Current Journal of Applied Science and Technology

31(5): 1-10, 2018; Article no.CJAST.45645
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Mineral and Trace Element Content in Different Parts of *Moringa oleifera* Grown in Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/45645
Editor(s):
(1) Dr. Teresa De Pilli, Assistant Professor, Department of Science of Agriculture of Food of Environment (SAFE), University of Foggia, Via Napoli, Italy.
Reviewers:
(1) K. D. Mini, MG University, India.
(2) Phyu Phyu Myint, University of Yangon, Myanmar.
Complete Peer review History: http://www.sciencedomain.org/review-history/27766

Original Research Article

Received 15 September 2018
Accepted 29 November 2018
Published 16 December 2018

ABSTRACT

Mineral concentration and trace element content in leaves (tender and matured), flowers and pods of *M. oleifera* grown in Bangladesh was investigated. Atomic Absorption Spectroscopy and UV visible spectroscopy methods were used for this analysis. Content of some of the essential elements such as Ca, Fe, P, Mn, Zn, Cr were found to be present in good amount. On the other hand trace elements Pb, Cd, Cr, and Ni were not detected and Arsenic was found to be present below the toxic limit. Ca is found positively but insignificantly correlated with Mn (r=0.402) and Zn (r=0.435) but negatively and significantly correlated with P (r= -0.697). Mn is positively but insignificantly correlated with Ca (r=0.402). However, Mn is also significantly correlated with Fe (r=0.842) and Zn (r=0.625) which indicates that the percentage of Mn, Fe and Zn in *M. oleifera* are significantly dependent on each other. Fe and Zn do not show any significant correlation with other observed metals. P is found insignificant and negatively correlated with Mn. The result of this study revealed that all the parts of *M. oleifera* is a good source of nutritionally important essential elements Ca, P, Mn, Zn and Cr, and, the leaves and flowers might be the potential sources of Fe supplements for human and livestock.

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Keywords: Moringa oleifera; leaves; pods; flowers; minerals; trace elements.

1. INTRODUCTION

Moringa oleifera is the most commonly cultivated species in the monogeneric family Moringaceae [1]. It is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan [2]. According to Oluduro [3] all parts of the *Moringa* tree are edible and have long been consumed by humans. Moringa plant contains a significant amount of nutrients such as protein, fibre and minerals [1,4,5]. It is a good source of vitamin C and phenolic antioxidants [6,7,8].

Minerals are essential in animal feed and human nutrition. Minerals cannot be synthesized by animals and humans but are provided from plants or mineral-rich water [9]. In many developing countries, the supply of minerals is inadequate to meet the mineral requirements of farm animals and a rapidly growing population [10]. Minerals and trace elements determination is important to enhance the production efficiency in plants and foods [11]. Some of the elements, which include iron, manganese, zinc and copper, are essential micronutrients with a variety of biochemical functions in all living organisms [12]. Different elements have many functions in plant growth and development. Metal ions, including iron, zinc and copper, are required for catalytic and structural properties of many proteins and therefore essential for growth and development of all organisms. Essential elements also play a main role in nerve transmission, blood circulation, cellular integrity, energy production and muscle contraction [13]. However, excessive amounts of these metals, or of non-essential metals such as cadmium (Cd) and lead (Pb), are toxic and inhibit plant growth [14]. In past few years research on trace element distribution in medicinal plants becomes important [15, 16]. Trace elements are essential for human health and they prevent several diseases, but when these elements are in high concentration they are dangerous. The atomic absorption spectroscopy (AAS) is an important method for the detection of trace elements [17,18]. Several works have been done, reporting the levels of nutrients, including minerals in *M. oleifera,* with emphasis on variations in the levels as a function of geographical locations where the plant is grown and the results showed that there could be variations in the levels of macro and micro mineral elements in the plant, depending on the soil properties of the geographical locations where it grow [10]. The environmental impact of these metals, as well as their health effects, has been a source of major concern. Their accumulation in plants highly depends on the availability in the soil [19]. Cultivation in soils containing high concentrations of heavy metals is one mechanism by which heavy metal contamination of herbal products has been documented [20]. Medicinal plants have been reported as a potential source of heavy metal toxicity to both man and animals [21]. In Bangladesh *M. oleifera* is widely cultivated in different areas of the country. However, no as such research is found on *M. oleifera* allowing evaluation of elemental concentration for different edible parts of *M. oleifera*. The aim of the present research was to make a study for evaluation of mineral concentration and trace elements content in tender leaves, matured leaves, flowers and pods of *M. oleifera* grown in Dhaka, Bangladesh. Elements found were major element (Ca) and minor elements (Zn, Fe, Mn, Cr, P, Ni, Pb, Cd, As). To the best of author's knowledge no as such comparative study among the tender leaves, matured leaves, flowers and pods of *M. oleifera* has been done earlier and the elemental composition of flowers of this plant is yet to be explored.

2. MATERIALS AND METHODS

2.1 Collection of Plant Material

M. oleifera samples (tender leaves, matured leaves, flowers and pods) were collected from six different plants grown in Dhaka, Bangladesh. The collected *M. oleifera* samples were cleaned to remove dirt and other impurities. Six trees were designated as T_1, T_2, T_3, T_4, T_5 and T_6. On the other hand MOTL, MOML, MOF and MOP means *M. oleifera* tender leaves, *M. oleifera* matured leaves *M. oleifera* flowers and *M. oleifera* pods respectively.

2.2 Drying and Storage of the Plant Material

The plant materials were separated from each other manually. All the plant parts were air dried separately under the shade for one week or longer till a constant weight was achieved. The plant materials were crushed by mixer grinder. The leaves (tender and matured), flower and pods were grinded separately in to powder form and immediately stored in air tight container until use.

2.3 Estimation of Moisture and Ash Contents

Moisture and ash contents, of the plant parts were determined by the ASTM method [22].

2.4 Estimation of Mineral Contents

All plant parts were digested by Microwave digestion system. Application note: HPR-AG-02, Milestone, Model: SK10TP. Determination of phosphorus content was done by UV visible spectroscopy (Analytikjena, Specord 205). On the other hand Ca, Mn, Fe, Zn, Ni, Pb, Cd, Cr and As were determined by atomic absorption spectroscopy (AAS) (Shimadzu, AA-7000).

2.5 Data Analysis

All the experiments were carried out in triplicates and results presented as mean ± standard deviation (SD). Correlation of the obtained data was done by 22 IBM SPSS software.

3. RESULTS AND DISCUSSION

3.1 Ash Content of Different parts of *M. oleifera*

Ash content of tender leaves, matured leaves, flowers and pods of six *M. oleifera* plants were done with three independent replicates and the data are presented as mean standard deviation (Table 1). The range of ash contents of the leaves (tender and matured) was found to be 7.36±0.30 to 8.56±0.31% and 8.39±0.35 to 12.23±0.36% respectively. On the other hand that of flowers and pods was ranged from 7.80±0.34 to 9.00±0.32% and 7.45±0.33 to 8.90±0.30% respectively. A number of elements important to nutrition are accumulated in plants.

The ash content in different parts of *M. oleifera* during this study was found to be within the WHO standard range (9±7.45%) [23]. High ash content in food is a calculate of high deposit of mineral contents [24].The ash value obtained in this study (Table 1) suggests that the leaves (tender and matured), pods and flowers of *M. oleifera* are a good source of inorganic minerals.

3.2 Mineral and Trace Elements Content

During the present research all the ashes obtained from different parts of *M. oleifera* were analysed for Ca, Mn, Fe, Zn, P, As, Ni, Pb, Cd and Cr.

Table-2 shows the concentration of Calcium (Ca) content in the tender and matured leaves of six *M. oleifera* plants which found to be ranged from 1816.99±1.28 mg/kg to 2363.51±1.27 mg/kg and 4288.32±1.27 mg/kg to 4932.60±0.96 mg/kg respectively. On the other hand in flowers and pods Ca was found to be present within the range 1142.78±0.96 mg/kg to 1560.34±1.27 mg/kg and 941.23±0.83 mg/kg to 1134.68±0.83 mg/kg respectively.

Table 1. Ash content in % level in different plant parts of *M. oleifera* samples

Plants	MOTL	MOML	MOF	MOP
T_1	8.56±0.31	10.64±0.31	8.50±0.31	8.12±0.35
T_2	7.93±0.35	9.82±0.34	9.00±0.32	7.45±0.33
T_3	7.64±0.31	8.39±0.35	8.04±0.35	8.90±0.30
T_4	8.45±0.34	12.23±0.36	9.30±0.33	8.23±0.32
T_5	7.68±0.30	10.68±0.34	7.80±0.34	7.93±0.34
T_6	7.36±0.30	11.00±0.36	8.70±0.31	7.50±0.32

T (1-6): Six different M. oleiferatrees, MOTL: M. oleifera tender leaves, MOML: M. oleifera matured leaves, MOF: M. oleifera flower, MOP: M. oleifera pods

Table 2. Calcium (Ca) content in mg/kg level in different plant parts of *M. oleifera*

Plants	MOTL	MOML	MOF	MOP
T_1	1816.99±1.28	4373.00±1.43	1142.78±0.96	941.23±0.83
T_2	2109.17±1.27	4932.60±0.96	1551.81±1.43	1001.08±0.95
T_3	1895.61±1.82	4717.55±1.27	1196.98±1.27	1101.69±0.96
T_4	2363.51±1.27	4913.53±0.94	1560.34±1.27	1122.64±0.94
T_5	2349.11±1.26	4665.45±1.27	1265.18±0.83	1134.68±0.83
T_6	2227.44±1.67	4288.32±1.27	1196.57±0.96	1069.40±0.96

T (1-6): Six different M. oleifera Trees, MOTL: M. oleifera tender leaves, MOML: M. oleifera matured leaves, MOF: M. oleifera flowers and MOP: M. oleifera pods

Calcium (Ca) is essential for every organism [25]. Lack of calcium ion in blood leads to a diversity of disease [26]. For human body Ca can be intake up to about 800 mg per day [27]. The present study revealed that all the parts of *M. oleifera* contained good amount of calcium (Table 2).Though Ca content in matured leaves and pods were found to be lower than the reported value [5] but it is found to be higher than the report of Jongrungchok and co-authors for matured leaves [1]. Till now no report is available for calcium content of *M. oleifera* flowers. Ca content in different parts of *M. oleifera* was found to be MOML>MOTL>MOF>MOP.

The concentrations of manganese (Mn) in the samples of *M. oleifera* tender and matured leaves were ranged from 22.47±0.83 mg/kg to 30.55±0.96 mg/kg and 31.11±0.47 mg/kg to 39.41±0.96 mg/kg respectively (Table 3). In flower and pods Mn contents were ranged from 39.50±0.96 mg/kg to 41.62±0.47 mg/kg and 10.05±0.96 mg/kg to 13.78±0.47 mg/kg respectively.

Manganese (Mn) activates many metalloenzymes like arginase, carboxylase, pyruvate; it works as co-factor in respiratory enzymes and provides resistance to disease. The estimated dietary intake of Mn in adults is 11 mg/day [26]. Though the Mn content in matured leaves and pods of present study were lower than the report of Aslam et al., (2005) but all the parts contained a good amount of Mn (Table 3). Among the four parts of *M. oleifera,* flowers found to contain highest amount of Mn (39.50±0.96 mg/kg to 41.62±0.47 mg/kg). Mn content in *M. oleifera* different parts was found to be MOF>MOML>MOTL>MOP.

The levels of Iron (Fe) in *M. oleifera* tender and matured leaves were ranged from 105.09±0.96 mg/kg to 272.13±0.96 mg/kg and 250.09±0.83 mg/kg to 310.37±1.27 mg/kg respectively (Table 4). Where as in flowers and pods its concentrations were ranged from 646.72± 1.43 mg/kg to 837.41±0.96 mg/kg and 33.05±0.96 mg/kg to 60.35±0.83 mg/kg respectively.

Iron (Fe) is necessary for the formation of hemoglobin iron and required in the process of cellular respiration in the human body [26]. Fe is also a necessary component of hemoglobin and myoglobin for oxygen transport and cellular processes of growth and division [28]. According to WHO report, around 600–700 million people worldwide are suffering from iron deficiency anemia, and the most of them are from developing countries [29]. The dietary limit of iron in the food is 10-60 mg per day [30]. Present study reveals that leaves and flowers contained high amount of Fe (Table 4), which indicating the leaves and flowers of Bangladeshi *M. oleifera* from Dhaka could be a potential source of Fe supplement for human and livestock. Fe content in different parts of *M. oleifera* was found to be MOF>MOTL>MOTL>MOP.

Table 3. Manganese (Mn) content in mg/kg level in different plant parts of *M. oleifera*

Plants	MOTL	MOML	MOF	MOP
T_1	22.47±0.83	37.56±0.48	41.62±0.47	13.78±0.47
T_2	24.32±0.96	33.60±0.95	41.35±0.83	11.38±0.96
T_3	23.03±0.47	35.44±0.83	40.67±0.47	10.12±0.83
T_4	23.04±0.96	31.11±0.47	40.92±0.83	12.89±0.47
T_5	30.55±0.96	35.01±0.83	39.50±0.96	10.05±0.96
T_6	28.14±0.83	39.41±0.96	40.52±0.83	12.54±0.47

T (1-6): Six different Trees, MOTL: M. oleifera tender leaves, MOML: M. oleifera matured leaves, MOF: M. oleifera flowers and MOP: M. oleifera pods

Table 4. Iron (Fe) content in mg/kglevel in different plant parts of *M. oleifera*

Plants	MOTL	MOML	MOF	MOP
T_1	251.22±1.26	286.98±0.94	646.72±1.43	60.35±0.83
T_2	105.09±0.96	250.09±0.83	699.10±1.27	33.05±0.96
T_3	268.18±1.26	254.99±1.26	837.41±0.96	34.95±0.96
T_4	181.92±1.28	292.52±0.94	700.45±1.27	40.34±1.26
T_5	207.7±1.43	310.37±1.27	700.53±1.43	43.68±0.83
T_6	272.13±0.96	294.40±0.96	691.63±0.96	48.60±0.96

T (1-6): Six different Trees, MOTL: M. oleifera tender leaves, MOML: M. oleifera matured leaves, MOF: M. oleifera flowers and MOP: M. oleifera pods

Table 5 shows the presence of Zinc (Zn) in different parts of *M. oleifera* plants. In tender and matured leaves of Zn was found to be present within the range of 42.31±01.27 mg/kg to 48.65±0.96 mg/kg and 42.51±0.83 mg/kg to 49.36±0.83 mg/kg respectively. On the other hand flowers and pods contained 41.84±0.83 mg/kg to 46.76 ±0.96 mg/kg and 35.44±0.96 mg/kg to 42.62±0.94 mg/kg of Zn respectively (Table 5).

Zinc (Zn) is required for brain development, DNA synthesis, steroid genesis, bone formation and for wound healing [26]. Results of the present study indicated the presence of higher levels of zinc in all parts of *M. oleifera* (Table 5) which is higher than the related research report of Aslam et al., (2005). Commonly daily intake of Zn is 12-15 mg per day [26]. Zn content in different parts of *M. oleifera* was found to be MOML>MOTL>MOF>MOP.

The concentrations of Phosphorus (P) in the samples of *M. oleifera* tender and matured leaves were ranged from 4800±2.46 mg/kg to 6500±2.51 mg/kg and 3200±2.52 mg/kg to 4900±3.65 mg/kg respectively and the flowers and pods contained 4500±2.85 mg/kg to 5700±3.05 mg/kg and 4400±2.67 mg/kg to 6000±3.67 mg/kg of phosphorus respectively (Table 6).

Phosphorus (P) is integral to many central metabolic processes [31].The present research revealed that all the four parts of *M. oleifera* contained good amount of phosphorus (Table 6). Phosphorus content in different parts of *M. oleifera* was found to be MOTL>MOP> MOF>MOTL.

Table 7 shows that Arsenic (As) content in *M. oleifera* tender leaves and matured leaves were found to be present in the range of 0.33±0.01 mg/kg to 0.39±0.01 mg/kg and 0.32±0.01 mg/kg to 0.47±0.02 mg/kg respectively, and that in flowers and pods were ranged from 0.41±0.02 mg/kg to 0.46±0.02 mg/kg and 0.31±0.01 mg/kg to 0.36±0.01 mg/kg respectively.

Table 5. Zinc (Zn) content in mg/kg level in different plant parts of *M. oleifera*

Plants	MOTL	MOML	MOF	MOP
T_1	47.52±0.48	46.18±0.94	45.77±0.94	38.95±0.96
T_2	48.65±0.96	47.48±1.28	45.24±1.27	42.62±0.94
T_3	44.12±0.83	45.77±0.48	41.84±0.83	35.44±0.96
T_4	42.31±1.27	42.51±0.83	46.76±0.96	39.55±1.27
T_5	47.90±0.83	43.69±0.96	44.98±0.83	41.77±0.83
T_6	43.55±0.96	49.36±0.83	43.60±1.27	40.94±1.27

T (1-6): Six different Trees, MOTL: M. oleifera tender leaves, MOML: M. oleifera matured leaves, MOF: M. oleifera flowers and MOP:M. oleifera pods

Table 6. Phosphorus (P) content in mg/kg level in different plant parts of *M. oleifera*

Plants	MOT	MOM	MOF	MOP
T_1	6500±2.51	4900±3.65	5700±3.05	6000±3.67
T_2	5400±3.26	3500±2.58	4600±3.45	4700±2.15
T_3	5400±2.40	3600±2.74	4700±2.74	4400±2.67
T_4	5300±2.89	3500±1.59	4500±2.85	4900±3.28
T_5	4800±2.46	3200±2.52	4800±2.93	5100±2.83
T_6	5100±3.85	4100±1.98	5100±3.35	5200±2.75

T (1-6): Six different Trees, MOTL: M. oleifera tender leaves, MOML: M. oleifera matured leaves, MOF: M. oleifera flowers and MOP: M. oleifera pods

Table 7. Arsenic (As) content in mg/kg level in different plant parts of *M. oleifera* samples

Plants	MOTL	MOML	MOF	MOP
T_1	0.39±0.01	0.47±0.02	0.44±0.03	0.33±0.02
T_2	0.37±0.01	0.41±0.01	0.43±0.03	0.36±0.01
T_3	0.38±0.02	0.36±0.02	0.42±0.02	0.34±0.03
T_4	0.33±0.01	0.45±0.02	0.41±0.02	0.31±0.01
T_5	0.35±0.03	0.38±0.01	0.45±0.01	0.32±0.01
T_6	0.36±0.01	0.32±0.01	0.46±0.02	0.35±0.02

T (1-6): Six different Trees, MOTL: M. oleifera tender leaves, MOML: M. oleifera matured leaves, MOF: M. oleifera flowers and MOP: M. oleifera pods

Arsenic (As) is an element essential to life and in medicinal plants concentration of As recommended is less than 1.0 mg/kg [32]. Excess amount of arsenic causes metabolic disorder, dermatitis, lung cancer, cardiovascular and neurological effects [15]. The concentration of As in all the samples of present research was found to be less than 1.0 mg/kg (Table 7).

Concentration of Ni in *M. oleifera* samples (tender leaves, matured leaves, flower and pods) were found to be below 0.1 mg/kg (Table 8). The concentrations of Pb, Cd and Cr, in all the experimental samples of *M. oleifera* were found to be less than 0.1 mg/kg, 0.01mg/kg and 0.1 mg/kg respectively (Table 8). Table 8 also shows the distribution of concentration of the essential and trace elements in *M. oleifera*.

Nickel (Ni) is required for production of insulin in the body. Lack of nickel causes liver disorder [33]. Ni has been considered to be an essential trace element for human and animal health [34]. The present research indicated that all the parts of *M. oleifera* contained Ni less than 0.1mg/kg. This is lower than the report of Elseed et al., (2016) [35]. Lead (Pb) is nonessential element and has no beneficial effects in humans and exposure of Pb produces harmful effects. Pb can cause abnormal brain, chronic nephritis of the kidneys, anemia, oxidative stress etc. The permissible limit of Pb set by WHO is 0.1 to 10 mg/kg [26]. In some research the level of Pb in *M. oleifera* leaves have been reported [36] which are higher than the present research. During the present study concentration of Pb in all the sample of *M. oleifera* were found to be below 0.1mg/kg (Table 8). Cd causes high blood pressure [37], damages kidneys [38]. Excess of Cd causes a disease known as Itai-Itai [39]. The permissible limit set by WHO is 0.2 to 0.81 mg/kg [26]. During the present study Cd was not detected in any parts of *M. oleifera* plants (< 0.01 mg/kg). Related results reported the level of Cd in *M. oleifera* leaves higher than the present report [40]. Deficiency of Chromium (Cr) causes diabetes, growth failure, hyperglycemia, neuropathy and atherosclerosis. Cr is also one of the known environmental toxic pollutants in the world. Excess of chromium causes respiratory trouble, liver and kidney damage, skin rashes etc. [15]. Result of the present study showed lower levels of Cr (<0.1mg/kg, Table 8) in all parts of *M. oleifera* that is less than the other reports on *Moringa* leave [35].

It was important to examine the correlations between the concentration of one element and other in *M. oleifera*. Table 9 revealed that in *M. oleifera* plant, Ca is found positively but insignificantly correlated with Mn (r=0.402) and Zn (r=0.435) but negatively and significantly correlated with P (r= -0.697). Mn is positively but insignificantly correlated with Ca (r=0.402). However, Mn is also significantly correlated with Fe (r=0.842) and Zn (r=0.625) which indicates that the percentage of Mn, Fe and Zn in *M. oleifera* are significantly dependent on each other. Fe and Zn do not show any significant correlation with other observed metals. P has insignificant and negative correlation with Mn.

Table 10 is representing the Recommended Dietary Allowances for Ca, Mn, Fe, Zn and P [41,42,43]. Table 11 presenting the calculated amount of different parts of dry *M. olifera* required to serve RDAs for Fe.

Table 8. The distribution of concentration of the essential and trace elements in *M. olifera*

	Minimum statistic	Maximum statistic	Mean statistic	Standard deviation statistic
Ca	941.23	4932.60	2289.03	1460.68
Mn	10.05	41.62	28.37	11.53
Fe	33.05	837.41	313.02	255.65
Zn	35.44	49.36	44.02	3.34
P	3200	6500	4791.67	800.50
*Ni	-	-	-	-
*Pb	-	-	-	-
*Cd	-	-	-	-
*Cr	-	-	-	-
As	0.31	0.47	0.38	0.05

**Below Detection Limit (BDL)*
BDL: Pb < 0.1mg/kg, Cd < 0.01mg/kg, Cr < 0.1 mg/kg, Ni < 0.1 mg/kg

Table 9. Correlation between the concentration of one element and other in *M. Oleifera*

		Ca (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Zn(mg/kg)	P (mg/kg)
Ca (mg/kg)	Pearson Correlation	1				
	Sig. (2-tailed)					
Mn (mg/kg)	Pearson Correlation	.402	1			
	Sig. (2-tailed)	.052				
Fe (mg/kg)	Pearson Correlation	-.086	.842**	1		
	Sig. (2-tailed)	.690	.000			
Zn (mg/kg)	Pearson Correlation	.435*	.625**	.310	1	
	Sig. (2-tailed)	.034	.001	.140		
P	Pearson Correlation	-.697**	-.335	-.075	-.067	1
(mg/kg)	Sig. (2-tailed)	.000	.109	.729	.757	

Correlation is significant at the 0.05 level (2-tailed);Correlation is significant at the 0.01 level (2-tailed)*

Table 10. Recommended dietary allowances (RDAs) for Ca, Mn, Fe, Zn and P [41,42,43]

Age	Ca (mg/day)		Mn (mg/day)		Fe (mg/day)		Zn (mg/day)		P (mg/day)	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-6 months	200	200	0.003	0.0003	0.27	0.27	2	2		
7-12 months	260	260	0.6	0.6	11	11	3	3		
1-3 years	700	700	1.2	1.2	7	7	3	3	460	460
4-8 years	1,000	1,000	1.5	1.5	10	10	5	5	500	500
9-13 years	1,300	1,300	1.9	1.6	8	8	8	8	1,250	1,250
14-18 years	1,300	1,300	2.2	1.6	11	15	11	9	1,250	1,250
19-50 years	1,000	1,000	2.3	1.8	8	18	11	8	700	700
51-70 years	1,000	1,200	2.3	1.8	8	8	11	8	700	700
71+years	1,200	1,200	2.3	1.8	8	8	11	8	700	700

Table 11. Calculated amount of different parts of dry *M. olifera* of Dhaka, Bangladesh to serve (RDAs) for Fe

Age	Tender leaves		Matured leaves		Flowers		Pods	
	Male	Female	Male	Female	Male	Female	Male	Female
Child (1-13)	32.65 – 46.65 g	32.65 – 46.65 g	24.86-35.52 g	24.86-35.52 g	9.82-14.03 g	9.82-14.03 g	160.96-229.94 g	160.96-229.94 g
Teen age (14-18)	51.31 g	69.97 g	39.07 g	53.27 g	15.43 g	21.05 g	252.93 g	344.91 g
Adults(19-70)	37.31 g	37.31-83.97 g	28.41 g	28.41-63.93 g	11.22 g	11.22-25.26 g	183.95 g	183.95 -413-89 g

(RDAs)-Recommended Dietary Allowances

Table-11 revealed that different parts of *M. oleifera* grown in Bangladesh, Dhaka is quite capable of meeting the RDAs of iron for all age groups of human. 32.62-46-65 g of tender leaves, 24.86-35.52 g of matured leaves and 9.82-14.03 g of flowers individually is sufficient to meet the demand of daily Fe requirements for children. On the other hand 51.31 g and 69.97 g tender leaves, 39.07 g and 53.27 g matured leaves, 15.43 g and 21.05 g flowers individually can serve the RDAs for Fe of teens male and female respectively. For the adults 37.31 g and 37.31-83.97 g (tender leaves), 28.41 g and 28.41- 63.93 g (matured leaves), 11.22 g and 11.22-25.26 g (flowers) will be required to meet the daily demand of Fe for the male and female respectively. Moreover the same dry *M. olifera* could also serve a certain percentage of RDAs for Ca, Mn, Zn and P.

4. CONCLUSION

Present study revealed that *M. oleifera* leaves (tender and matured), flowers and pods grown in Dhaka , Bangladesh is a good sources of useful elements (Ca, Fe, Zn, Mn, P). On the other hand harmful heavy metals (Pb, Cd, Cr) were not detected and Arsenic (As) was found to be present below the toxic limit. Different parts of *M. oleifera* grown in Bangladesh especially tender leaves, matured leaves and flowers individually could be used for meeting the RDAs for iron of all age groups of human. The variation of useful elements and trace element contents of *M. oleifera* leaves, flowers and pods found in this study than some of the earlier studies might be due to climatic and edaphic factors, the cultivation method used and age of the plants. So leaves (tender and matured), flowers and pods of *M. oleifera* from Dhaka, Bangladesh might be good sources of important essential elements and leaves and flowers could be a potential source of Fe supplement for human and livestock. But these need to be further explored for use as supplements and sources of dietary minerals in human and animal food or feed.

ACKNOWLEDGEMENTS

The authors are grateful to the authority of BCSIR for all the support during the present research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/27766