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COMPARATIVE EVALUATION OF SOME NUTRIENT CONTENTS OF *Moringa oleifera* LEAVES PROCESSED UNDER THREE DIFFERENT DRYING METHODS; SUN-DRYING,AIR-DRYING AND OVEN-DRYING

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ABSTRACT

Moringa oleifera is one of the green leafy vegetables that are under-exploited and under-utilized. Available researches have shown that *Moringa oleifera* is rich in nutrients and can be used as a food-based strategy in combating nutrient deficiencies. The study was carried out to comparatively evaluate some nutrient contents of *Moringa oleifera* processed under different drying methods. Three drying methods *viz.* sun-drying, air-drying and oven-drying were used as the treatments while the fresh leaves served as control. The experiment was laid in Completely Randomized Design (CRD) with seven replications. Proximate analysis for each of the treatments was conducted to determine the protein, moisture, carbohydrate, fat and fibre contents. Vitamin C content for each of the treatments was also determined. The data collected were analysed using analysis of variance (ANOVA), and the treatment means separated using least significant difference (LSD) at 5% probability level. The results showed that drying resulted in concentration of nutrients available in fresh *Moringa oleifera* leaves. There were significant differences ($p<0.05$) in carbohydrate, protein and moisture contents amongst the three different drying methods. Vitamin, fibre and fat contents for the 3 drying methods were statistically at par but differed significantly with fresh leaves. The study showed that superior nutrient retention was obtained in air-drying treatment compared to sun-drying and oven drying treatments. Air-drying method could therefore be recommended for processing of *Moringa oleifera* leaves.

KEYWORDS: *Moringa oleifera*, Drying methods, Nutrient content, Processing, Proximate analysis.

INTRODUCTION

Moringa oleifera belongs to a monogenetic family, the Moringacea. It is a species of vegetable tree crop. The tree originated from Agra and Oudh in North western region of India to south of the Himalayan Mountains (Ramachandran, 1980) now widely cultivated throughout the tropics and is found in many countries of Africa, Asia, Middle East, Central and South America, Sri Lanka, India, Mexico, Malaysia and Philippines (Gupta *et al*., 2007). It is easy to cultivate and are resistant to drought. It is one of such under-utilized plants in Africa. *Moringa oleifera* leaves are sparingly utilized in some parts of Nigeria especially in the Northern region where they are used in preparation of soup and other delicacies especially in the dry season when there is scarcity of other more popular vegetables like *Telfairia occidentalis* (Pumpkin), *Vernonia amygdalina* (bitter leaf), *Talinum triangulare* (water leaf), *Amaranthus spp.* (green vegetables) and other popular vegetables. The immature green pod of *Moringa oleifera* is known as "drumsticks". The leaves are highly nutritious, being a significant source of beta-carotene, vitamin C, protein, Iron and potassium (Kumari *et al*., 2006). The leaves are also cooked or stored as dried powder for many months without refrigeration and reportedly without the loss of nutritional value. Moringa leaves have a number of medicinal values such as analgesic, antihypertensive activity and anti-inflammatory effects (Kumari *et al*., 2006; Caceres *et al*., 1992; Marugandan *et al*., 2001). The leaves are also reported to possess various biological activities, including hypocholesterolemic, anti-diabetic, hypertensive agent (Mehta *et al*., 2003; Kar *et al*., 2003; Faizi *et al*., 1995; Guevara *et al*., 1999) and regulate thyroid hormone (Tahiliani *et al*., 2004). Reports have also described the plant to be highly potent anti-inflammatory agent (Ezeamuzle *et al.*, 1996) and anti-tumor activity (Murakami *et al*., 1998).

Processing of vegetables makes it safe for consumption and destruction of pathogens. Drying is a dehydrating process employed in processing vegetables. It also slows down the action of enzymes, but does not inactivate them (Henneman and Malone, 1994). Because drying removes moisture, the vegetables become smaller and lighter in weight. The commonest methods of drying are; sun-drying, air-drying and oven-drying. Sun-drying involves the exposure of vegetables to direct sun rays. Air-drying method requires air-current. In this method, vegetables are kept under shade and are exposed to air current. Air-drying is also referred to shade drying. Oven-drying requires the use of oven set at certain temperature.

Moringa oleifera leaves if well processed and utilized can be used as a food supplement and will go a long way in reducing malnutrition, micro-nutrient deficiency and some other health problems especially in developing countries.

Fugile (1999) reported that *Moringa oleifera* leaves, when dried, has varied percentage nutrient content which depended on the drying method adopted. Mbah *et al* (2012) and Asente *et al* (2014) also reported that proximate composition of *Moringa oleifera* varied with location. The study was therefore aimed to comparatively evaluate the nutrient contents of *Moringa oleifera* leaves dried under sun-drying, air-drying and oven-drying methods of drying in Iwollo, southeastern Nigeria.

MATERIALS AND METHODS

Sample Collection

Fresh *Moringa oleifera* leaves were collected from Enugu State polytechnic, Iwollo, in the month of August, 2015. The samples were collected at the same time and in one location to avoid the effect of soil variation on the nutrient content of the leaves. The collected samples were stored at room temperature in a closed environment.

Sorting

Fresh, green, undamaged, non-insect infected leaves were selected. Discoloured, decayed and wilted leaves were discarded before washing as they will give bad flavour to the whole batch. Also, wilted and decayed leaves can lead to loss of nutrients (Adeyeye and Otokiti, 1999).

Washing

The leaves were washed thoroughly three times with distilled water to remove all adhering dust and dirt particles. The leaves were tied together in small bunches after washing and were hung in an airy space to drain away extra water. The leaves were then weighed and were equally distributed into 3 batches for sun-drying, air-drying and oven-drying.

Experimental Design

Completely Randomized Design (CRD) was used in the study. Drying was done using drying trays. Three drying methods *viz*. sun-drying, air-drying, and oven-drying were regarded as treatments. Fresh leaves were used as control. The treatments were replicated seven times.

Drying Methods

Sun-drying

Sun-drying of *Moringa oleifera* leaves was done by placing the leaves on cotton sheets and then covered with cheese cloth to keep off dusts and insects. The cotton sheets and the leaves were therein placed in a direct heat of the sunlight on a roof away from animals, traffics and dust; and turned occasionally to ensure even drying. The leaves were brought indoor at night as the temperature during night drops. Sudden temperature change could put moisture back into the leaves and lengthen the drying time. Sun drying was completed at 13% moisture content of the leaves. The leaves took four consecutive days to dry in the sun.

Air-drying

The air dried leaves were spread on cotton sheets, but instead of keeping them on the roof, the leaves were kept in the room. The room selected for air drying was well ventilated. Natural current of air was used for air drying the leaves. It took about 6 days for the leaves to dry completely and become crisp and brittle to touch. The leaves sample was subjected to air by exposing it in open and well ventilated room between 10pm-5am daily till the sample attained constant weight and at room temperature of ±25^{o}C.

Oven-drying

The leaves were loaded on the tray, forming one single layer of the dehydrator and were dried in the dehydrator by forced air technique. The oven was pre-heated to 60^{o}C.

Proximate Analysis

The dried leaves samples were prepared in a powdery form and subjected to proximate analysis to determine the moisture, protein, fat, fibre, and carbohydrate contents as described by AOAC (2012). Proximate analysis was also conducted for fresh *Moringa oleifera* leaves to serve as control.

Vitamin C determination

Vitamin C content in the dried and fresh leaves was determined using the standard procedures described by AOAC (2012).

Statistical Analysis

The data collected on nutrient contents of *Moringa oleifera* leaves for the treatments were subjected to statistical analysis using analysis of variance (ANOVA) with GenStat Release 10.3DE software (2012). Comparison between treatment means was made using least significant difference (LSD) at 0.05 probability level.

RESULTS

The results of the analysis of variance of some nutrient contents of *Moringa oleifera* leaves dried under sun, oven and air including fresh leaves (control) were shown in Table 1. There were significant differences ($p<0.05$) among the different drying methods in all the nutrient contents evaluated when compared with control. Fresh leaves had significantly ($p<0.05$) higher values in Moisture content, Vitamin C, and Fat content; and significant ($p<0.05$) lower values in Carbohydrate, Protein and Fibre contents when compared to dried leaves. Among the dried leaves, there were significant differences ($p<0.05$) in Carbohydrate (CHO), Moisture and Protein contents among the treatments. In CHO, Air-drying statistically differed ($p<0.05$) with Sun-drying which was statistically at par with Oven-drying. The highest value of CHO was obtained in Air-drying (32.14%) and the lowest (27.71%) in Oven drying treatment. Similarly, the highest protein content was obtained in Air-drying (24.43%) followed by Sun-drying (21.43%) which was statistically at par with Oven-drying treatment (20.43%). In the same trend the highest value of Moisture content was obtained in Air-drying (10.04%) followed by Sun-drying (8.01%) and the lowest in Oven-drying (6.00%). All the three drying treatments (Sun-drying, Air-drying and Oven-drying) were statistically at par in Vitamin C, Fat, and Fibre contents.

TABLE 1: Some nutrient contents of *Moringa oleifera* leaves dried under different drying methods

Treatments	CHO (%)	Moisture (%)	Protein (%)	Vitamin C (%)	Fat (%)	Fibre (%)
Fresh leaves	12.69^{c}	75.79^{a}	6.74^{c}	200.67^{a}	10.17^{a}	0.917^{b}
Sun-drying	28.86^{b}	8.01^{c}	21.43^{b}	99.67^{b}	6.85^{b}	1.379^{a}
Air-drying	32.14^{a}	10.04^{b}	24.43^{a}	99.80^{b}	6.91^{b}	1.437^{a}
Oven-drying	27.71^{b}	6.00^{d}	20.43^{b}	100.01^{b}	6.99^{b}	1.449^{a}
LSD (0.05)	*1.180*	*0.1902*	*2.353*	*1.084*	*0.341*	*0.1055*

Mean values within each column with the same letter are not significantly different ($p>0.05$).

DISCUSSION

Moringa oleifera, a leafy vegetable, is highly perishable and seasonal. To ensure regular availability of the leaves, processing becomes pertinent. Drying makes the leaves not to deteriorate faster. The results of some nutrient contents of *Moringa oleifera* leaves dried under different drying methods showed that the leaves samples after drying became a concentrated source of nutrients. The results are in agreement with the studies done by Lakshmi and Vimla (2000) which showed that the leaves retained good amount of protein, fibre and calcium in the various samples of the leaves dried by sun-drying and cabinet-drying. Similar finding was reported by Jemina and Bhavani (2004) in dried green leafy cauliflower.

Low values of moisture content obtained after drying in all the drying treatments as compared to fresh leaves was as a result of loss of water content during drying. The loss in moisture in the processed leaves increased nutrient density. The trend in nutrient contents of *Moringa oleifera* leaves dried under different drying methods was in agreement with the reports of Alakali *et al*. (2015), Adeyemi *et al*. (2014), Mensah *et al.* (2012) and Mbah *et al*. (2012). The varied moisture contents among the different drying methods could be as a result of varied drying temperatures. This is in agreement with the findings of Alakali *et al*. (2015) who reported that moisture content of *Moringa oleifera* decreased significantly from fresh leaves to samples dried in the shade and to oven dried samples as the temperature increased.

Carbohydrate content increased significantly ($p<0.05$) with drying. This is in agreement with the findings of Adeyemi *et al*. (2014), Alakali *et al*. (2015), Gernah and Sengev (2011), Mensah *et al.* (2012) and Mbah *et al*. (2012). Kumar *et al*. (2014) reported that mild drying conditions with lower temperature may improve the product quality but decrease the drying rate. This could explain why highest percentage of carbohydrate was obtained in air-drying treatment compared to sun-drying and oven-drying treatments. Increased carbohydrate could lead to increased sweetness (Asente *et al*., 2014). Mbah *et al.* (2012) reported that the lower carbohydrate content in fresh leaves compared to dried leaves could be attributed to the utilization by microflora for the formation of carbon skeleton for synthesis of nutrients.

Fresh leaves had lower protein content compared to dried leaves. The lower percentage protein in fresh leaves could be as a result of higher percentage moisture. This suggests that drying increases the protein content of *Moringa oleifera* leaves. As the drying temperature increased from Air-drying to Sun-drying and to Oven-drying, protein decreased significantly ($p<0.05$). This could be as a result of corresponding denaturalization of protein with increasing temperature (Fugile, 2001).

Though, there was non-significant difference ($p>0.05$) among air-drying, sun-drying and oven-drying treatments in Vitamin C, Fat and Fibre contents, there was significant difference when compared to fresh leaves. The reduced value of Vitamin C in air, sun and oven dried leaves compared to fresh leaves could be as a result of exposure to heat and air which could have resulted to oxidation. The higher fat content in fresh leaves compared to the different drying treatments suggested that drying did not increase the fat content of the leaves. Dried leaves contained low fat which could be good to health. Lower fibre content was obtained in Fresh *Moringa oleifera* leaves. This could be attributed to the higher moisture content in fresh leaves. The higher fibre content in the processed leaves could be due to dehydration and concentration of dry matter. The superior value obtained in air-drying treatment over sun-drying and oven-drying in most of the nutrient contents evaluated could be attributed to the indirect heat the *Moringa oleifera* leaves received during the drying process (Lakshmi and Vimla, 2000).

CONCLUSION AND RECOMMENDATION

The abundantly available inexpensive leaves of *Moringa oleifera* can serve as a pool house of nutrients and can be used in developing countries to combat nutrient deficiencies. Drying is one of the most possible strategies of processing green leafy vegetables which are highly seasonal and perishable. The study showed that drying methods of processing *Moringa oleifera* resulted in concentration of the nutrients. *Moringa oleifera* leaves retained valuable nutrients after drying. Dried leaves are better source of fibre, protein and carbohydrate than the fresh leaves. There was variation in the nutrient contents of *Moringa oleifera* leaves as influenced by different drying methods. Air-drying treatment gave superior values in carbohydrate, protein and moisture contents therefore could be recommended for processing of *Moringa oleifera* leaves.

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