IMPACTS OF DRYING METHODS ON PROXIMATE AND MINERAL COMPOSITIONS OF SOME VEGETABLES: *Telfairia occidentalis*, *Allanblackia floribunda, Moringa oleifera* and *Ocimum gratissimum*

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Abstract
This experiment was aimed at evaluating the impacts of drying methods on proximate and mineral compositions of Telfairia occidentalis, Allanblackia floribunda, Moringa oleifera and Ocimum gratissimum. Three drying methods were employed: - 40^{o}C, sun drying and ambient based on varying heat intensities. Proximate components (such as moisture, ash, fat, fibre, protein and carbohydrate) as well as mineral elements (iron, zinc, potassium and nitrogen) were analysed using standard procedures. Results have shown that proximate composition differed significantly (P<0.05) with different drying method. M. oleifera recorded the highest moisture, fibre and protein irrespective of the drying methods. In the same vein, the highest percentage for ash was attained for A. floribunda and the highest percentage for fat was recorded by T. occidentalis. The highest percentage for carbohydrate was recorded for O. gratissimum irrespective of the drying methods. Regardless of the drying method, A. floribunda recorded the highest mean for iron among the four vegetables while O. gratissimum had the highest value for zinc and potassium and M. oleifera recorded the highest for nitrogen. Air drying suffices as the most suitable method for preserving A. floribunda while oven drying (40^{o}C) has shown to be most suited for preserving T. occidentalis, based on the consistency of the components with the methods. In a similar fashion, sun drying suffices as the most suitable method for preserving Moringa leaves while oven drying (40^{o}C) has shown to be the most suited method for preservation O. gratissimum.
Keywords: *Telfairia occidentalis*, *Allanblackia floribunda*, *Moringa oleifera*, *Ocimum gratissimum*, drying methods.

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1. INTRODUCTION

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 ranges between 60-98.8°C (Idowu, 2008) and which aid their quick deterioration. Processing has therefore played a great deal in the preservation of these high valued plant resources. 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). The basic essence of drying is to reduce the moisture content of the product to a level that prevents deterioration within a certain period of time, normally regarded as the safe storage period as reported by Ekechukwa and Norton (1998). In this experiment three techniques for foods drying were used; sun drying, cabinet (oven) drying and freeze drying. For the first two drying, two processes take place simultaneously which include a heat transfer to the product from the heating source and mass transfer of moisture from the interior of the product to its surface and from the surface to the surrounding air.

Telfairia occidentalis is a member of the Curcurbitaceae family and is indigenous to southern Nigeria, used by an estimated 30 to 35 million people including the Efik, Ibibio and Urhobo (Akoroda, 1990). It is commonly cultivated for its edible seeds which is high in protein and fat. The leaves contain a high amount of antioxidants and hepato-protective and microbial properties (Nwanna *et al.,* 2008). *Allanblackia floribunda* belongs to the family Clusiaceae found in the moist tropical forest which stretches across Africa from Liberia to Tanzania (Pye-smith, 2009). The tree thrives well in the Niger Delta Region of Nigeria, especially in abandoned forests (acidic soils) with rainfall as high as 2400mm. Commonly known as the horse-radish tree, *Moringa oleifera* belongs to the Moringaceae family. It is a multipurpose tree widely distributed in India, the Philippines, Sri Lanka, Thailand, Malaysia, Burma, Pakistan, Singapore, the West Indies, Cuba, Jamaica and Nigeria (Ramachandran *et al.,* 1980). Highly valued for its medicinal property, *Ocimum gratissimum* is a member of the family Lamiaceae is indigenous to tropical areas especially Libya. The plant is used as food spice and for the treatment of ailments such as malaria, diabetes, respiratory and urinary tract infections, cough, fever, diarrhoea, abdominal pains, pneumonia, conjunctivitis, oral wounds and tooth infection (Iwalokun *et al.,* 2003). This experiment is thus geared towards evaluating the different drying methods vis-à-vis their impacts on quality of the selected notable vegetables.

2. MATERIALS AND METHODS

Sample Collection and Preparation

M. oleifera and *O. gratissimum* were collected from Flower Garden, Ilorin South Local Government Area, Ilorin, Kwara State, Nigeria while *T. occidentalis* and *A. floribunda* were collected from Mandate market, Ilorin West Local Government, Ilorin, Kwara State, Nigeria. Fresh leaves of the vegetables obtained were washed to remove dust and sand thereby avoiding inoculations on the leaf surfaces.

Drying

The drying methods employed in this experiment include oven drying (40ºC), sun drying and ambient (air-drying). The major factor distinguishing the methods is the heat intensity. Drying of samples was conducted using the methods described by Mbah *et al.* (2012) with few modifications.

Proximate analysis

The proximate analysis of the food samples was carried out according to Association of Official Agricultural Chemists (AOAC) procedure (2005) for moisture, fat, ash and crude fibre. Protein was determined by the method described by Pearson (1976).

Minerals quantification

The dried sample (0.5 g) was taken in digesting glass tube. Ten milliliters (10 ml) of HNO_3 was added to the sample. The resulting mixture was kept overnight at room temperature. Thereafter, 4.0 ml per-chloric acid ($HClO_3$) was added to the mixture and kept in fume cupboard. The temperature was increased gradually starting from 50ºC to 300ºC in the digestion unit. The digestion was achieved in about 70-80 minutes as indicated by the appearance of the white fumes. The mixture was allowed to cooled and transferred into 100 ml volumetric flasks and the volume of the contents were made up to 100 ml with distilled water. The resulting solution was filtered. The filtrate was then used for the mineral determination. Nitrogen (N) was determined using micro Kjeldhal method. Iron (Fe) and zinc (Zn) were determined through Atomic Absorption Spectrophotometer (AAS). Potassium (K) was determined by Flame Photometer following the method of Allen (1989).

Statistical 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. All means were expressed as means ± standard error of three replicates.

3. RESULTS AND DISCUSSION

Results

Proximate Composition

Results of this experiment show that drying methods significantly ($P<0.05$) affected the moisture, ash, fat, fibre, protein and carbohydrate of all the vegetables.

The highest percentage moisture for all the vegetables aside *M. oleifera* was recorded under ambient condition, an indication that is the least dried (Figure 1). The lowest percentage moisture was recorded for the oven-dried (40°C) leaves of the three plants and thus the most effective in drying them. *M. oleifera*, on the other hand followed a contrasting trend where the highest percentage moisture was recorded for the oven-dried leaves and the lowest percentage moisture was recorded under ambient condition. Regardless of the drying method, *M. oleifera* recorded significantly higher moisture of all the four plants (Figure 1).

Percentage ash of both *M. oleifera* and *O. gratissimum* differ significantly (P<0.05) across the drying methods (Figure 2). Air dried leaves recorded the highest values followed by the oven-dried (40°C) and sun dried leaves in descending order. Percentage ash content of *T. occidentalis* followed a similar pattern as its moisture content. The percentage ash of *A. floribunda* recorded by the oven-dried leaves was significantly highest. *A. floribunda*, regardless of the drying method, recorded the highest ash content of all the four plants (Figure 2).

There was significant difference between fat content of *T. occidentalis* dried under ambient condition, which had significantly highest magnitude, and the other drying methods. Percentage fat content of sundried *A. floribunda* differ significantly from the oven-dried but statistically similar to those dried under ambient method. Fat content of oven-dried (40°C), ambient and sundried leaves of *A. floribunda* followed in ascending order. Air dried *M. oleifera* leaves had significantly higher fat, followed by oven-dried and sundried leaves in descending order.).

O. gratissimum leaves dried at 40ºC differ significantly from sun dried and air dried leaves, both of which are statistically similar and recorded the highest value. *T. occidentalis* recorded the highest percentage fat regardless of the drying method (Figure 3).

Fibre content of the four vegetables differs significantly across all the drying methods (Figure 4). However, *M. oleifera* maintained the highest fibre content irrespective of the drying method. Percentage fibre content of *T. occidentalis* dried using ambient method was significantly highest, followed by oven-dried (40°C) and sundried leaves in descending order. *A. floribunda* recorded highest fibre content under oven drying followed by ambient and sun drying in descending order. *M. oleifera* fibre differ significantly across the drying methods while fibre of oven dried and sun dried *O. gratissimum* leaves were statistically similar (Figure 4).

Aside *M. oleifera*, drying methods significantly affected the protein contents of the vegetables (Figure 5). Percentage protein content of *T. occidentalis* dried with oven (40°C) was significantly highest, followed by ambient and sundried leaves in descending order. The same trend was also recorded for *A. floribunda*. However, percentage protein of *A. floribunda* dried at 40°C and ambient were statistically similar at P<0.05. As for *O. gratissimum*, leaves dried at 40°C recorded the highest protein, followed by sun dried and air dried leaves. Irrespective of the drying methods, however, *M. oleifera* maintained the highest protein content (Figure 5).

With respect to percentage carbohydrate (Figure 6), *T. occidentalis* dried with oven recorded the highest percentage followed by sun drying and air drying in decreasing order. *A. floribunda*, recorded the highest percentage carbohydrate for the sun dried leaves while the leaves dried at 40°C and ambient were statistically similar at P<0.05. Percentage carbohydrate of *M. oleifera* and *O. gratissimum*, followed similar trend as in fibre content, on account of significance (P<0.05). However, *O. gratissimum* maintained the highest percentage carbohydrate regardless of the drying methods (Figure 6).

Mineral composition

Mineral composition (Iron, zinc, potassium and nitrogen) of all the vegetables was significantly (P<0.05) affected by the drying methods applied (Table 1). All minerals of *A. floribunda* were significantly similar, except for nitrogen which differed significantly across the drying methods. Sundried *A. floribunda* leaves had the lowest iron (Fe) while the oven-dried (40°C) leaves recorded the highest zinc (Zn) and nitrogen (N). However, sundried *A. floribunda* recorded the lowest values of zinc and nitrogen which differs significantly with N of the sundried sample. Potassium (K) was absent in dried *A. floribunda* leaves. Potassium and nitrogen were significantly highest in oven-dried *T. occidentalis* while the sun drying and ambient methods recorded the highest values of iron and zinc respectively. Potassium and nitrogen of *T. occidentalis* differed significantly while iron and zinc were statistically similar across the drying methods. Amount of element maintained by *M. oleifera* leacves showed no significance across the drying methods except potassium which differed significantly across the drying methods. Oven-dried and air dried *M. oleifera* maintained the highest potassium and nitrogen respectively. Potassium, nitrogen and zinc of *O. gratissimum* differed significantly across the drying methods while amount of iron was statistically similar. Oven-dried *O. gratissimum* maintained the highest amount of mineral element while the sequence of the other methods remained inconsistent. Regardless of the drying method, *A. floribunda* recorded the highest mean for iron among the four vegetables while *O. gratissimum* had the highest value for zinc and potassium and *M. oleifera* recorded the highest for nitrogen (Table 1).

Discussion

Effects of Drying Methods on Proximate Composition

Vegetables are ranked as perishable due to the high water content which as well resulted in high moisture content they possess. Because of their high moisture content, they become susceptible to infestations by 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 speed up the process of deterioration due to the high respiration rate. In order, to reduce spoilage and increase shelf life of perishables, thermal processing plays an integral role and one of such processing techniques is drying. Moreover, despite the effectiveness of many drying methods that have been employed it is imperative to know their effects on nutritional components of the dried materials (Dauthy, 1995; Idah *et al.,* 2010) in order to arrive at a suitable drying technique that could guarantee longer shelf life and as well maintain the nutritional values of the dried products.

From the results of the experiment, it was observed that that were oven-dried were lower in moisture content compared to those that were dried by other methods except for *M. oleifera*.

Lower moisture content indicates longer shelf life as the condition prevent the growth of pathogens on the leaves. This observation of moisture content of *T. occidentalis* and *A. floribunda* agreed with the work of Amoo and Moza (1999) where oven drying and sun drying methods were found to significantly reduce the moisture content *Leptadenia hastate* leaves. Lower moisture content of leafy vegetables for oven-dried and sun dried was also reported by Manisha and Narayan (2015) and Oluwalana (2013). Percentage moisture retained by *O. gratissimum* leaves agree with the range of values reported by Mlitan *et al*. (2014). The moisture content of oven dried (40ºC) *M. oleifera* leaves was higher compared to those reported by Tsado *et al*. (2015) and Umar *et al*. (2015)

Percentage ash obtained by both *M. oleifera* and *O. gratissimum* followed a similar pattern as the percentage moisture, with leaves dried at ambient recording the highest magnitude. Ash retained by *M. oleifera* leaves was higher compared to values reported by Tsado *et al*. (2015) which ranged between 6.72±0.03% and 7.93±0.11% for *Vernonia amygdalina*, across the drying methods. Basil leaves in this experiment disagrees with the findings of p, (2015) as % ash content was relatively low. The ash content of leaves of both *M. oleifera* and *O. gratissimum* representing the mineral contents of the drying methods attained its peak at ambient temperature. This therefore suggest that higher amount of minerals could be produced when the leaves are preserved at ambient temperature. It was observed from the leaves of *T. occidentalis* and *A. floribunda* that the higher the percentage moisture, the lesser the percentage ash and vice-versa. This has been suggested by the result in which *A. floribunda* retained the least moisture after the drying and higher ash content compared to *T. occidentalis*. *A. floribunda* and *T. occidentalis* recorded their highest ash contents at 40°C and ambient respectively. The higher ash content observed in dried tallow leaves pronounces it as a larger source of minerals.

T. occidentalis and *A. floribunda* leaves that were oven dried and air dried maintained higher protein content when compared to those that were sun dried. Oluwalana (2013) however reported that appreciable increase in crude protein content was noticed in sundried and oven-dried *Amaranthus hybridus* samples. According to Ukegbu and Okereke (2013), there is also high percentage protein recorded for sundried *T. occidentalis*. The mean protein recorded for dried *T. occidentalis* stands well above the findings of Orhuamen *et al* (2012) and Oni *et al.* (2015). Although, drying method did not significantly affect the protein content of *M. oleifera*, it was observed that, as the drying temperature increased from ambient to 40°C, crude protein decreased.

Similar result was reported by Tsado *et al*. (2015) and Umar *et al* (2015). A deviation from this trend was observed in *O. gratissimum* were percentage protein decreased with decreasing temperature from 40°C to ambient.

Percentage fat and fibre of *T. occidentalis* attained their peak at ambient temperature while sun dried *A. floribunda* recorded highest fat and oven-dried *A. floribunda* recorded highest fibre. Oluwalana (2013) reported a contrasting trend for *Amaranthus hybridus* were high percentage fat was recorded for oven dried and high percentage fibre for sundried. The crude fat for all the different drying methods for both *M. oleifera* and *O. gratissimum* were relatively higher compared to those reported by Abioye *et al*. (2014), which ranged between 2.29% and 2.26% for *Adansonia digitata* leaves. Crude fat content of food products is an index of storability in respect of lipid oxidation. *M. oleifera* and *O. gratissimum* accrued their highest fat at ambient and 40ºC respectively. This is an indication of genotypic difference among the plants. Air dried *M. oleifera* retained moderate fibre content compared to sun dried and oven dried leaves which had the highest and lowest fibre respectively. Fibre content of sun dried *M. oleifera* compared to fat accrued suggests that leaves preserved at the by sun drying are healthier compared to other drying methods. Range of values for the drying methods obtained are lower than those reported by Tsado *et al*. (2015). *O. gratissimum* retained its highest fibre content for sun dried while the fibre content was moderate for oven dried. The values were similar to those reported by Ajayi, (2015). Adequate intake of dietary fiber is recommended for healthy food.

As for percentage carbohydrate, oven-dried and sundried leaves recorded higher values than the air dried samples for *T. occidentalis* and *A. floribunda*. This is not dissimilar to the report of Oluwalana (2013) on *Amaranthus hybridus*. Basil leaves maintained higher carbohydrate regardless of the drying methods. *M. oleifera* recorded highest percentage carbohydrate for sundried samples followed by oven dried and ambient in decreasing order. Umar *et al.* (2015) reported that carbohydrate content increased as a result of drying by at least 6 times the initial concentration. Mustapha and Babura (2009) reported that the carbohydrate level in *Moringa* is comparatively higher (10.1 %) when compared to other vegetables such as carrot (8.7 %) and sorrel (7.1 %).

Effects of Drying Methods on Mineral Composition

It was observed that the mineral contents of the vegetables were significantly affected by the drying methods. Regardless of the drying method, *A. floribunda* recorded the highest mean for iron among the four vegetables while *O. gratissimum* had the highest value for zinc and potassium and *M. oleifera* recorded the highest for nitrogen.

The high content of nitrogen in the vegetables indicated that the vegetables are good source of free energy as suggested by Abiodun *et al*. (2010).

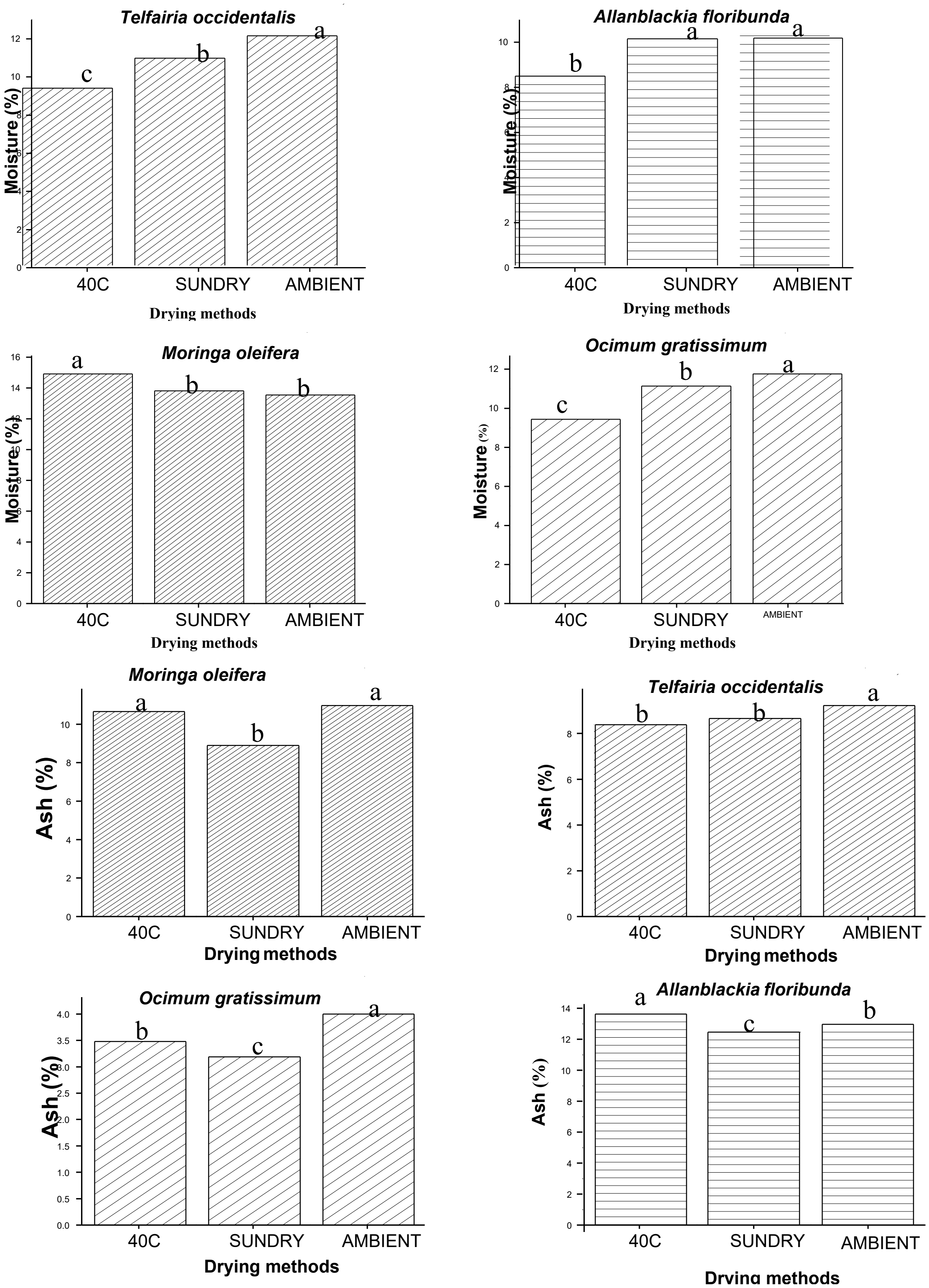

Figure 1: Percentage moisture and ash contents of *M. oleifera*, *O. gratissimum*, *T. occidentalis* and *Allanblackia floribunda* as influenced by different drying methods. Vertical bars represent standard errors (± SE) of treatment means.

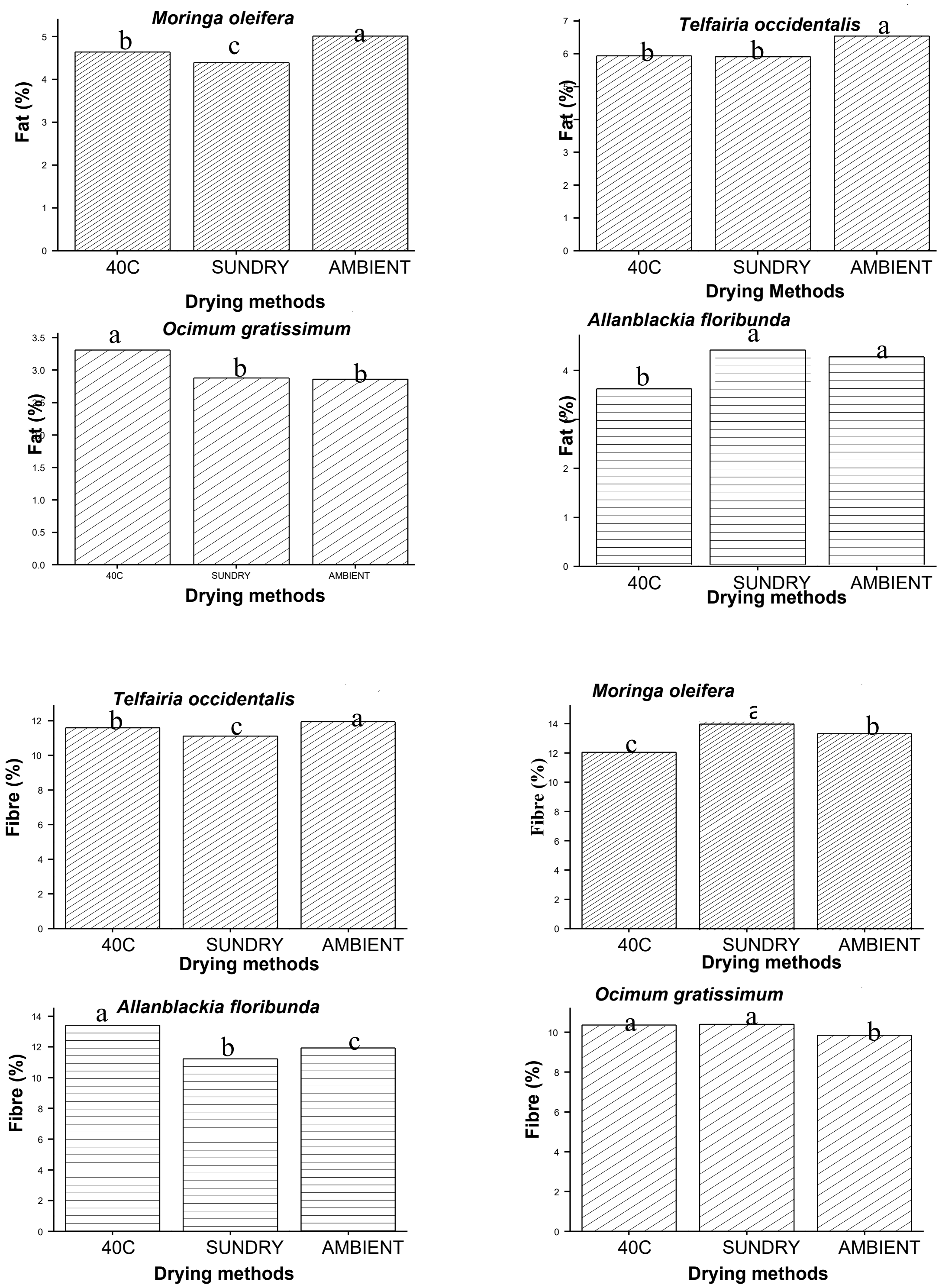

Figure 2: Percentage fat and fibre content of *M. oleifera, O. gratissimum, T. occidentalis* and *Allanblackia floribunda* as influenced by different drying methods. Vertical bars represent standard errors (± SE) of treatment means.

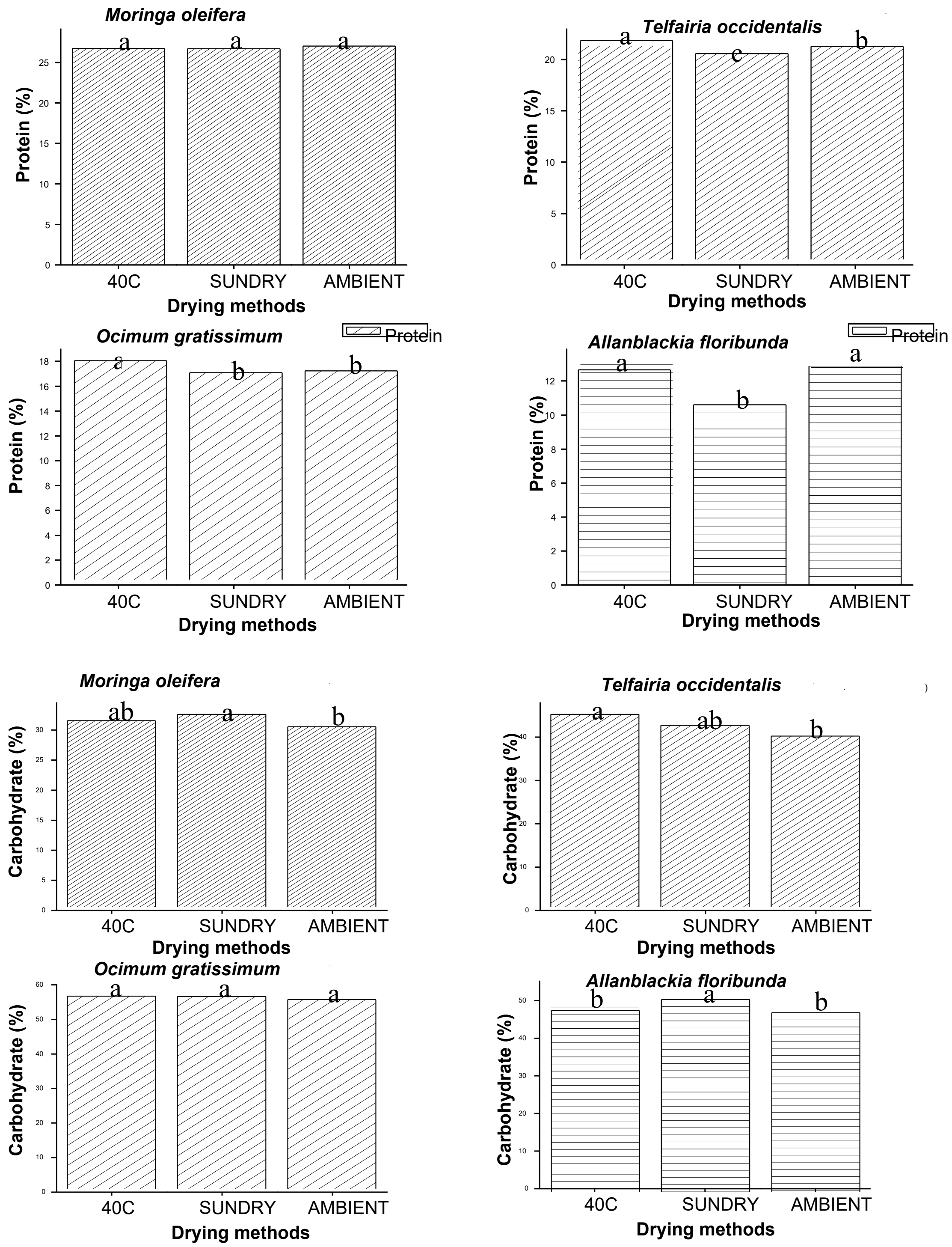

Fig. 3: Percentage protein and carbohydrate content of *M. oleifera, O. gratissimum, T. occidentalis* and *Allanblackia floribunda* as influenced by different drying methods. Vertical bars represent standard errors (± SE) of treatment means.

Table 1: Mineral composition of *Moringa oleifera, Ocimum gratissimum, T. occidentalis* and *A. floribunda* as influenced by different drying methods.

Sample	Drying methods	Fe(Mg/100ml)	Zn(Mg/100ml)	K (Mg/100ml)	N(Mg/100ml)
Moringa oleifera	40°C	0.10±0.00[a]	0.080±0.00[a]	125.00±2.89[a]	42.78±0.29[a]
	Sundry	0.10±0.00[a]	0.090±0.00[a]	100.00±0.00[c]	42.73±0.18[a]
	Ambient	0.10±0.00[a]	0.090±0.00[a]	110.00±0.00[b]	43.24±0.39[a]
	Mean	0.10±0.00	0.087±0.00	111.67±3.73	42.92±0.17
Ocimum gratissimum	40°C	0.25±0.03[a]	0.120±0.00[a]	195.00±2.89[a]	28.19±0.19[a]
	Sundry	0.20±0.00[a]	0.085±0.03[c]	130.00±0.00[c]	26.65±0.13[b]
	Ambient	0.20±0.00[a]	0.100±0.00[b]	140.00±0.00[b]	26.86±0.06[b]
	Mean	0.22±0.01	0.102±0.05	155.00±10.14	27.23±0.25
Telfairia occidentalis	40°C	0.20±0.00[a]	0.07±0.00[a]	25.00±5.00[a]	34.10±0.27[a]
	Sundry	0.30±0.00[a]	0.07±0.00[a]	10.00±0.00[b]	32.07±0.11[c]
	Ambient	0.20±0.00[a]	0.08±0.00[a]	10.00±0.00[b]	33.17±0.51[b]
	Mean	0.23±0.21	0.73±0.02	15.00±3.40	33.12±0.38
Allanblackia floribunda	40°C	0.30±0.00[a]	0.07±0.00[a]	0.00±0.00[a]	20.26±0.25[a]
	Sundry	0.20±0.00[a]	0.06±0.00[a]	0.00±0.00[a]	16.98±0.96[b]
	Ambient	0.30±0.00[a]	0.06±0.00[a]	0.00±0.00[a]	20.61±0.53[a]
	Mean	0.27±0.21	0.63±0.02	0.00±0.00	19.28±0.77

4. CONCLUSION

From the findings of this experiment, it cannot be established that a particular method of drying from the three drying methods considered is suitable for all the vegetables due to varying degrees of success of the methods as it is depicted from the results of the analysis.

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