.89±0.21^{cd}
	B. alba	38.82±1.22^{c}	14.00±0.12^{cd}	15.23±0.05^{b}	29.35±0.23^{de}	9.47 ± 0.01^{b}	29.97±0.23^{de}
	A. hybridus	35.88±1.24^{c}	15.46±0.21^{cd}	20.43±0.23^{cd}	31.81±1.20^{de}	11.79±0.11^{c}	25.82±0.11^{d}
	T. triangulare	36.50±1.33^{c}	18.73±1.11^{d}	29.87±1.02^{e}	24.14±0.26^{d}	7.35 ± 0.10^{ab}	16.35±1.00^{c}
	C. biafrae	37.04±0.13^{c}	12.55±1.01^{cd}	19.37±0.01^{cd}	24.23±0.14^{cd}	10.15 ± 0.01^{b}	16.57±0.13^{c}
	C. rubens	44.70±0.13^{c}	10.07 ±1.03^{b}	23.76±0.42^{d}	24.09±1.23^{c}	8.09 ± 0.01^{ab}	29.68±0.02^{d}

Each value is a mean of five replicates ± standard error of each sample. Values having the same alphabet as superscript in the same column are not significantly different at 0.05 significant levels.

3.3. Effect of Drying Methods on the Anti-Nutritional Factors Present in Vegetables

The effect of different drying methods on the anti-nutritional components of the tested vegetables was presented in Table 3. Significant differences occur among the dried vegetables regardless of the drying method used. Tannin, Oxalate, Saponin, Salkowski, Flavonoid and Phlobatannin were the anti-nutritional factors observed. However,Salkowski and Flavonoid were absent in all the dried vegetables in spite of drying method used. The air dried and freeze dried vegetables were noted to record high value of the anti-nutritional components than those that were oven dried and sun dried thus Fresh dried>Freeze dried>Sun dried> Oven dried. *T. occidentalis*recorded the highest value of tannin and oxalate regardless of the drying method used and was significantly ($p<0.05$) different from all other vegetables dried by the same methods. *B. alba*air dried recorded the highest value of 6.05 of saponin and was significantly ($p<0.05$) different from other vegetables dried with other methods. However, all the vegetables that were air dried and freeze dried had high value of saponin than those that were sun dried and oven dried. Also, it was noted that all the sun dried and oven dried vegetables had no Phlobatannin.

Table3. *Effect of different drying methods on the anti-nutritional components of different vegetables*

DRYING METHODS	PLANT MATERIALS	Tannin	Saponin	Oxalate	Salkowski	Flavonoid	Phlobatannin
Oven	*T. occidentalis*	3.52±0.01^{c}	3.92±0.12^{bc}	0.38±1.11^{c}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	B. alba	3.23±0.00^{b}	4.99±0.01^{f}	0.29±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	A. hybridus	3.20±0.01^{b}	3.36±0.01^{a}	0.30±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	T. triangulare	3.01±0.01^{a}	3.72±0.00^{b}	0.27±0.01^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	C. biafrae	3.11±0.00^{ab}	4.00±011^{c}	0.33±0.01^{ab}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	C. rubens	3.22±0.01^{b}	3.79±1.33^{b}	0.26±0.01^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Sun	*T. occidentalis*	3.72±0.14^{f}	4.00±0.00^{c}	0.43±0.02^{d}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}

	B. alba	3.00±0.01^{a}	5.01±0.00^{ef}	0.33±0.00^{ab}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	A. hybridus	3.21±0.03^{b}	3.38±0.03^{a}	0.33±0.11^{ab}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	T. triangulare	3.31±1.01^{bc}	3.77±1.01^{b}	0.32±0.10^{ab}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	C. biafrae	3.36±0.03^{c}	4.01±0.00^{c}	0.35±0.01^{b}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	C. rubens	3.42±0.11^{c}	3.84±0.22^{b}	0.31±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Fresh	*T. occidentalis*	4.54±0.02^{g}	5.76±0.13^{f}	0.67±0.01^{h}	0.00±0.00^{a}	0.00±0.00^{a}	0.20±0.00^{cd}
	B. alba	4.32±0.01^{fg}	6.05±0.00^{g}	0.45±0.00^{d}	0.00±0.00^{a}	0.00±0.00^{a}	0.24±0.01^{c}
	A. hybridus	3.68±0.11^{d}	4.14±0.01^{d}	0.48±0.00^{e}	0.00±0.00^{a}	0.00±0.00^{a}	0.13±0.00^{b}
	T. triangulare	4.36±0.00^{f}	4.00±0.01^{c}	0.52±0.01^{f}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	C. biafrae	4.13±0.01^{f}	4.33±0.02^{e}	0.40±0.01^{cd}	0.00±0.00^{a}	0.00±0.00^{a}	0.14±0.01^{b}
	C. rubens	3.99±0.02^{e}	4.04±0.01^{c}	0.39±0.01^{c}	0.00±0.00^{a}	0.00±0.00^{a}	0.18±0.01^{c}
Freeze	*T. occidentalis*	4.46±0.10^{fg}	4.46±0.02^{e}	0.63±0.00^{g}	0.00±0.00^{a}	0.00±0.00^{a}	0.19±0.01^{c}
	B. alba	4.22±1.00^{f}	5.24±1.01^{f}	0.40±0.01^{c}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	A. hybridus	3.63±0.11^{d}	3.98±0.12^{c}	0.45±0.00^{d}	0.00±0.00^{a}	0.00±0.00^{a}	0.11±0.00^{b}
	T. triangulare	4.31±0.01^{f}	3.83±0.01^{bc}	0.48±1.00^{e}	0.00±0.00^{a}	0.00±0.00^{a}	0.15±0.13^{b}
	C. biafrae	4.00±0.11^{ef}	4.11±0.00^{d}	0.37±0.00^{bc}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
	C. rubens	3.81±0.12^{e}	3.99±0.02^{c}	0.37±1.02^{bc}	0.00±0.00^{a}	0.00±0.00^{a}	0.11±0.01^{b}

Each value is a mean of five replicates ± standard error of each sample. Values having the same alphabet as superscript in the same column are not significantly different at 0.05 significant levels.

4. DISCUSSION

Vegetables are generally referred to as perishable because of their high content of water which as well resulted in high moisture content found in them. Because of their high moisture content, they become important host for microorganisms such as fungi and bacteria. Idah *et al*. (2010) opined that the high content of water in perishables not only pave way for microbial growth but also fast track the process of deterioration because of the high respiration rate. In order, to reduce spoilage and increase shelf life of perishables, processing plays a vital and integral role and one of such processing techniques is drying. Moreover, despite the effectiveness of many drying methods that have been employed it is important to know their effects on nutritional components of the dried materials (Dauthy, 1995; Idah *et al.,* 2010) in order to come out with drying technique that could guarantee longer shelf life and at the same time maintain the nutritional values of the dried product.

In this work, all the vegetables are fresh and rich in moisture at the initial stage before drying. However, it was observed that the vegetables that were oven dried were lowered in moisture content compared to those that were dried by other methods especially those that were air dried which recorded the highest moisture content. Moisture being one of the major factors in the growth of microorganism and reduction in shelf life of any perishable and non-perishable commodities need to be reduced in order to inhibit the organism's self- killing enzyme (autolytic enzymes) as suggested by Ladan *et al.* (1997) as well as Abiodun *et al* (2012). The result obtained in this work agreed with the work of Amoo and Moza, 1999) in which oven drying and sun drying methods were found to significantly reduce the moisture content *Leptadenia hastate* leaves. Also, the research of Idah *et al.* (2010) in which high temperature was found to significantly reduced moisture content of tomatoes compared to other drying method used acquiesced with this work. Nevertheless, this result is not in agreement with the result of Abiodun *et al* (2012) in which freeze drying method was found most appropriate to reduce moisture content of *Ocimum gratissimum* and *O. basillicum.*Oven drying method could be recommended for drying all the vegetables tested since it appeared to be most effective than other drying methods in term of moisture reduction.

However, the result obtained showed that all other proximate component tested including protein, fat, fibre, ash and carbohydrate were highly affected by both oven drying and sun drying methods. Vegetables that were air dried and freeze dried maintained their protein, fat,fibre, ash and carbohydrate content when compared to those that were oven dried and sun dried. The result obtained could be due to the fact that all this proximate components are actually affected by heat as suggested by Idah *et al.* (2010) as well as Abiodun *et al.* (2012). Heat alone is capable of destroying the nutritional component of perishables including vegetables because many of the nutritional factors found in vegetables are liable to heat. The result obtained in this work agreed with the work of Abiodun *et al* (2010) as well as Aletor and Abiodun (2013) in which sun drying method was found to affect nutritional component of dried fruits.

It was observed that the mineral contents of the vegetables were significantly affected by the drying methods. All the mineral contents was higher in fresh, freeze and air dried samples than oven and sun dried samples except for nitrogen and phosphorus in which there was inconsistencies in their values across the drying methods. The high content of nitrogen in all the vegetables indicated that the vegetables are good source of free energy as suggested by Abiodun *et al.* (2010). The presence of Ca, and magnesium indicated that the vegetables tested are good source of metallic element needed for good healthy teeth, strong bone, healthy muscles and nerves including blood clotting. However, the decrease in the values of the oven dried and sun dried samples indicated that oven and sun drying method may cause destruction of these important elements. This work agreed with the work of Morris *et al.* (2004) as well as Abiodun *et al.* (2010). This work also agreed with the work of Abiodun *et al.* (2010) as well as Peppas *et al.* (2000) in term of trace element like zinc, manganese, copper and iron. All these trace elements were significantly reduced in vegetables dried with oven and sun.

The vegetables content Tannin, Saponin, Oxalate and Phlobatannin out of six anti-nutritional factors tested for. However, it was noted that these element were greatly reduced by oven drying and sun drying methods with phlobatannin appeared to be most affected. This work agreed with the work of Abiodun *et al.* (2010) as well as Matazu and Haroun (2004) in which sun dyring method was found to reduce the composition of these anti-nutritional factors.

5. Conclusion

Base on the result obtained in this research showed that freeze drying method could be more promising in preserving these vegetables since it appeared to have less moisture content, high mineral contents and anti-nutritional factors when compared to other methods.

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