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EFFECT OF BOILING TIME AND SUN DRYING ON THE NUTRIENT COMPOSITION OF MORINGA OLEIFERA LEAF POWDER

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Equal quantities of Moringa leaves were boiled for varying length of time - 2½ min (2½ BSU), 5 min (5 BSU), 7½ min (7½ BSU) and 10 min (10 BSU) at 100 °C and sun dried (32 °C±1) for two days. Fresh moringa leaves (FRESH) and unboiled sun dried leaves (SU) served as controls. The dried samples were milled, sieved and used for analyses. The crude protein content decreased ($p<0.05$) from 28.64% for SU to 27.06% for 10BSU with boiling time. The ash content of the dried samples also decreased (10.54%-8.50%) with boiling time. Boiling time also had a significant ($p<0.05$) negative effect on the crude fibre content (8.20%-2.20%) of the MLP samples. The FRESH had lower ($p<0.05$) values for all the proximate composition. All the vitamins determined decreased with boiling time except for vitamin B1. Vitamin A content decreased from 18.64 mg/100 g to 18.00 mg/100 g for SU and 10 BSU. Vitamin C content reduced from 22.50 mg/100 g to 5.28 mg/100 g while vitamin B1 content increased from 1.46 mg/100 g to 1.96 mg/100 g. All the minerals determined decreased ($p<0.05$) with boiling time. Iron and zinc contents decreased from 16.47 mg/100 g to 15.13 mg/100 g, 31.52 mg/100 g to 26.03 mg/100 g respectively. The fresh sampled had lower ($p<0.05$) values for all the minerals determined.

Keywords: Moringa leaf powder, Sun drying, Boiling, Nutrient

INTRODUCTION

Moringa oleifera Lam is a native of eastern India but now found throughout the semi-arid tropics. *Moringa oleifera* is a small, fast-growing evergreen or deciduous tree that usually grow up to 10 to 12 m in its height, it belongs to the family Moringaceae (Ramachandran *et al*., 1980; and Morton, 1991). It is a perennial, erect, slender and medium sized with many arching branches. The tree has been said to grow well in the humid tropics or hot dry lands, can survive destitute soils, and is little affected by drought (Morton, 1991). It is widely cultivated and naturalized in tropical India, Africa, tropical America, Sri lanka, Mexico, Malaysia and the Philippine Islands (Sabale *et al.,* 2008) The moringa tree is cultivated and the various plant parts such as leaves, pods, flowers, roasted seeds are used as vegetables, roots mainly for spice, seeds for cooking and cosmetics oil; all plant organs are used in medicine (Rebecca *et al.,* 2006).

Moringa leaves are consumed in different parts of the world both as food and as medicine. The leaves of this plant are used as vegetables in soup preparation or cooked and mixed with grounded groundnut cake and other spices, and then eaten as food (Kawo *et al.,* 2009). In Nigeria, moringa leaves are used in soup preparation especially in the dry season when there is scarcity of other more popular vegetables. The leaves are also utilized in folk medicine in the treatment of various ailments like treating of wounds, stabilizing blood pressure and blood sugar. Moringa leaves have been described to be rich in both nutrients and phytochemicals. It has been reported that dried mornga

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leaves contains as much as 30% protein with all of the nine essential amino acids present in various amounts (Makkar and Becker, 1997). Moringa leaf is also rich in iron, calcium and vitamin A. Fahey (2005) described moringa as a plant food of high nutritional value, ecologically and economically beneficial, readily available and therefore of great benefit in places where starvation is eminent.

Vegetables undergo post-harvest treatments such as boiling and drying in order to cook them, extend their shelf life and preserve them as well as to ensure safety and wholesomeness (Edward, 2001; and Oboh, 2003). Such treatments however, have been reported to cause changes in their nutritive and nonnutritive chemical constituents leading to losses of these constituents (Ramberg and Mc Analley, 2002; and Morris *et al.*, 2004). It becomes necessary therefore to study the effect of some processing methods on the nutritional composition of vegetables in order to know the best method that will achieve minimal loss. The objective of this present study therefore was to determine the effect of boiling time and sun drying on the nutrient composition of moringa leaf powder.

MATERIALS AND METHODS

Moringa Leaf Powder Preparation

The moringa leaves were collected from a farmyard in Gboko, Benue State, Nigeria. The leaves were stripped, washed thoroughly with clean water and allowed to drain. The leaves were divided into 6 equal lots of 500 g each. One lot was left fresh and analyzed immediately. Four portions were boiled with equal volume of water (500 ml) at 100 ^{o}C for 2½ min (2½ BSU), 5 min (5 BSU), 7½ min (7½ BSU) and 10 min (10 BSU) respectively. The boiled leaves were drained and then spread thinly on aluminum trays to dry in the sun (32 ^{o}C ± 1) for 2 days. The sixth lot was sun dried without any boiling treatment. The dried leaves where ground (hammer mill, Thomas Willey mills, model Ed-5, Germany) sieved with a screen of 2 mm pore size, placed in amber coloured glass containers and stored in the refrigerator (-4 ^{o}C) for anlaysis.

Proximate Composition

Moringa leaf powder was analyzed for its proximate contents using the AOAC (2005) method. The moisture content was determined by air-oven drying at 105 °C for 8 hrs, and the crude protein contents by microKjeldah method. The lipid content was determined using petroleum ether (bp. 60-80 °C) in a soxhlet extraction apparatus and crude fiber content by dilute acid and alkali hydrolysis. Carbohydrate contents were calculated by difference of total contents from 100.

Vitamin A Determination

Vitamin A was determined using the method by Alexander and Griffiths (1993). A 1 g sample was weighed into a beaker and macerated with 10 ml mixture of acetone and n-hexane (1:1) and filtered. 10 ml of 50% $(NH_4)_2SO_4$ solution was added, vigorously shaken and allowed to settle. Then the upper layer was collected and the absorbance read in Spectrophotometer (Spectro21D, Pec Medicals, USA) at 450 nm against hexane as blank betacarotene served as standard. Retinol equivalent was obtained by the conversion factor: 1 μg retinol equal to 12 μg of dietary beta-carotene.

Vitamin C Determination

Vitamin C was determined using the 2, 6-dichlorophenolindophenol dye method described by Jones and Hughes (1983). The ascorbic acid of both the fresh and dried sales were extracted by grinding 1 g of each sample in a hammer mill (Thomas Willey mills, model Ed-5, Germany) with a small amount of sand and 6% metaphosphoric acid (v/v) each extract was made up accurately to 15 ml, mixed and centrifuged (Gallenhamp centrifuge, England) at 3000 g for 15 min at room temperature. Five milliliters of the supernatant was titrated against standard 2, 6-dichlorophenolindophenol dye (1 mL = 0.2 g of ascorbic acid), the dye had been previously standardized by titration against a 0.02% standard solution of ascorbic acid in 6% metaphosphoric acid.

Determination of Vitamin E

This was determined using the method described by Pearson (1976). One gram of each sample was mascerated with 20 ml of ethanol and then filtered.ome mililitre of the filterate was taken and to it was added 1 ml of 0.2% ferric chloride in ethanol, I ml of alcoholic 0.5% α-diphyrildyl and made up to 5 ml with ethanol. Absorbance was taken at 520 (Spectro21D, Pec Medicals, USA) nm using α-tocopherol as standard.

Determination of Vitamin B_1 Content

This was determined by the method of Snell and Snell (1962). Extraction with 20 ml distilled water was done on 0.5 g of each sample and 15 ml of isobutyl alcohol was added. This was followed by shaking slowly for 20 min. the isobutyl alcohol layer was separated with a separating funnel, collected and dried by adding with shaking a spatula tip of

anhydrous sodium sulphate. Absorbance was read at 369 nm with a spectrophotometer (Spectro21D, Pec Medicals, USA).

Determination of Vitamin B_3 Content

This was determined by the method described by Snell and Snell (1962). A 0.0 g weight of the sample was extracted with 20 ml distilled water, thereafter 1 ml aliquot was collected and mixed with 6.5 ml distilled water, 0.5 ml of ammonia, 1 ml cyanogen bromide, 1 ml sulphonilic acid and 0.5 ml of concentrated HCl. This was made up to 10 ml with distilled water and then absorbance (Spectro21D, Pec Medicals, USA) was taken at 430 nm using nicotinic acid as standard.

Deterination of Mineral Content

Mineral composition was determined using the Atomic Absorption Spectrophotometer (AAS) (UNICAM 960 series) as described by AOAC (2005).

Statistical Analysis

The obtained data were analyzed using one-way analysis of variance (ANOVA) and the significant differences between means were determined by post hoc Duncan's multiple range test. Differences were considered to be significant when $p<0.05$. Data were analysed using SPSS package.

RESULTS AND DISCUSSION

Effect of Boiling Time and Sun Drying on the Proximate Composition (%) of Moringa Leaf Powder

Table 1 above shows the effect of boiling time and sun drying on the proximate composition of Moringa Leaf Powder (MLP). It could be observed that both boiling time and drying had significant ($p<0.05$) effects on the proximate composition of the vegetable. The moisture content of the fresh leaves was highest (84.8%). The protein content of the fresh samples (2.16%) was the less than for the sun dried samples which ranged from 27.06% for 10 min to 28.64% for SU. Reduction in moisture contents resulted in corresponding increases in dry matter contents due to concentration of soluble solids. The protein content of fresh moringa leaves obtained in this study was lower than those obtained by Yang *et al.* (2006), who obtained a value of 5.7%. The discrepancy could have been due to higher moisture content of the studied samples 84.8% against 75% obtained by Yang *et al.* (2007). Differences in agro-climatic conditions and/or differences in maturity level of the leaves used for the studies could also have contributed to the observed discrepancy (Foidl *et al.*, 2001). The protein content of the sun dried sample (SU) is similar with the results of previous researchers. Oduro *et al.* (2008) reported 27.51% protein content on dry matter basis. Foidl *et al.* (2001) obtained values of 25.1%-29% for leaves from different countries while Makkar and Becker (1997) got 26%. The protein content of dried moringa leaves is higher than for most vegetables for instance, *Amaranthus caudatus* (20.59%) (Etuk *et al.*, 1998), cassava leaves (*Manihot utilisima*) contained 24.88% protein. *Vitex doniana* ("Uchakoro") had 5.12% (Nnamani *et al.*, 2009) but lower than *Piper Guineeses* 29.78% and *Talinum triangulare* 31.00% (Akindahunsi and Salawu, 2005). Sweet potatoe leaves contained between 16.78%-25.39% crude protein (Oduro, 2008).

The significantly ($p<0.05$) lower protein content of the boiled samples in relation to the unboiled sundried sample could have been due to leaching of some protein into cooking water. Boiling time did not however have any significant ($p<0.05$) effect on protein content of the samples except for 2½ SU minute boiled that had higher value probably as a result of lower resident time in water resulting to minimal leaching. The fat content of all the samples varied significantly with fresh leaves having the least fat content (0.53%). With drying however, the fat content significantly increased (1.77%) possibly as a result of concentration due to drying. Boiling had a significantly ($p<0.05$) lowering effect on fat content and this could be as a result of leaching into boiling water. All the boiled and sun dried samples did not show any significant variation in fat content. The fat content observed in this study is lower than that (5.2%-6.5%) recorded by Foidl *et al.* (2001). Variations in agro-climatic conditions, different ages of the trees and differences in maturity of leaves could be the cause of this disparity. The value of the crude fat for the fresh leaves is low when compared to those of *Talinum triangulare* (5.90%), *Baseila alba* (8.71%), *Amaranthus hybridus* (4.80%), *Calchorus africanum* (4.20%) (Ifon and Bassir, 1979; and Akindahunsi and Salawu, 2005).

The result of the ash content showed that boiling and sun drying has significant ($p<0.05$) effect on the samples. The fresh sample had the least value of 1.67%, with drying however the ash content of the other samples increased. The sun dried sample had ash content of 10.54% while the boiled and dried samples had ash

Table 1: Effect of Boiling Time and Sun Drying on the Proximate Composition (%) of Moringa Leaf Powder

Sample	Moisture	Crude Protein	Ether Extract	Ash	Crude Fibre	Carbohydrates
Fresh	84.8^{a} ±0.15	2.16^{e} ± 0.11	0.53^{d} ±0.007	1.65^{e} ±0.31	1.15^{e} ±0.21	10.86^{ed} 0.41
SU	7.00^{d} ±0.85	28.64^{a} ± 0.16	1.77^{a} ±0.03	10.54^{a} ±0.26	8.20^{a} ±0.14	52.05^{c} ±0.72
2½ BSU	8.2^{b} ±0.28	27.76^{b} ±0.13	1.27^{b} ±0.11	9.05^{b} ±0.21	2.85^{b} ±0.07	53.72^{b} ±0.48
5 BSU	8.1^{b} ±0.14	27.13^{d} ±0.05	1.17^{bc} ±0.10	8.93^{c} ±0.04	2.20^{d} ±0.28	54.67^{ab} ±0.04
7½ BSU	7.5^{c} ±0.14	27.20^{c} ±0.03	1.22^{b} ±0.03	8.50^{d} ±0.28	2.30^{c} ±0.28	55.58^{a} ±0.48
10 BSU	7.5^{c} ±0.28	27.06^{d} ±0.03	1.26^{b} ±0.04	8.50^{d} ±0.00	2.30^{c} ±0.14	55.68^{a} ±a0.30

Note: Fresh - fresh moringa leaf, SH - unboiled shade dried, SU - unboiled sun dried, 2½ BSU - moringa leaf boiled for 2½ min and sun dried, 5 BSU - moringa leaf boiled for 5 min and sun dried, 7½ BSU - moringa leaf boiled for 7½ min and sun dried, 10 BSU - moringa leaf boiled for 10 min and sun dried. Values on the same column bearing different superscripts are significantly different ($p \leq 0.05$).

content ranging from 8.50-9.05%. The significant decrease in ash content as a result of boiling could be attributed to leaching of some mineral content into the cooking water. The ash content of fresh leaves was lower than the value of 2.3 g/100 g obtained by Duke (1983). The ash content of fresh moringa leaves is lower than 6.3% reported for *Ipomoea aquatic* and 4.95% for *Ficus infectoria* (Gupta1and Yadav, 2016). The crude fibre content of the samples varied significantly ($p<0.05$) with treatment. Expectedly, the fresh samples had the least value of 1.15%. Duke (1983) observed a similar value of 0.9% for fresh samples. All the boiled and dried samples had lower ($p<0.05$) fibre content (2.20%-2.85%) than the unboiled sun dried samples 8.20%. This loss could be as a result of leaching into boiling water. Some studies have also suggested that heat processing can change the solubility and other physicochemical properties of fiber (Kunzek *et al.*, 1999). The values obtained for the dried leaves were below that obtained by Fuglie (2001) and Oduro *et al.* (2008) who reported values of 19.2% and 19.25% respectively. The crude fibre of moringa leaf powder obtained in the present study is higher than those for *Talinum triangulare* (6.20%), *Piper guineeses* (6.40%), *Corchorus olitorius* (7.0%), bitter leaves (*Vernonia amygdalina),* 6.5% (Akindahunsi and Salawu, 2005).

The carbohydrate content of the samples varied from 10.67% for fresh leaves to 55.68% for 10 BSU. These values are inconsistent with those obtained by Fuglie (2001), 13.4% and 38.2% respectively. The reason for the difference is attributed to differences in the values of the other proximate constituents. The general reduction of nutrients due to boiling is consistent with the finding of Lisiewka and Kmicik (1996) who observed that blanching reduced the dry matter content of broccoli and cauliflower.

From the foregoing, it could be concluded the Moringa Leaf Powder (MLP) is a rich source of protein, ash and crude fibre. Consumption of 100 g of Moringa leaf powder may therefore be capable of providing 27 g of protein which satisfies the recommended daily allowance of protein for children (FAO, 1986). The high ash content implies that MLP is rich in minerals. This is significant since the prevalence rate of both protein energy and mirconutrient malnutrition (especially iron and zinc) remain high with devastating consequences for health and productivity. In Africa, people have always depended on traditional leafy vegetables to meet their nutritional needs. The vegetables represent cheap but quality nutrition for large segments of the populations in both urban and rural areas. Consumption of moringa leaf powder could therefore provide a more affordable, more easily available therefore a more sustainable option for the alleviation of these health problems. The high fiber content implies that MLP could also be useful in reducing cholesterol (Ballesteros *et al.*, 2001), reducing blood pressure (Osilesi *et al.*, 1991) improving colon function and helping to protect against heart disease and cancer (Rao, 2003). The low fat content of the leaves are beneficial to health for according to Antia *et al.* (2006), a diet providing 1-2% of its caloric of energy as fat is said to be sufficient to human beings as excess fat consumption is implicated in certain cardiovascular disorders such as atherosclerosis, cancer and aging. Most of these nutrients were however negatively affected by processing.

The Effect of Boiling Time and Sun Drying on the Vitamin (mg/100 g) Composition of MLP

Table 2 shows the results of the effect of boiling time and sun drying on the vitamin composition of MLP. The vitamin A, C, B_1, B_3 and E content of the fresh vegetable were 13.60 mg/100 g, 5.24 mg/100 g, 1.87 mg/100 g, 3.16 mg/100 g, 6.01 mg/100 g and 6.10 mg/100 g and all these values were significantly lower than values for the processed vegetables except for vitamin B_1. All the treatments resulted in significant variations in the vitamin content of the samples. The vitamin A content of this vegetable was significantly elevated by sun drying (18.64 mg/100 g). The value decreased with boiling time from 18.64 mg/100 g to 18.00 mg/100 g. A similar trend was also observed for vitamin C, the boiled and sun dried sampled depreciated in value from 22.50 mg/100 g to 5.28 mg/100 g.

The fresh leaves contained significantly more vitamin B_1 than the sun dried. This means that the drying process had a profound negative effect on the vitamin. The vitamin B_1 values for the boiled and sun dried samplesreducedd from 1.46 mg/100 g to 1.96 mg/100 g. The value of vitamin B_1 increased ($p<0.05$) with boiling time Drying of fresh leaves led to significant improvement of the vitamin B_3 value of the vegetables. This could have been due to concentration. A steady decrease in this vitamin was observed with increase in boiling time for the sun dried ones (167.45.00 mg/100 g to 84.15 mg/100 g). The vitamin E value of the fresh samples were significantly ($p<0.05$) lower than those of the treated sample. There was a steady decline of this vitamin with increase in boiling time (77.95 to 64.45 mg/100 g). The increase in the vitamins in the dehydrated samples in relation to the fresh with the exception of vitamin B_1 observed in this study is in agreement with the observation of Morris *et al.* (2004) who reported that generally, except for thiamine (vitamin B_1), removal of moisture results in increased concentration of nutrients. Fuglie (1998) reported that the vitamin A content of fresh and shade dried vegetable were 6.80 mg/100 g and 16.3 mg/100 g, for vitamin B_1 he had 0.21 mg/100 g and 2.64 mg/100 g. The discrepancy between his values and those obtained in this study may have been due to differences in both drying methods and agro-climatic conditions. Loss of vitamin as a result of processing has been observed by other researchers. They recorded losses up to 70% and even more for ascorbic acid in cooked vegetables (Bassir and Umoh, 1977) 11%-66% loss in thiamine (Rumm-Kreuter and Demmel, 1990). The high solubility of ascorbic acid in water and the relative ease with which it is oxidized makes this vitamin particularly susceptible to processing conditions (Franke *et al*., 2004). High retention of certain components, such as vitamin E in vegetables, has been reported during processing, storage and cooking (Korus, 2002).

The Effect of Boiling Time and Sun Drying on the Mineral Composition (mg/100 g) of Moringa Leaf Powder

The Table 3 shows the effect of boiling time on the mineral composition of sun dried moringa leaf powder. The processing methods had significant effect ($p<0.05$) on the mineral values of the samples. The iron content of the processed MLP ranged from 15.13 mg/100 g to 16.47 mg/100 g for 10 BSU and SU respectively. The zinc content of the

Table 2: Effect of Boiling Time and Sun Drying on the Vitamin Composition (mg/100 g) of Moringa Leaf Powder

Sample	Vitamin A (mgRE)	Vitamin C	Vitamin B_1	Vitamin B_3	Vitamin E
Fresh	$13.60^{f}\pm0.14$	$5.24^{e}\pm0.03$	$1.87^{c}\pm0.11$	$32.13^{f}\pm0.30$	$6.10^{i}\pm0.14$
SU	$18.64^{a}\pm0.42$	$22.50^{a}\pm0.71$	$1.46^{e}\pm0.001$	$167.45^{a}\pm0.60$	$78.00^{a}\pm0.23$
2½ BSU	$18.60^{a}\pm0.28$	$11.75^{b}\pm0.71$	$1.45^{e}\pm0.002$	$100.00^{b}\pm.60$	$77.95^{a}\pm00.7$
5 BSU	$18.53^{a}\pm0.23$	$11.50^{c}\pm0.14$	$1.62^{d}\pm0.025$	$94.68^{c}\pm0.30$	$71.90^{d}\pm0.14$
7½ BSU	$18.40^{b}\pm0.14$	$11.00^{d}\pm0.57$	$1.83^{bc}\pm0.003$	$91.06^{d}\pm1.20$	$69.55^{e}\pm0.35$
10 BSU	$18.00^{c}\pm0.00$	$5.28^{e}\pm0.04$	$1.96^{a}\pm0.018$	$84.15^{e}\pm0.15$	$64.45^{g}\pm0.21$

Note: Fresh - fresh moringa leaf, SH - unboiled shade dried, SU - unboiled sun dried, 2½ BSU - moringa leaf boiled for 2½ min and sun dried, 5 BSU - moringa leaf boiled for 5 min and sun dried, 7½ BSU - moringa leaf boiled for 7½ min and sun dried, 10 BSU - moringa leaf boiled for 10 min and sun dried. Values on the same column bearing different superscripts are significantly different ($p\leq0.05$). mgRE = mg retinol equivalent.

Table 3: Effect of Boiling Time and Sun Drying on the Vitamin Composition (mg/100 g) of Moringa Leaf Powder

Sample	Fe	Zn	Mg	Cu	Na
Fresh	1.98^{d}±0.04	6.01^{d}±0.62	1.71^{d}±0.06	NE	NE
SU	16.47^{a}±1.43	31.52^{a}±2.11	29.77^{a}±1.42	0.166^{b}±0.01	39.58^{a}±2.07
2½ BSU	16.14^{a}±1.37	27.05^{b}±1.53	23.26^{b}±1.19	0.06^{b}±0.03	23.33^{b}±1.64
5 BSU	16.00^{b}±1.22	27.00^{b}±1.81	21.19^{c}±1.16	0.06^{b}±0.002	22.98^{b}±1.63
7½ BSU	15.63^{bc}±1.61	27.00^{b}±1.34	20.45^{c}±1.54	0.06^{b}±0.001	22.34^{b}±1.27
10 BSU	15.13^{c}±1.18	26.03^{c}±1.72	20.23^{c}±1.38	0.06^{b}±0.002	21.33^{c}±1.52

Note: Fresh - fresh moringa leaf, SH - unboiled shade dried, SU - unboiled sun dried, 2½ BSU - moringa leaf boiled for 2½ min and sun dried, 5 BSU - moringa leaf boiled for 5 min and sun dried, 7½ BSU - moringa leaf boiled for 7½ min and sun dried, 10 BSU - moringa leaf boiled for 10 min and sun dried. Values on the same column bearing different superscripts are significantly different ($p \leq 0.05$). NE-not evaluated.

processed samples ranged from 26.03 mg/100 g to 31.52 mg/100 g, while the magnesium content varied from 20.23 mg/100 g to 29.77 mg/100 g. The sodium value of the samples was from 21.33 mg/100 g to 39.58 mg/100 g for 10 BSU and SU respectively. The values of all the minerals decreased with increasing boiling time. This trend could be attributed to leaching effect. Mepba *et al*. (2007) also observed a reduction in mineral content of vegetables due to blanching and cooking. The iron content of dried MLP is lower than the values (20.58 mg/100 g to 33.79 mg/100 g) reported by Jongrungruangchok *et al*. (2010). The iron content of fresh leaves is higher than that reported for some other vegetables. Chauhan *et al*. (2014) reported iron content of 0.012 mg/100 g for *Andrographis paniculata* and 0.034 mg/100 g for *Boerhaavia diffusa*. MLP could therefore be described as a good source of iron, zinc, magnesium and sodium. Despite boiling and drying MLP could be said to contain a substantial amount of iron and zinc. This is significant because the prevalence iron deficiency anaemia in Africa is raising public health concern. According to WHO (2008), 67.6% of preschool aged children and 57.1% of all pregnant women in Africa are suffering from iron deficiency anaemia. Since the major driver of anaemia in the developing countries is poverty, the result of this study highlights the potential of MLP as an affordable and easily available resource for alleviating IDA and zinc deficiency.

CONCLUSION

Sun dried moringa leaf powder is a rich source of essential nutrients like protein, vitamin A, iron and zinc and so it could serve as a more affordable source of these nutrients in the developing countries. These nutrients are however affected by boiling and drying. In contrast to sun drying, boiling led to significant reduction in the content of the nutrients. This implies that to get the maximum benefit from moringa leaves care must be taken not to cook for a long period of time and to use as little water as possible when cooking the vegetables in order to conserve these nutrients. Sun drying method which is cheap and abundantly available in most of the African countries showed to be a good method of concentrating the nutrients of moringa leaves.

It is therefore recommended that nutritional education should be undertaken to teach the rural women on the best method of processing these leaves and to promote the utilization and consumption of this nutrient dense resource. Further studies on the effect of other methods of drying and cooking on the nutrient composition of moringa leaves is also advocated.

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