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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Effect of Drying Techniques on the Proximate and Other Nutrient Composition of *Moringa oleifera* Leaves from Two Areas in Eastern Nigeria

B.O. Mbah, P.E. Eme and A.E. Paul
Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka, Nigeria

Abstract: This study was carried out to evaluate the proximate, micronutrients and anti-nutrients composition of *Moringa oleifera* leaves. The *Moringa oleifera* leaves were sourced from two areas of Eastern Nigeria viz: Anambra and Enugu state. The leaves were obtained fresh, cleaned and washed prior to treatments (sun dried, shade dried and oven dried), tied and kept intact for further analysis. The result revealed that FA (fresh Anambra) and FN (fresh Nsukka) had high moisture content (73.51% and 70.33% respectively) and low protein content (10.78% and 6.13% respectively).The processed leaves had low fat content as compared with the FA and FN (4.41%, 4.28%, 2.12%, 2.11%, 6.69% and 4.28% vs 12.48% and12.23%). The different drying techniques improved the protein, fibre, carbohydrate, thiamin, vitamin A, calcium and zinc level of the leaves. The result also showed that the anti-nutrients (phytate, oxalate and saponin) were decreased by the different drying treatments whereas tannin was increased by them. There is need for nutrition education to mothers on how to incorporate these processing techniques on *Moringa oleifera* in order to maximize its nutrient potentials.

Key words: Drying techniques, proximate, nutrient composition, eastern Nigeria

INTRODUCTION

The need to meet nutritional requirement through adequate food supplies and proper selection of diet has been a basic determinant of stability and progress, human being require food to pursue essential functions such as growth, development and reproduction (Onimawo, 2001). Hunger and malnutrition are highly prevalent in the developing countries. FAO (2001) reported that absolute number of food unsecured in developing world increased from 780 million to 798 million. In Nigeria, about 7.8 million people were undernourished in 1995-1997 and increased to 9.1 million in 1999-2001 (SCN, 2004).

In Nigeria, the malnourished are increasing due to poverty, lack of access to nourishing food, low food production, low availability of macronutrient in foods, ignorance of the availability of foods such as *Moringa oleifera* plant. Hunger and malnutrition precipitate low productivity and economic losses. Today, there are many edible and palatable plant foods, however, very little is consumed as part of our daily diet (Ching and Mohamed, 2001). The major contribution of fruits and vegetables to human are vitamin A, folate, ascorbate as well as good amount of some minerals.

Food processing transforms raw foods into their edible forms; it also increases shelf life, digestibility, flavor, nutritive value among other benefits. Salting, drying, blanching, soaking, sprouting, dehulling and fermentation change the chemical composition of food and increases the storage and shelf life of foods. Various foods presuppose different processing techniques (Akpapunam, 2007).

Moringa oleifera is one of the lesser known vegetables found in Nigeria ecosystem. The leaves are highly nutritious, they are significant source of beta-carotene, vitamin C, protein, iron and potassium. *Moringa oleifera* leaves contain more of vitamin A than carrot, more vitamin C than oranges and more potassium than bananas. The protein quality of Moringa leaves compares very well with that of milk and eggs (Gardener and Ellen, 2002). The leaves and stems of *Moringa oleifera* are known to have large amount of calcium oxalate crystals which are decreased by processing making them more available to the body (Gardener and Ellen, 2002).

The leaves are cooked and used as spinach. In addition, its leaves are commonly dried prior to pulverization as powder for fortification and supplementation especially in complementary infant feeds. The dried and pulverized powder is added to pap, cereals and drinks to improve nutriture (Gardener and Ellen, 2002).

This study is aimed at determining the effect of different drying techniques on the proximate and other nutrient composition of *Moringa oleifera* leaves sourced from different two areas in Eastern Nigeria.

Corresponding Author: P.E. Eme, Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka, Nigeria

MATERIALS AND METHODS

The leaves of *Moringa oleifera* was collected from two different areas in eastern Nigeria (University of Nigeria, Nsukka in Enugu state and Ezihu village in Aguata local government area of Anambra state).

Sample preparation

Sorting: Fresh, green, undamaged, non-insect infected were selected. Bruised, discoloured, decayed and wilted leaves were discarded before washing the leaves.

Washing: The stalks of the leaves were cut from the main branches and the leaves were washed thoroughly three times with plenty of water to remove all the adhering dust, dirt particles. The drumstick leaves grow on number of thin branches attached to the main branch. The thin branches were kept intact during washing for the easy handling of the leaves. After washing, the stems of the leaves were tied together in small bunches and was hung in an airy space to drain away extra water and to air-dry the leaves. The residual moisture was evaporated at a room temperature, before the actual drying process on a clean paper with constant turning over to avert fungal growth. After air drying, all the stems and branches of the leaves were removed and only the leaves of drumstick were used for drying. The leaves were then weighed and divided equally into three batches for sun drying, shade drying and oven drying.

Drying techniques

Sun 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 direct sunlight on a roof away from animals, traffic and dust and turned occasionally to assure even drying. The leaves were brought indoor at nights. The leaves were sun-dried for four days and were stored in a cellophane bag for analysis.

Shade drying: The air-dried leaves was spread on cotton sheets and kept in a well-ventilated room at a temperature on 25±2°C for days. Natural current of air was used for shade-drying the leaves. It took about six days for the leaves to dry completely and become crisp and brittle to touch.

Oven drying: The leaves were loaded thin in the trays for drying using forced air. The oven was pre-heated to 60°C and this temperature was maintained for one hour for the leaves to dry. The leaves were dried for 4 hr until it was completely dried. Then it was properly labeled and stored in a transparent cellophane bag.

Chemical analysis: The dried leaves was analysed for proximate composition (protein, fat, fibre, carbohydrate and ash), vitamins (vitamin B1, vitamin A), minerals (iron, iodine, zinc, calcium) and anti-nutrients (phytate, oxalate, saponin, tannin).

The proximate analysis of the dried *Moringa oleifera* from different locations was determined in triplicate. Protein was determined by micro-kjedahl procedure as modified by Pearson (1976). Fat content was determined by extraction with petroleum ether as outlined by Pearson (1976). Crude fibre was determined by modified Weende method. Ash was obtained by dry ashing in the furnace at 600°C for 2 hrs. Total carbohydrate was determined by difference method. Moisture was determined by drying method. Vitamin A was determined using TCA method. Vitamin B1 was determined using the method of Pearson (1976). Zinc and Calcium was determined by the atomic absorption spectrophotometric method while Iron were determined by colourimetric method. Phytate level were determined by colourimetric produre described by Latta and Eskin (1980). Tannins and Saponin were determined using spectrophotometric methods while Oxalate was determined by a method described by Dye and modified by Iwuoha and Kalu (1995).

Data analysis: The data collected were statistically analyzed using means and standard deviation with SPSS (Statistical Package for Social Sciences) version 17.

RESULTS

Table 1 presents the proximate composition of *Moringa oleifera* leaves at different drying techniques. The moisture content varied from 5.11 to 73.51%. The FA had the highest value (73.51%) followed by FN(70.33%). The SAA, SUA and SAN had comparable values of 6.75%, 6.55% and 6.35% respectively. The SUN and OVA had 6.12% and 5.13% respectively while the OVN had the least value (5.11%). The protein composition ranged from 6.13 to 33.38%. The SAN had the highest value (33.38%). The SAA, SUA, OVN, OVA, SUA, SUN and FA had 32.66%, 26.00%, 25.31%, 24.43%, 18.91% and 10.78% respectively. The FN had the least value (6.13%). The fat composition varied. It varied from 2.11 to 12.48%. The OVN had the least value (2.11%) followed by the OVA (2.12%). The SUA, SAN and SUN had comparable values of 4.14%, 4.28% and 4.24% respectively. The SAA and FN had 6.69% and 12.23% respectively. The FA had the highest value (12.48%). The ash composition varied from 0.86 to 3.14%. The SUA had the highest value (3.14%). The OVA and OVN each had the 2.01% respectively. However, the SUN, SAA and SAN had 2.96%, 1.28% and 1.26% respectively. The FN had the least value (0.86%) followed by the FA (0.81%). The fibre composition ranged from 1.19 to 1.59%. The FN had the least value (1.19%) followed by the FA (1.24%) though the SAN and SUA each had 1.47% respectively, they also had comparable values with OVN

Table 1: The proximate and micronutrient composition of *Moringa oleifera* leaves at different drying techniques

Nutrient	SUA	SUN	OVA	OVN	SAA	SAN	FA*	FN*
Moisture %	6.55	6.12	5.13	5.11	6.75	6.35	73.51	70.33
Protein %	24.43	18.91	25.13	26.00	32.66	33.38	10.78	6.13
Fat %	4.41	4.28	2.12	2.11	6.69	4.24	12.48	12.23
Ash %	3.14	2.96	2.01	2.01	1.28	1.26	0.87	0.86
Fibre %	1.47	1.34	1.52	1.48	1.59	1.47	1.24	1.19
Carbohydrate %	60.00	66.39	64.22	63.29	51.03	53.30	1.12	9.26
Vitamin B1 (mg/100 g)	0.73	0.80	0.49	0.54	0.85	0.89	0.41	0.44
Vitamin A (mg/100 g)	2.54	2.80	1.78	2.17	2.93	3.69	1.40	1.65
Iron (mg/100 g)	0.39	0.73	0.37	1.15	0.40	0.38	1.43	2.30
Calcium (mg/100 g)	1.27	1.44	1.95	3.23	2.59	3.56	1.25	1.23
Zinc (mg/100 g)	0.78	0.96	0.58	0.68	0.80	0.85	0.54	0.58

*Serves as the control. SUA = Sun Dry Anambra, SUN = Sun Dry Nsukka, OVA = Oven Dry Anambra, OVN = Oven Dry Nsukka, SAA = Shade Dry Anambra, SAN = Shade Dry Nsukka, FA = Fresh Anambra, FN = Fresh Nsukka

Table 2: Anti-nutrient composition of *Moringa oleifera* leaves at different drying techniques

Nutrient (mg/100 g)	SUA	SUN	OVA	OVN	SAA	SAN	FA*	FN*
Tannin	1.84	1.37	1.56	1.25	1.60	1.62	0.23	0.20
Phytate	9.09	3.25	5.95	1.30	4.55	3.25	9.44	9.42
Oxalate	3.59	3.53	2.76	2.83	3.26	3.28	3.63	3.76
Saponin	0.31	0.33	0.49	0.49	0.83	0.84	0.85	0.90

*Serves as the control. SUA = Sun Dry Anambra, SUN = Sun Dry Nsukka, OVA = Oven Dry Anambra, OVN = Oven Dry Nsukka, SAA = Shade Dry Anambra, SAN = Shade Dry Nsukka, FA = Fresh Anambra, FN = Fresh Nsukka

(1.48%) and OVA (1.52%). The SUN had 1.34% while the SAA had the highest value (1.59%). The carbohydrate value ranged from 1.12-66.39%. The SUN had the highest value (66.39%) followed by OVA (64.22%). The OVN, SUA, SAN and SAA had 63.29%, 60.00%, 53.30% and 51.10% respectively. The FA had the least value (1.12%) followed by FN (9.26%).

The Vitamin B1 composition ranged from 0.41 to 0.89 mg/100 g. The SAN had the highest value (0.80 mg/100 g) followed by SAA (0.85 mg/100 g). The SUN, SUA and OVN had 0.80 mg/100 g, 0.73 mg/100 g and 0.54 mg/100 g respectively. The OVA and FN had comparable values of 0.49 mg/100 g and 0.44 mg/100 g respectively while the FA had the least value (0.41 mg/100 g). The vitamin A composition varied from 1.40 to 3.69 mg/100 g. The SAN had the highest value (3.69 mg/100 g) followed by SAA (2.93 mg/100 g). The SUN, SUA, OVN and OVA had 2.80 mg/100 g, 2.54 mg/100 g, 2.17 mg/100 g and 1.78 mg/100 g respectively. The FA had the least value (1.40 mg/100 g) followed by FN (1.65 mg/100 g). The iron composition varied. It varied from 0.37 to 2.30 mg/100 g. The OVA had the least value (0.37 mg/100 g) followed by SAN (0.38 mg/100 g) and then the SUA (0.39 mg/100 g). The SAA, SUN and OVN had 0.40 mg/100 g, 0.73 mg/100 g and 1.15 mg/100 g respectively. The FN had the highest value (2.30 mg/100 g) followed by FA (1.43 mg/100 g). The calcium composition ranged from 1.25 to 3.56 mg/100 g. The FA had the least value (1.25 mg/100 g) followed by the SUA (1.27 mg/100 g) and then the FN (1.35 mg/100 g). The SUN, OVA and SAA had 1.44 mg/100 g, 1.95 mg/100 g and 2.59 mg/100 g respectively. The SAN had the highest value (3.56 mg/100 g) followed by the OVN (3.23 mg/100 g). The zinc composition varied from 0.54 to 0.96 mg/100 g. The SAA, SUA and OVA had 0.80 mg/100 g, 0.78 mg/100 g and 0.68 mg/100 g respectively. The FN and OVA each had 0.58 mg/100 g respectively while the FA had the least value (0.54 mg/100 g).

Table 2 presents the anti-nutrient composition of *Moringa oleifera* leaves at different drying techniques. The tannin composition varied from 0.20-1.84 mg/100 g. The SUA had the highest value (1.84 mg/100 g) followed by SAN (1.62 mg/100 g). The SAA, OVA, SUN, OVN and FA had 1.60 mg/100 g, 1.56 mg/100 g, 1.37 mg/100 g, 1.25 mg/100 g and 0.23 mg/100 g respectively. The FN had the least value (0.20 mg/100 g). The phytate composition varied. It varied from 1.30 to 5.44 mg/100 g. The FA had the highest value (9.44 mg/100 g). The SUA, OVA and SAA had 9.09 mg/100 g, 5.95 mg/100 g and 4.55 mg/100 g respectively. The SAN and SUN each had 3.25 mg/100 g respectively while OVN had the least value 1.30 mg/100 g. The oxalate composition varied from 2.76 to 3.76 mg/100 g. The OVA had the least value (2.76 mg/100 g) followed by OVN (2.83 mg/100 g). The SAA, SAN, SUN, SUA and FA had comparable values of 3.26 mg/100 g, 3.28 mg/100 g, 3.53 mg/100 g, 3.59 mg/100 g and 3.63 mg/100 g respectively. The FN had the highest value (3.76 mg/100 g). The saponin composition ranges from 0.31 to 0.90 mg/100 g. The SUA had the least value (0.31 mg/100 g) followed by SUN (0.33 mg/100 g). The OVA and OVN each had 0.49 mg/100 g respectively. The SAA, SAN and FA had comparable values of 0.83 mg/100 g, 0.84 mg/100 g and 0.85 mg/100 g respectively. The FN had the highest value (0.90 mg/100 g).

DISCUSSION

Among the eight different samples of *Moringa oleifera* leaves used in this study, only the FA and FN had very high moisture (73.51 and 70.33%) (Table 1). This could be as a result of the freshness of the samples and also that it has not undergone any form of treatments. Leafy vegetables are highly perishable and seasonal. They require a special processing treatment to prevent post harvest losses. This therefore implied that treatment (different drying techniques) of *Moringa oleifera* leaves makes them not to deteriorate faster. The variation between the FA and FN could be due to location as a result of different climate and soil composition. The lower protein of FA and FN (10.78 vs 6.13%) was not surprising when correction was made for residual moisture. This suggests that treatment (different drying techniques) increase the protein content of *Moringa oleifera* leaves. The loss in moisture in the processed leaves increased nutrient density, a commonly observed phenomenon. The higher fat content of FA and FN (12.48 and 12.23%) as compared with the other samples revealed that treatments (sun drying, shade drying and oven drying) did not improve the fat content of the leaves. The low fat content of the processed leaves (4.41, 4.28, 2.12, 2.11, 6.69 and 4.24%) (Table 1) as compared with FA and FN is normal. This suggests that processed *Moringa oleifera* leaves could be used as a better food for the community that requires low fat diets. The increase in ash of the processed vegetables (3.14, 2.96, 2.01, 1.28 and 1.26%) as compared with the FA and FN (0.87 and 0.86%) was again due to the removal of residual moisture and increased nutrient density. The lower fibre content for the FA and FN (1.24 and 1.19%) (Table 1) were attributed to their high moisture content while the higher fibre content of the processed vegetables could be due to dehydration and concentration of dry matter. Fibre has useful role in providing roughage that aids digestion (Lisa, 1997). The lower carbohydrate content of FA and FN (1.12 and 9.1) was not surprising. This must have been due to utilization by microflora for the formation of carbon skeleton for synthesis of nutrients. Carbohydrates contribute to fat metabolism and spare proteins as energy source for human beings (Gordon, 2000; Gaman and Shenngton, 1996).

The higher and comparable vitamin B1 values of SAN and SAA (0.85 and 0.89 mg/100 g respectively) (Table 1) as compared to the other samples, showed that shade-drying is the best method to increase the vitamin B1 of *Moringa oleifera* leaves. The trend is the same for vitamin A, the higher values of SAA and SAN (2.93 and 3.69 mg/100 g) (Table 1) revealed that shade drying has an edge over sun-drying and oven-drying in availability of vitamin A in *Moringa oleifera* leaves. The higher iron in FA and FN leaves (1.43 and 2.30 mg/100 g) (Table 1) suggests that fresh samples of the leaves are better sources of iron than processed leaves. It also showed higher calcium content of processed leaves (1.27, 1.44, 1.95, 3.22, 2.59 and 3.56 mg/100 g) than fresh samples (1.25% and 1.23%). This indicates that treatments (sun-drying, shade-drying and oven-drying) improved calcium content of the leaves. The SAN (3.56 mg/100 g) had the highest calcium value which implies that it is a better source of this nutrient than the other samples. The comparable zinc values for sun and shade dried leaves (0.78 and 0.96 mg vs 0.80 and 0.85 mg respectively) (Table 1) suggest that neither of the processing methods had an advantage in improving zinc quality of *Moringa oleifera* leaves. The SUN had the highest zinc value (0.96 mg/100 g) which showed that it will contribute more of this nutrient than the other samples. The lower tannin values for FA and FN (0.23 and 0.20 mg) (Table 2) as compared to the other samples indicates that drying methods increases the tannin content of the leaves. The FA and FN had a higher oxalate value (3.63 and 3.76 mg/100 g) (Table 2) as compared with the other samples explains that processed leaves had a lower oxalate content. The oven-dried leaves (2.76 and 2.83 mg/100 g) had the lowest oxalate content. The oven-dried leaves (2.76 and 2.83 mg/100 g) had the lowest oxalate value which shows that oven-drying is the best method of reducing oxalate content of *Moringa oleifera* leaves. The saponin content of the leaves was generally low (0.31 to 0.90 mg/100 g). The lower SUA and SUN (0.31 and 0.33 mg) (Table 2) as compared to the other samples suggest that sun drying had an edge over the other processing methods in reducing saponin content of *Moringa oleifera* leaves. The phytate values for SUA, OVA, FA and FN (9.09 mg/100 g, 5.95 mg/100 g, 9.44 mg/100 g and 9.42 mg/100 g) respectively were higher than the toxic limit of phytate (5.00 mg/100 g) (Munro and Basrer, 1969). The high level of phytate in these leaves may pose some health challenges for these samples.

Conclusion: The different drying techniques had an effect on the nutrients and anti-nutrients of *Moringa oleifera* leaves. All the drying techniques improved the protein, fibre, carbohydrate, vitamin B1, vitamin A, calcium and zinc level of the leaf. The *Moringa oleifera* anti-nutrients (tannin, oxalate and saponin) were decreased by the different drying treatments whereas tannin was increased by them.

Recommendation:

- Because *Moringa oleifera* is a cheap source of micronutrients in addition to other nutrients, it should be used in food supplementation, fortification and complementation (especially in infant feed).

- Nutrition education on preparation and incorporation of *Moringa oleifera* leaves should be done to mothers both in the rural and urban slums who are ignorant of the nutrient potentials of the leaves.
- There should be proper education in various communities on the economic and nutritional importance of sun, shade and oven-drying food preservation and processing techniques for green leafy vegetables.

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