Article

Effects of processing on *Moringa oleifera*

E. T. Gyamfi[1,2], I. K. Kwarteng[1], M. O. Ansah[3], A.K. Anim[1], M. Ackah[1], Lebene Kpattah[1], Nash O. Bentil[1]

[1]Ghana Atomic Energy Commission, National Nuclear Research Institute, Nuclear Chemistry and Environmental Research Centre, P. O. BOX LG80, Legon-Accra, Ghana

[2]Department of Nuclear Sciences and Applications, Graduate School of Nuclear and Allied Sciences, P. O. BOX AE1, Atomic Campus, Accra, Ghana

[3]Ghana Atomic Energy Commission, Biotechnology and Nuclear Agriculture Research Institute, P. O. BOX LG 80, Legon-Accra, Ghana

E-mail: evagyamfi@gmail.com

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Abstract

Food processing is to minimize the growth of microorganisms during the storage period, thus promoting longer shelf life and reduced hazard from eating the food. Air, freeze and oven drying were employed in the study. Mineral analysis of dried leaf samples considered include sodium, magnesium, phosphorus, potassium, calcium, manganese, chromium, iron, copper, cadmium, zinc among others using fast sequential atomic absorption spectrometer, vis-uv spectrophotometer and Neutron Activation Analysis (NAA). Leaf samples from different areas showed variations with respect to macro and micro mineral contents. The study revealed that dried leaf powder of Moringa can serve as an excellent source of minerals.

Keywords mineral; processing; atomic absorption spectrometry.

1 Introduction

Processing food including plants and vegetables makes it safe for consumption and destruction of pathogens. The factors that affect nutrient content resulting from food processing are; sensitivity of the nutrient to light, heat, oxygen (Morris et al., 2004). Other methods apart from air drying that can be used to dry *Moringa* include freeze drying and oven drying. The different ways of food preparation and preservation may affect significantly the concentration and availability of minerals, vitamins and other essential compounds in food. Some reports have documented losses of nutrients from vegetables during drying (Yadav and Sehgal, 1997) and cooking (Kachik et al., 1992; Kidmose et al., 2006). The most popular drying method for *Moringa* is air drying (drying at a room temperature). Drying has been used traditionally as a method of preserving certain vegetables in Ghana and most developing countries. One such plant vegetable in Ghana is *Moringa oleifera*. The basis for drying is to reduce the moisture content to a level which prolongs shelf life during storage and reduces colonization by microorganisms (Eklou et al., 2006). Drying is also one of the methods of food preservation employed to reduce losses in quantity and quality which will otherwise occur (Habou et al., 2003). Processing food including plant vegetables makes it safe for consumption and destruction of pathogens. The main aim of the study was to determine the processing method suitable for processing *Moringa* and yet retains higher concentrations of elements.

2 Materials and Methods

2.1 Sample collection and preparation

Leaves of *Moringa oleifera* were collected from ten different plants into clean polythene containers and transported to the laboratory. Samples were then washed with de-ionized water and divided into three portions for drying.

2.2 Description of drying methods used

The samples were divided into three portions and the drying methods; freeze drying, air drying and oven drying were employed to dry the various portions. A portion of the samples were air dried at (room temperature ie.25^0C±4^0C) for seven (7) days. A portion of the samples were freeze dried for 24 hrs using CHRist LMC-1 manufactured in Germany. Dried samples were ground to fine powder using an electronic laboratory blender. The pulverised plant materials were secured in zip-loc bags, well labeled and stored at 4ºC for analysis.

2.3 Preparation of samples for neutron activation analysis

About 0.2g of each of the dried samples were weighed into pre-cleaned polythene foils, wrapped with forceps and the foils heat –sealed. Two (2) replicates of each of the samples were prepared. Two replicates of compositionally appropriate standard reference material of peach leaf 1547 from National Institute of Standards and Technology (NIST) were also prepared similarly and irradiated together with the samples. The wrapped samples were packed into 7 ml polyethylene capsules and heat sealed. Each capsule contained a reference material that is sandwiched between the samples. The reference materials were used as a comparator standard for gamma spectrum evaluation using the relative method of standardization for neutron activation analysis (NAA) and to check for the accuracy of the analytical method used.

2.4 Neutron activation

The sealed polyethylene vials were introduced into the reactor by a pneumatic transfer system. The samples were then irradiated as medium-lived and short-lived depending on the half life of the element of interest. The nuclear data in Table 1 was followed. Samples for the analysis of medium-lived radioisotopes were irradiated for 1hour with thermal neutrons at a n flux of $5x10^{11}$ neutrons $cm^{-2}s^{-1}$ at the inner irradiation sites of the Ghana Research Reactor-1 (GHARR-1) facility, situated at the Ghana Atomic Energy Commission (GAEC). The GHARR-1 is a 30kw tank-in-pool miniature neutron source reactor (China Institute of Atomic energy). It uses 90.2% enriched uranium(U-235)-Aluminium alloy as fuel. It is cooled and moderated with light water and beryllium acts as reflectors (Akaho and Nyarko, 2002). Samples for the analysis of short-lived radionuclides were irradiated for 10 seconds. At the end of the irradiation, samples and standards were allowed to decay to eliminate inferring radioisotopes. In addition, the decay period allows the activities induced in the samples to reach acceptable levels for handling to ensure safety of human health.

2.5 γ- Activity measurement of samples and standards

Analysis of induced radioisotopes of interest were performed on a PC-based gamma- ray spectroscopy system. The spectroscopy system consist of a Canberra high purity germanium(HPGe) N-type coaxial detector(model GR 2518-7500SL) with a resolution of 1.8 keV relative to the 1332.5keV γ- energy line of ^{60}Co at full width at half Maximum (FWHM) ; a relative efficiency of 25% ;and a peak-to-Compton ratio of 55. Samples and standards were placed on the high purity germanium (HPGe) γ- ray detectors and γ-activity of the induced radioisotopes measured at the same position and distance from the detector. The measurement time for short-lived and medium-lived radioisotope depended on the activity of the induced radionuclide. The samples and standards were each counted for 10 minutes to acquire the gamma-energy peaks. Samples were measured first and then followed by the standards. A Plexiglas source support was mounted on the detector in order to maintain the same geometry for both samples and standards. Quantifications of the elements were achieved using the comparator method.

Table 1 Nuclear data used to determine elemental concentrations (Filby et al., 1970)

Element	Reaction	Half life	Energy (Kev)	ti	td	tc
K	^{41}K (n, γ) ^{42}K	12.36h	1524.7	1hr	24hrs	10min
Na	^{23}Na (n, γ) ^{24}Na	15.02h	1368.6; 2754.1	1hr	24hrs	10min
Br	^{81}Br (n, γ) ^{82}Br	35.3h	554.3; 776.5	1hr	24hrs	10min
Mg	^{26}Mg (n, γ) ^{27}Mg	9.45min	1014.4	10s	1-5 min	10min
Mn	^{55}Mn (n, γ) ^{56}Mn	2.58h	846.7; 1810.7; 2112	10s	1-5 min	10min
Ca	^{48}Ca (n, γ) ^{49}Ca	8.7min	3084.4	10s	1-5 min	10min
Cl	^{37}Cl (n, γ) ^{38}Cl	3.7min	1642.4, 2167.5	10s	1-5 min	10min

2.6 Atomic Absorption Spectrometer (AAS) and UV-Spectrometry analysis

Metallic micro mineral (V, Cd, Pb,Cr, Fe, Cu and Zn ions) composition were determined by acid digestion of the dried and pulverized samples of *Moringa* leaves using Milestone laboratory protocol (1996-2000). 5 mL of NHCl as well as 1mL of H_2O_2 were added to 0.50 g moringa sample, mixture was kept in a programmed microwave oven to achieve the desired digestion, digestate was allowed to cool followed by transfer into a 15 mL test tube where digested sample was made to the 10 mL mark with distilled water. The metallic micro mineral compositions were then measured using the fast sequential Atomic Absorption Spectrometer, AAS, technique (Varian AA240FS) while the vis-uv spectrophotometer (Shimadzu Corp., Tokyo, Japan) was employed for the determination of phosphate (PO_4^{3-}) at 780 nm and 410nm for Nitrate (NO_3^-).

3 Results and Discussion

3.1 Statistical analysis

The results were analysed using SPSS version 16 and Microsoft excel statistical package. Analysis of variance (ANOVA) was used to determine the mean , standard deviation and test of significance. Bar charts were drawn for better visibility. Figures 1 and 2 shows the concentrations of elements in *Moringa* leaves studied based on three processing methods (air, freeze and oven drying) for the two study areas.

3.2 Elemental composition

Major elements, also known as macro minerals, are those elements which are needed in the body in quantities greater than 100 milligrams per day. These elements make up more than 99% of the mass of human bodies. The macro minerals that are needed by the body to function include Calcium, magnesium, phosphorus, sulphur and electrolytes elements (chlorine, potassium, and sodium). The major elements analysed in this study were nitrogen, phosphorus, sodium, magnesium, potassium, chlorine, and calcium. A common trend in the results shows the levels of elements in the order; freeze dry>air dry>oven dry. Thus the oven drying method reduces the concentrations due to the heat. Samples collected from Techiman have relatively higher concentrations compared to samples from Otiakrom except in few cases. For example, from the major elements analysed using the freeze drying method, Mg recorded the highest concentration of 77.4 mg/kg in a sample from Otia as against 60.99 mg/kg in a sample from Techiman. The general trend however followed the order; P (61.62 mg/kg)> Mg (60.99 mg/kg) > N (51.36 mg/kg) > Na (40.81 mg/kg) > Ca (40.40 mg/kg) > K (26.98 mg/kg) >

Cl (5.64 mg/kg) for samples Techiman whilst the samples from Otia measured the concentrations (mg/kg) in the order; Mg (77.40)> Na (69.01) > N (49.98) > P (30.26) > K (22.6) > Ca (22.00) > Cl (6.27). Even though different trends were observed in the samples from the different sampling points, Chlorine measured the least concentrations. For the samples analysed using the air drying method, all the elements, except Mg and Cl, in the samples from Techiman were higher compared to the concentration of elements in samples from Otiakrom. The concentrations of Mg and Cl in the samples from Otiakrom were 58.10 mg/kg and 5.64 mg/kg as against 57.30 mg/kg and 2.68 mg/kg respectively for the air dried samples. Interestingly, Mg measured the highest concentration as recorded for the freeze drying method. With the oven drying method, apart from Mg (53.00 mg/kg) which was measured in the sample from Otiakrom against 36.14 mg/kg measured in the sample from Techiman, all the other major elements analysed had higher concentrations in samples from Techiman than in samples from Otiakrom.

Trace elements are also known as micronutrients and are found only in minute quantities in the body - yet they are vitally important. The quantities in which they are found are so small, that they can only be detected by spectrographic methods or by using radioactive elements. The trace elements analysed in this study were zinc, vanadium, manganese, iron, chromium, copper, bromine and aluminium. From the samples analysed using the freeze drying method, Mn measured the least concentration of 2.00 mg/kg whiles 74.93 mg/kg was measured for Fe, all in samples from Techiman. Similarly, 1.81 mg/kg was measured for Mn in a sample from Otiakrom whiles Fe measured 73.77 mg/kg in a sample from Techiman. With the oven drying method, however, Mn measured 1.01 mg/kg and Mg measured 57.30 mg/kg in samples from Techiman and Otiakrom respectively.

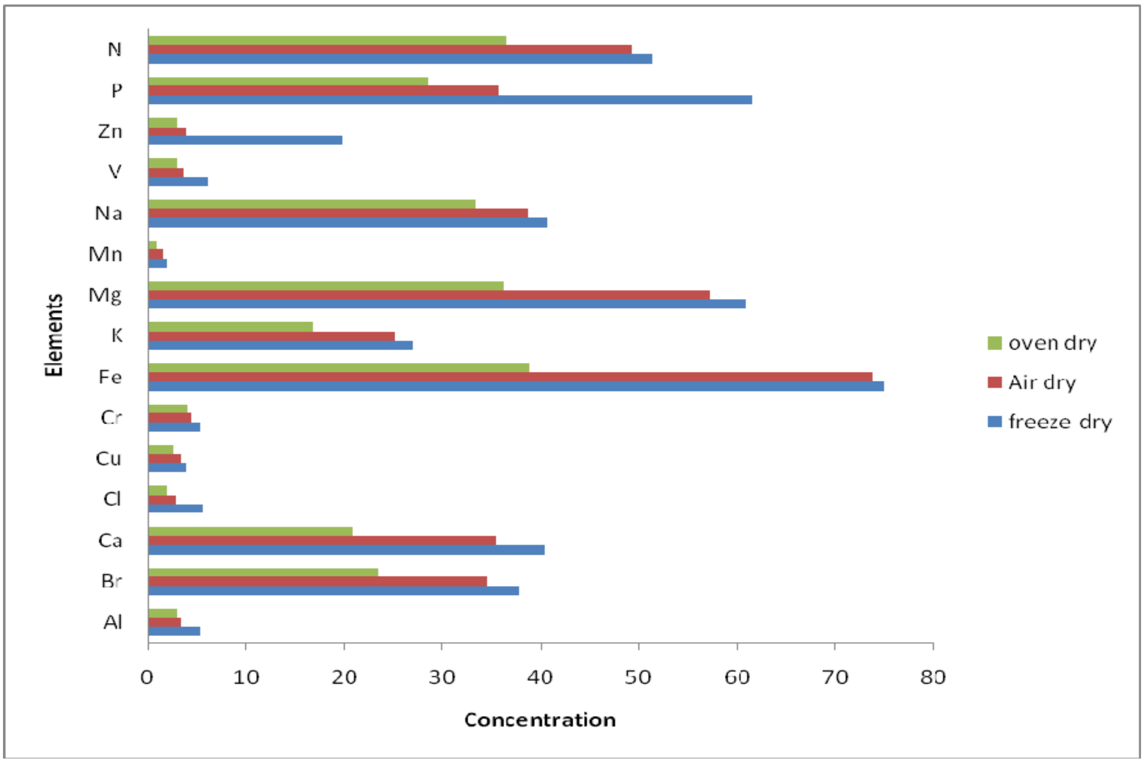

Fig. 1 Concentrations of elements based on the three drying methods of samples from Techiman.

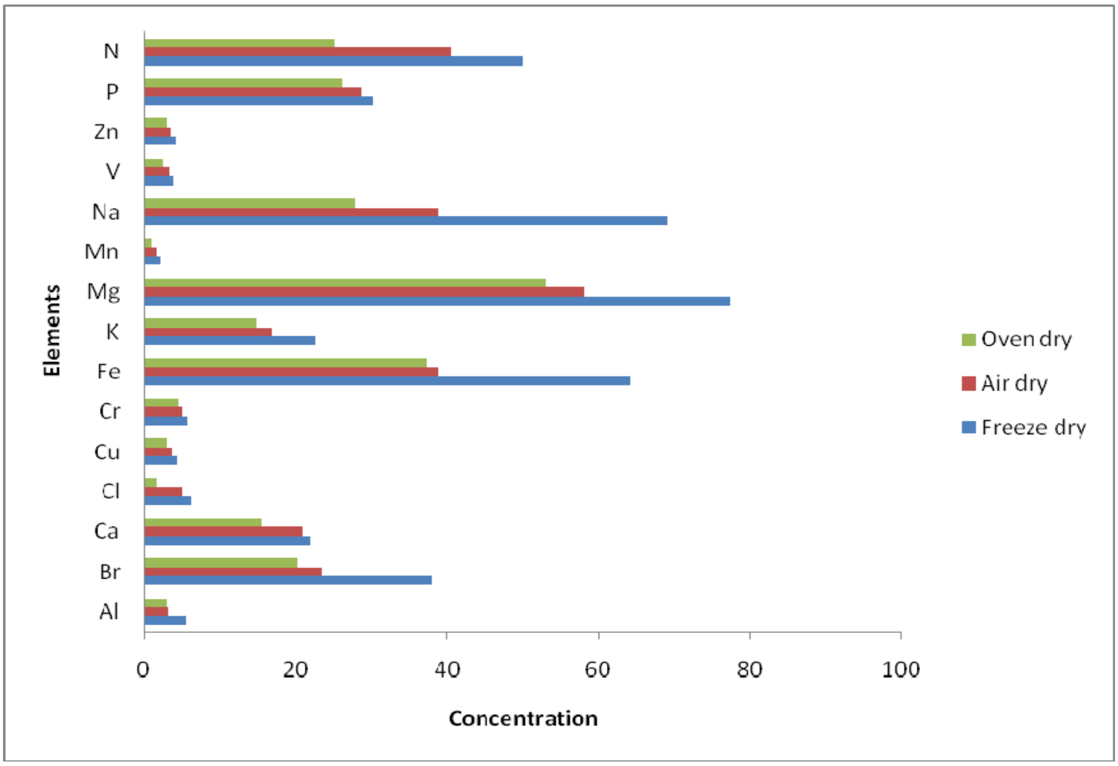

Fig. 2 Concentrations of elements based on the three drying methods of samples from Otiakrom.

Of the three drying methods used, freeze dried samples recorded higher mean concentration levels for all the elements followed by air and oven dried samples respectively. This is because freeze drying is able to retain most of the nutrients since during freeze drying, external influences are minimal. Generally, samples from Techiman recorded higher concentrations compared to Otiakrom. Thus the level of elements in *Moringa* is dependent on the soil type on which the plant was cultivated and other factors such as:

Analytical technique used for the analysis of the *Moringa* samples

Period between sample collection and analysis

Conservation of samples between collection and its analysis (drying, freezing, etc)

Natural variations among source samples

Genetic background (cultivars, ecotype)

Cultivation methods (inputs, frequency of harvests)

Table 2 Effect of processing on elements concentration from otiakrom using analysis of variance (ANOVA)

Name of Element	Freeze Dry		Air Dry		Oven Dry		
Element	Range n=10	Mean ± SD	Range n=10	Mean ± SD	Range n=10	Mean ± SD	*P* -value
Aluminum	2.11-8.33	5.52 ± 2.00	1.07-8.45	3.19 ± 1.54	1.25-5.57	3.08± 2.67	0.026
Bromine	9.13-34.56	37.90±7.60	3.17-32.9 0	23.46±7.41	3.17-32.99	20.36±7.53	<0.001
Calcium	105.0-205.0	22.0±1.75	136-371	20.9± 1.49	136-371	15.5±0.75	0.018
Chlorine	1.19-8.64	6.27±1.68	1.00-9.47	5.64±3.34	4.59-9.48	1.68±0.53	0.727
Copper	4.00-5.00	4.42±0.28	3.28-4.20	3.88±0.59	3.22-4.20	3.82±0.24	0.007
Chromium	3.76-6.56	5.81±0.60	3.76-6.56	5.46±0.97	3.28-5.88	4.63±0.87	0.091
Iron	48.40-87.40	64.27±13.55	22.40-55.40	38.87±8.54	24.36-51.40	37.26±9.71	<0.001
Potassium	17.8-30.1	22.6±4.50	158.0-19.30	16.95±1.25	17.0-18.7	14.9±4.83	<0.001
Magnesium	59.8-94.2	60.99±10.1	100.1-95.3	58.1±4.06	100-98.2	57.3±3.47	<0.001
Manganese	1.34-3.16	2.14±0.60	1.50-1.62	1.81±0.08	1.21-1.10	1.01±0.04	<0.001
Sodium	19.37-77.91	69.01±7.66	1.45-4.26	38.75±11.68	65.74-23.27	27.85±6.54	<0.001
Vanadium	1.17-8.49	3.79±1.66	2.76-4.36	3.48±0.45	1.46-6.56	2.56±1.02	<0.001
Zinc	3.16-5.24	3.70±0.61	2.77-4.36	3.66±2.06	3.08-4.96	3.49±0.54	0.636
Phosphate	20.30-31.90	30.26±2.37	25.55-32.05	28.63±2.06	21.50-30.01	26.03±3.41	<0.001
Nitrate	39.90-48.80	49.98±3.12	39.90-48.80	36.60±0.60	18.97-35.01	25.08 ±2.76	<0.001

SD= Standard Deviation; n= Number of Samples; *F* = test of significance; *P*= Probability

Table 3 Effect of processing on elements concentration from techiman using analysis of variance (ANOVA)

Name of Element	Freeze Dry Freeze dry		Air dry		Oven dry		
	Range n=10	Mean ± SD	Range n=10	Mean ± SD	Range n=10	Mean ± SD	*P*-value
Aluminum	1.45-9.60	5.38±2.73	3.75-6.45	3.39±0.86	1.07-8.45	3.19 ± 1.54	0.087
Bromine	28.00-52.45	37.90±7.59	16.20-47.46	34.56±9.13	3.17-32.9 0	23.46±7.41	0.006
Calcium	132.0-97.70	40.40±3.42	100.0-87.40	35.39±2.57	136-371	20.9± 1.49	0.254
Chlorine	1.48-6.25	5.64±3.34	1.91-3.85	2.68±0.56	1.00-9.47	2.61±1.17	0.661
Copper	1.48-6.25	3.88±0.24	2.00-4.44	3.82±0.72	3.28-4.20	3.34±0.59	0.921
Chromium	2.56-10.68	5.46±0.97	2.60-5.96	4.44±2.40	3.76-6.56	4.02±1.06	0.494
Iron	39.37-98.40	74.93±7.09	39.37-98.40	73.77±16.73	22.40-55.40	38.87±8.54	0.125
Potassium	23.20-33.70	26.98±1.55	17.40-26.20	25.22±7.91	158.0-19.30	16.95±1.25	0.155
Magnesium	48.60-74.60	60.99±6.75	95.3-100.1	57.30±4.06	32.00-81.80	36.14±2.72	0.027
Manganese	2.00-2.26	2.00±0.08	1.88-2.18	1.81±0.04	1.50-1.65	1.12±0.08	0.069
Sodium	23.05-89.55	40.81±20.97	1.45-4.26	38.75±11.68	20.25-53.26	33.42± 5.96	0.215
Vanadium	1.17-8.49	6.19±2.61	1.12-6.47	3.69±1.69	2.76-4.36	3.48±0.45	0.002
Zinc	10.48-37.64	19.80±9.85	2.52-5.08	3.88±0.72	2.77-4.36	3.66±2.06	<0.001
Phosphate	58.15-66.75	61.62±2.22	30.33-40.31	35.68±2.72	25.55-32.05	28.63±2.06	<0.001
Nitrate	49.80-55.00	51.36±1.49	41.51-51.45	49.28±2.21	39.90-48.80	36.60±0.60	<0.001

SD= Standard Deviation; n= Number of Samples; *F* = test of significance; *P*= Probability

4 Conclusion and Recommendation

The study clearly shows processed *Moringa* contains different kinds of nutrients that can be utilised to improve good health and nutrition. However, freeze drying recorded higher concentrations of element, followed by air drying and oven drying respectively. Air drying could be the preferred drying method since it is economical.

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