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MORINGA OLEIFERA LAM. FLOWERS: A PROMISING NUTRITIONAL AND MEDICINAL SUPPLEMENT

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ABSTRACT
Moringa oleifera Lam. is the most widely cultivated species of a monogeneric family, Moringaceae which is native to sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. Now it is widely cultivated and has become naturalized throughout India and in many locations in the tropics. It is well known plant for its nutritional and medicinal potential; but most of the work has been regarding leaves and pods; therefore in the present study nutritive as well as medicinal potential of flowers was evaluated. Estimation of primary nutrients (Lipids, Crude fat, Carbohydrates, Proteins, fibres), vitamins (ascorbic acids and carotenoids) and antioxidants (Lycopene, anthocyanin and simple phenolics) was done. Minerals were estimated in terms of ash yield. Ash was analyzed qualitatively and quantitatively for its mineral constituents. Material was also screened for the presence of bioactive molecules to understand medicinal potential.

KEYWORD: *Moringa oleifera*, flower, nutritional, medicinal.

INTRODUCTION
Moringa oleifera is the most widely cultivated species of a monogeneric family Moringaceae which is native to sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. Now it has become naturalized in many areas in the tropics. It is also known as the horseradish tree, drumstick tree, moonga, moongna and shewaga.

Moringa oleifera is a fast growing, aesthetically pleasing small tree. The species is characterized by its long, drumstick shaped pods with winged seeds. The tree has been shown to grow up to 4 meters and can bear fruits in the first year.[1]

According to Fahey *etal*[2] *Moringa oleifera* is advocated as an outstanding indigenous source of highly digestible protein, calcium, iron, vitamin C, and carotenoids suitable for utilization in many of the so called "developing" regions of the world where undernourishment is a major concern. All aerial parts of the *Moringa* tree are edible and have long been consumed by humans. The roots are shredded and used as condiment in the same way as horseradish. Leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value.[3] Kasolo *et al*[4] showed the presence of different phytochemicals viz. tannins, steroids, triterpenoids, flavonoids, saponins, anthraquinones and alkaloids in leaves collected from Uganda. Sohaimy *et al*[5] found leaves to be a rich source of essential amino acids and minerals; the extract was found to be antimicrobial in addition, hence it is suggested as medicinal food especially for infants and nursing mothers.

Flowers and pods are made into vegetable. Seeds are eaten green or used in curries; mature dry seeds roasted, powdered and steeped for tea.[6] In several countries traditionally rural and tribal people use coarsely crushed seeds to purify the water. Onsare *et al*[7] have proved that the seed coat powder totally inhibits the growth of *E. coli*. There is need to advocate this age old water purification method so that people in remote areas can get freedom from water borne diseases. Auwal *et al*[8] studied antibacterial and haematoloical activity of aqueous seed extract and found that the folk use of seeds against bacterial infections, anaemia and as immunomodulatory by people of north eastern Nigeria is very much proper.

Flowers of *Moringa oleifera* exhibit high medicinal value as a stimulant, aphrodisiac, abortifacient and cholagogue. Flowers are reported to be used to cure inflammations, muscle diseases, hysteria, tumors, and enlargement of the spleen; lower the serum cholesterol, phospholipid, triglyceride, VLDL, LDL cholesterol to

phospholipid ratio and atherogenic index.[9,10,11,12] They also decrease the lipid profile of liver, heart and aorta in hypercholesterolemic rabbits and increase the excretion of faecal cholesterol.[13] Flowers are diuretic.[14] Pakade *et al*[15] found strong antioxidant activity of leaves and flowers. In Asia the flowers are mixed together with other foods. However, nutritional evaluation of flowers has been done here for the first time.

Moringa oleifera belongs to the group of high -yielding nutritious browse plants with every part having food value.[16] Over past two decades, many reports have appeared related to nutritional and medicinal properties of *Moringa* leaves and pods, however, very little information is available about the flowers. In north Maharashtra, traditionally, flowers are used to prepare a delicious dish by mixing with soaked and grinded gram dal.[17] Present study was aimed to generate information about the nutritional and medicinal value of *Moringa* flowers.

MATERIAL AND METHODS

Sample collection

Flowers were collected from roadside plants from Dhule district of North Maharashtra (Plate 1). Plant was identified using standard flora[18] and voucher specimen was deposited at the herbarium of Department of Botany, Govt. Vidarbha Institute of Science and Humanities, Amravati (voucher specimen no. PPK–06).

Sample preparation

Fresh flowers were collected during Januray – February 2009 and thoroughly washed after removing stamens. For analysis fresh material was preserved at 4°C. Flowers were shade dried, powdered and preserved in sterile bottle at room temp. for further studies.

Sample analysis

***Moisture content*:** Sample was kept in hot air oven at 100°C for 18 hours and weighed. Loss in weight was considered as a measure of moisture content and presented in percent.[19]

***Crude fibre*:** Crude fibre content in the sample was estimated according to Maynard[20] procedure.

***Total carbohydrates*:** The sample was hydrolyzed with 2.5N HCl for three hours in boiling water bath, followed by neutralizing with sodium carbonate. It was then centrifuged, supernatant collected and estimation done following Hedge and Hofreiter.[21]

Starch: Plant tissue was homogenized in hot ethanol and filtered. Residues repeatedly washed by hot ethanol and then extracted with distilled water and perchloric acid. Starch content was estimated in terms of sugars produced by digestion of starch using Anthrone reagent spectrophotometrically at 630 nm and multiplying the sugar value thus obtained by starch factor (glucose content X 0.9).[21]

Reducing sugars: Plant tissue was extracted with hot 80% ethanol; supernatant collected and evaporated on water bath. The residue was dissolved in water and reducing sugars were estimated spectrophotometrically at 620 nm by Nelson-Somogyi's method.[22]

Non-reducing sugars: Plant material was extracted with hot ethanol, supernatant collected and evaporated on water bath. The residue was dissolved in distilled water and incubated for 30 min. by adding H_2SO_4, cooled and drop of methyl red indicator was added followed by neutralization with NaOH. To the neutralized sample alkaline copper tartarate reagent was added, kept in a boiling water bath for 10 minutes, cooled; arsenomolybdate reagent added and absorbance read at 620 nm. Standard graph was prepared with glucose and amount of non-reducing sugars present in the sample calculated using formula given below.[23]

$$\text{Non - reducing sugar (\% mg)} = \frac{\text{Sugar value from graph } (\mu g)}{\text{Aliquot sample (1 ml)}} \times \frac{\text{Total vol. of extract(10 ml)}}{\text{Weight of sample (100 mg)}} \times \frac{1}{1000}$$

***Crude protein*:** Fresh tissue was homogenized in chilled 10% TCA and centrifuged at 5000 rpm. Residue was treated with NaOH and filtered. To the filtrate Biurette reagent was added and incubated for 10 min at room temperature. Absorbance measured at 540 nm. Standard graph was prepared with Bovine's serum.[24]

***Protein from nitrogen*:** Total nitrogen content was determined by using Micro Kjeldahl Method. Protein content was calculated by multiplying the total nitrogen content by factor 6.[25][25]

***Crude fat*:** Dry powder (5 g) was taken in thimble and extracted in preweighed flask by Soxhlet extractor with Petroleum ether for 16 hr and extract evaporated on water bath. Increase in weight of flask gave the fat content.[26]

***Lipid*:** Lipids were extracted by using Bligh and Dyer method.[27]

***Ascorbic acid (Vitamin C)*:** Sample was extracted with oxalic acid and dehydrogenated by bromination and then treated with 2,4 dinitrophenyl hydrazine to form osazone which was dissolved in Sulphuric acid to give an orange-red colour solution which is measured at 540nm.[28]

***β-Carotene (Pro–Vitamin A)*:** Tissue was extracted with distilled methanol and extract partitioned with ether; ether layer separated and evaporated to dryness on water bath. Residue dissolved in ethanol. Lipids and chlorophyll were removed by KOH and kept in a dark at room temperature overnight. Equal volume of water was added to partition the ether layer. Ether layer was collected, evaporated to dryness and residue was dissolved in ethanol then absorbance was measured at 420 nm. Standard graph was prepared using β-carotene of high purity. Carotenoid content (µg/gm) in sample was calculated using calibration curve.[23]

***Vitamin A*:** The value of vitamin A was calculated by assuming 0.6 µg of carotene equivalent to 1IU of vitamin A (Gopalan *et al*, 2004).

***Retinol*:** The value of retinol µg per 100 g was estimated by taking into consideration that one International Unit of vitamin A is equivalent to 0.3 µg of retinol.[29]

***Lycopene*:** The lycopene content was determined following Sadasivam and Manickam.[28]

***Anthocyanin*:** Fresh tissue was homogenized in alcohol and centrifuged. Alcohol extract was treated with HCl in aqueous methanol followed by addition of Anthocyanin reagent. Incubated for 15 minutes in dark and absorbance was read at 525 nm. Anthocyanin content was expressed as A_{523} value.[30]

***Chlorophyll*:** Fresh tissue was extracted with chilled 80% acetone. The solution was centrifuged, supernatant collected and volume made 100 ml with acetone. Different chlorophyll contents were measured spectrophotometrically at 645 nm, 652 nm and 663 nm.[31]

***Phenol*:** Plant material was extracted in 10 ml methanolic HCl. Supernatant evaporated to dryness on water bath and the residue was dissolved in distilled water, volume made to 7 ml; 0.5 ml Folin-Phenol reagent added and allowed to stand for 3 minutes. 1 ml of 35% sodium carbonate was added and again allowed to stand for one hour. Absorbance read at 630 nm. (Standard used caffic acid).[32]

***Food energy*:** Food energy was calculated from the content of the proximate principles assuming that proteins, carbohydrates and fats yield 4, 4 and 9 K cals/g, respectively.[33]

***Mineral content*:** The sample (10 g) was weighed in a silica crucible and kept in a muffle furnace for about 5-6 h at 600°C; cooled in a desiccator and weighed. Weight of ash gives mineral content.[25]

***Quantitative mineral analysis*:** About 0.5 g of finely powdered sample was digested following wet digestion procedures using conc. HNO3. Digested samples were used for elemental analysis. Sodium (Na), potassium (K) and calcium (Ca) determined using Flame photometer and iron (Fe) and phosphorus (P) spectrophotometrically.[34] Mineral content was estimated per 100 gm dry weight of the tissue and then converted into per 100 gm fresh weight since flowers are eaten fresh.

***Qualitative mineral analysis*:** Minerals were detected following Johanson.[35]

***Bioactive compounds*:** Presence of different bioactive molecules was detected using standard simple screening methods.[36,37,38,39,40,41]

Statastical analysis: The data was collected in triplicate and standard error of mean was calculated according to Steel *et al*.[42]

RESULT AND DISCUSSION

Nutrient values were obtained per 100 g fresh weight of flowers (Table 1).

Table 1: Nutrients Per 100 gm Fresh Tissue

Sr. No.	Nutrients	Fresh weight
1	Moisture content (g)	81.62 %
2	Crude fiber (g)	0.145±0.009
3	Carbohydrate (g)	
	a. Total Carbohydrate (g)	0.673±0.001
	b. Starch (g)	0.241±0.007
	c. Reducing sugars (g)	0.383±0.007
	d. Non-reducing sugars (g)	0.046±0.005
4	Crude Protein (g)	0.420±0.004
5	Total Nitrogen* (mg)	0.898±0.005
6	Protein from N	1.81±0.02
7	Crude fat (mg)	0.881±0.005
8	Lipids(mg)	0.153±0.005
9	Food energy (K. cal)	17.95
10	Mineral content (g)	1.91

Analysis of proximate composition of *M. oleifera* flowers has showed high content of carbohydrate, protein and fat. There is great difference between values of crude protein and protein obtained from nitrogen content (N x 6.25). Yeoh and Wee[43] have clearly shown that nitrogen multiplication factor (6.25) does not give correct protein value, as it is basically calculated for leguminous seeds. The edible portion of the flowers provides 17.95 Kcal of energy per 100g fresh weight. Vitamin and antioxidant content were also estimated per 100 gm fresh weight (Table 2 & 3).

Table 2: Vitamin Content Per 100 gm Fresh Tissue

	Ascorbic acid (Vit. C)	Carotene (Provitamin A)	Vitamin A	Retinol
Fresh wt.	7.6±0.05 mg	200±0.4	33333.3 IU	98.3±0.5

Table 3: Antioxidant Content Per 100 gm Fresh Tissue

Lycopene (mg)	Anthocyanin (mg)	Chlorophyll (mg)			Phenol (g)
		Chl-a	Chl-b	Total Chlorophyll	
0.34±0.007	0.13±0.005	5.13±0.02	6.10±0.04	11.23±0.02	0.041±0.003

Minerals were estimated in terms of ash yield. They play an important role in many physiochemical processes which are essential to life. Ash analysis was done both qualitatively and quantitatively (Table 4).

Table 4: Qualitative and Quantitative Mineral Profile

			mg/100gm dry wt	mg/100gm fresh wt
1	Phosphorus	+	108.7±0.7	19.66
2	Sodium	+	224.8±0.4	41.24
3	Calcium	+	176.3 ±0.2	32.34
4	Potassium	+	3653±0.4	671
5	Iron	+	261.9±0.05	48.11
6	Sulphur	+	--	--
8	Chloride	+	--	--
9	Aluminium	+	--	--

Qualitative mineral profile shows the presence of calcium, potassium, iron, sulphur, chlorine, aluminium, phosphorus and sodium. Potassium was found to be highest followed by iron, sodium, calcium and phosphorus. Potassium ions are important in neuron (brain and nerve) function, and in influencing osmotic balance between cells and the interstitial fluid, with their distribution mediated in all animals by the so-called Na+/K+-ATPase pump.[44] Dietary need of potassium per day is 3500 mg. In case of deficiency powder of dried flowers can be used in the form of curry. The micronutrient deficiencies which are of greatest public health significance are iron deficiency, causing varying degrees of impairment in cognitive performance, lowered work capacity and immunity to infection.[45] Medical reports show that very severe anaemia is a direct cause of maternal and child mortality.[46] Daily requirement of iron is 18 mg where as *Moringa* flowers provide 48.11 mg Iron per 100 g flowers. The regular use of flowers in diet can be useful in combating anaemia. Sodium is the principal cation in extracellular fluids. It regulates plasma volume and acid-base balance, involved in the maintenance of osmotic pressure of the body fluids, preserves normal irritability of muscles and cell permeability, activates nerve and muscle function.[47,48] As external sodium intake is part of our life its content in vegetables is of least importance.

Nutrient and mineral content of *M. oleifera* flowers when compared with the available values of leaves and pods were found to be richer in fats, β-carotene, sodium, potassium and iron (Table 5).

Table 5: Comparative nutrient values per 100g fresh weight and minerals per 100g dry weight of leaves, flowers and pods

Nutrient	Flower	Leaves	Pod
Carbohydrate (gm)	3.6	12.5	8.53
Crude Fiber (gm)	0.78	0.9	3.2
Protein (N x 6.25) (gm)	1.81	6.70	2.10
Fat (gm)	4.60	1.70	0.2
Vitamin – C (mg)	41.87	220	141
ß – Carotene (mg)	1086.6	6.78	NA
Food Energy (Kcal)	17.95	91.7	44.32
Minerals			
Phosphorus	108.7	112	50
Sodium	224.8	9	42
Calcium	176.3	185	30
Potassium	3653	337	461
Iron	261.9	4	0.36

www.allthingsmoringa.com@2010,http://www.nutrition-and-you.com/moringa.html (USDA national nutrient database).

Babu[49] has also reported that vitamin A content of *Moringa* flowers is much higher than locally available food sources used by Malawi tribe of eastern Africa. Calcium and phosphorus content is almost at par with leaves. i.e. overall flowers are more nutritious in most of the micronutrients than leaves and pods except vitamin C.

Gopalan *et al*[29] have published nutritive values of some common Indian foods. To understand the nutritional potential of *M. oleifera* flowers studied here, the nutritive values were compared with the values available for two commonly consumed flowers in Indian diet, viz., *Sesbania grandiflora* (Agathi) and *Musa paradisiacal* (Plaintain) (Table 6).

Table 6: Comparative Nutrient And Mineral Values Of Flowers Per 100 G Fresh Weight Of Drumstick (*M. oleifera*), Agathi (*Sesbania grandiflora*) *and* Plaintain (*Musa paradisiaca*) flower

	Drumstick	Agathi	Plaintain
Moisture	81.62	92.9	89.9
Crude Fiber (gm)	0.14	1	1.7
Protein (N x 6.25) (gm)	1.81	0.5	0.7
Fat (gm)	0.88	0.8	1.3
Carbohydrate (gm)	0.67	4.4	5.1
Vitamin – C (mg)	7.7	NA	16
ß – Carotene (mg)	200	NA	27
Food Energy (Kcal)	17.95	26.8	34.9
Minerals			
Calcium (mg)	32.34	9	32
Phosphorus (mg)	19.66	5	42
Sodium (mg)	41.24	NA	20.1
Iron (mg)	48.11	NA	1.6
Potassium (mg)	671	NA	185

(Gopalan *et al*, 2004) (NA – values not available)

Moringa oleifera flowers were found to be rich in protein (1.81g) than Agathi (0.5) and Plaintain (0.7) flowers. *Moringa* (0.88g) and Agathi (0.8g) flowers showed near about same fat content. Phosphorus is located in every cell of the body and is vitally concerned with metabolic processes[47]; phosphorus content of *Moringa* flowers was found to be 4 times more than Agathi. *Moringa* flowers can be a good source of of β-carotene as it was found to be 10 times higher than Plaintain flower. Calcium content of *Moringa* (32.34 mg) is equivalent to those of Plaintain flowers (32 mg) while they are richer than Plaintain flowers in sodium and iron content.

Preliminary qualitative analysis of flowers for bioactive molecules exhibits encouraging results. The medicinal properties of flowers are due to the presence of flavones, leucoanthocyanin, napthol, hydroquinone, tannin, fatty and organic acids and polyoses (Table 7).

Table No. 7 Qualitative Profile For Bioactive Molecule

Flavone	Leucoanthocyanin	Napthol	Hydroquinone	Tannin	Fatty acid	Polyoses
++	+	+	+	+	+	+

Flowers of *Moringa* have earlier also been reported to contain flavonoids such as quercetin, kaempferol, rhamnetin, isoquercitrin and kaempferitrin.[50] In addition they are reported to be rich in Ca, K, waxes and alkaloids.[51,52] Alkaloids were found to be absent from the present study material.

Hydroquinone is found to inhibit tumor cell respiration[53], thus these flowers can act as good anticancer agent. Tannins have shown potential antiviral[54,55], antibacterial, antimicrobial[56,57,58,59] and antiparasitic effects.[60]

Polyoses are reported to provide tightening effects to the skin; effective as anti-wrinkle agent.[61] Flower paste can be recommended as cosmatics.

Carotenoids have been linked with enhancement of the immune system and decreased risk of degenerative diseases such as cancer, cardiovascular disease, age-related macular degeneration, and cataract formation.[62,63,64,65,66,67,68]

Effective role of *Moringa oleifera* flowers in many biological activities has been proved. Pakade *et al*[69] showed high free radical scavenging and DPPH reducing activity in *Moringa oleifera* leaves and flowers than

Peas, Cabbage, Spinach, Broccoli and Cauliflower. They also found that total phenolic content of *Moringa* was almost twice that of the conventional vegetables and the total flavonoid content was three times that of the selected conventional vegetables.

Kumar *etal*[70] 2010 showed good hepatoprotective activity of methanol extract of leaves and flowers of *M. oleifera.* Anthelmintic activity of *Moringa* flowers and leaves has been demonstrated by Bhattacharya *et al.*[71] Roots, leaves, flowers, gum and the aqueous infusion of seeds is diuretic.[72]

CONCLUSION

Moringa oleifera flowers are good source of fat, vitamin A, antioxidants, carotenoids and minerals like iron and potassium. Presence of different bioactive molecules also proves their medicinal potential. During the survey for wild edibles in North Maharashtra, it was found that flowers were consumed by the tribals for their unique test and flavor. While making chutney rural people mix flowers with soaked, grinded Grahm dal and curd which makes the dish not only tasty but also highly nutritious. So promoting these flowers for consumption will definitely enrich our food basket.

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