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Nutritional Assessment of Different parts of *Moringa oleifera* Lamm collected from Central India

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ABSTRACT

Moringa is especially promising as a food source in the tropics. This rapidly-growing tree is a perennial softwood tree with timber of low quality, but for centuries has been advocated for traditional medicinal and industrial uses. All parts of the Moringa tree are edible and have long been consumed by humans. However, all the plant parts of Moringa oleifera from Central India have not been investigated for their nutritive values. The present study showcases a comprehensive investigation on different plant parts of Moringa oleifera collected from Jabalpur. All the parts have good amount of nutritionally important minerals and were devoid of toxic heavy metals, making them suitable as a source of nutrition for both human and animals.

Key words: *Moringa oleifera*, proximate analysis, nutritive value

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INTRODUCTION

Approximately 80% of the world population depend exclusively on plants for their health and healing [1]. The last few decades have seen chemical revolution and most of things that affect the human health such as food, drugs, agriculture and environment have been filled with chemicals. As the new discoveries are being made day by day, and the adverse effects of chemicals are being exposed; the focus have been shifted towards the natural products.

Moringa oleifera Lam. is the most widely cultivated species of a monogeneric family, Moringaceae which is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. This rapidly-growing tree (in Hindi called as Munga or Sahjan) was also utilized by the ancient Romans, Greeks and Egyptians; it is now widely cultivated and has become naturalized in many locations in the tropics. *Moringa oleifera* Lam. (drumstick tree, horseradish tree) is an indigenous tree from north-western India and is often cultivated in hedges and home yards. The tree is valued mainly for the tender pods, which are esteemed as a vegetable [2]. Flowers and young leaves are also eaten as vegetables.

India shows a rich biodiversity because of every climate in the world available here. The traditional knowledge in Ayurveda is still in practice which has made a good amalgam of traditional and scientific knowledge. *Moringa oleifera* tree has in recent times been advocated as an outstanding indigenous source of highly digestible protein, Ca, Fe, vitamin C, and carotenoids suitable for utilization in many of the so called “developing” regions of the world where undernourishment is a major concern. *Moringa* trees have been used to combat malnutrition, especially among infants and nursing mothers. Three non-governmental organizations in particular—Trees for Life, Church World Service and Educational Concerns for Hunger Organization—have advocated *Moringa* as “natural nutrition for the tropics” [3]. *Moringa* is especially promising as a food source in the tropics because the tree is in full leaf at

the end of the dry season when other foods are typically scarce. Ogby and Affiku [4] investigated proximate analysis of *Moringa oleifera* leaves and found the presence of high crude protein (17.01% ±0.1) and carbohydrate (63.11% ±0.09). The leaves also contained appreciable amounts of crude fibre (7.09% ±0.11), ash (7.93% ± 0.12), crude fat (2.11% ±0.11) and fatty acid (1.69% ±0.09). The total ash content showed it contained minerals, Ca (1.91% ±0.08), K (0.97% ±0.01), Na (192.95±4.4), Fe (107.48±8.2), Mn (81.65±2.31), Zn (60.06±0.3) and P (30.15±0.5) parts per million (ppm). Magnesium (0.38% ±0.01) and copper (6.10±0.19) were the least. Oluduro [5] estimated antimicrobial properties and nutritional potentials of *Moringa oleifera Lam* leaf in South-Western Nigeria. However, no complete study could be found on *Moringa oleifera* allowing comparisons of nutritive values for all edible plant parts of *M. oleifera*. The present study in an attempt to assess the nutritive value of *Moringa oleifera* tree collected from the central India region and compares their nutritive values critically.

MATERIALS AND METHODS

Collection of plant material

The whole plants of *Moringa oleifera* were purchased from the local nursery of Jabalpur (MP). From these young plants (approx. length of 1 to 2 meter), roots, stem and leaves were obtained. The whole plants were taken out of the soil, washed and root, stem and leaves were separated manually.

For fruit and seeds, the fully grown pods of the *M. oleifera* from fully grown trees (from same nursery) were used. These pods were picked during the summer. Form the pods (drumsticks), the seeds were separated and rest of the pod was used a fruit source.

Drying the plant material

The plant parts were separated from each other manually. All the parts were air dried under shade for one week or longer till a constant weight was achieved. The care was taken to observe the fungal growth on wet parts especially of leaves and roots.

Grinding and sieving of the plant material

Once dried up to constant weight, the plant materials were ground in a mixer grinder. The leaf, seeds, fruit and the roots were easily grinded in to powder form. Such powder was passed through a test sieve having 100 µM pore size (Sonar, India) to obtain a particle size that is less than 100 µM. The remaining course powder was again grinded and sieved. The process was continued four to five times or till the material could not be ground further. The fine powder of less than 100 µM was immediately stored in an air tight container for further use.

Estimation of moisture Content [6]

For moisture content, the plant part was stored 105°C for 8 h and the loss of weight was recorded. Briefly, 1 g of the powdered sample was weighed in a beaker of known weight. The sample was then placed in hot air oven at 105°C for 8 h. The plant material was cooled and weighted again to determine water loss in powdered sample.

Estimation of fat content [6]

The apparatus used for estimation of fat is Soxhlet extractor. To determine the percentage of fat the dried sample of plant was extracted with petroleum ether. It was then distilled off completely and dried. The oil weight and percentage of oil was calculated.

Estimation of crude fiber [6]

During the acid and subsequent alkali treatment, oxidative hydrolytic degradation of native cellulose and considerable degradation of lignin occurs. The residue obtained after final filtration was weighed, incinerated, cooled and weighed again. The loss in weight is the crude fiber content.

Estimation of ash Percentage [6]

For estimation of ash, the plant part was incinerated at higher temperature. Briefly, 2 g of sample in a crucible was incinerated in to the Muffle furnace at 600˚C for 6 hours. The crucible was then cooled, the sample was reweighed and the percentage of ash calculated.

Estimation of Nitrogen percentage [7] [8]

The micro Kjeldahl method was used for Nitrogen estimation. Sample was digested by with concentrated sulfuric acid in the presence of copper sulphate. The ammonia was distilled by the addition of excess sodium hydroxide. Released ammonia was collected in boric acid and titrated with standard hydrochloric acid using methylene blue as an indicator. Total protein was calculated by multiplying nitrogen percentage by 6.25.

Estimation of Carbohydrates [9]

The phenol and sulphuric acid method was used for carbohydrate estimation. For this 100 mg of sample was digested for 3h with 2.5N HCl. During digestion, all the carbohydrate was converted into glucose which was further dehydrated of hydroxyl methyl furfural. The solution was neutralized with sodium carbonate. One milliliter of phenol was added to each test tube and 1 ml concentrated sulphuric acid was then carefully dispensed to each tube. The solution was allowed to stand for 20 min before taking the absorbance at 490nm. The absorption was converted to glucose concentration using a standard curve of D-glucose prepared in the same manner (R^2=0.97).

Estimation of nutritive value

After estimation of protein, fat and carbohydrate, the nutritive value was calculated as per the following formula.

Nutritive value (Kcal per 100 g) = 4 (Protein%) + 9 (Fat%) + 4 (Carbohydrate%)

Estimation of Mineral contents:

Acid digestion method was used to digest all the organic matter of dry plant powder with sequential combination (1:2.5:1) of perchloric acid, nitric acid and sulphuric acid at 125°C temperature. After complete digestion the sample was cooled, diluted with distilled water up to final volume of 50 ml.

The estimation of phosphorus was done biochemically using vanadomolybdophosphoric acid method [6]. The amount of phosphorus was calculated using standard curve of phosphorus. Other nutritionally important minerals i.e. Na, K, Ca, Fe, Mg, and Zn along with toxic heavy metals i.e. Hg, Pb, As and Se was done via Inductively coupled plasma-Atomic Emission Spectroscopy (ICP-AES) at sophisticated Analytical Instrument facility, Indian institute of Technology, Mumbai (IIT, Bombay).

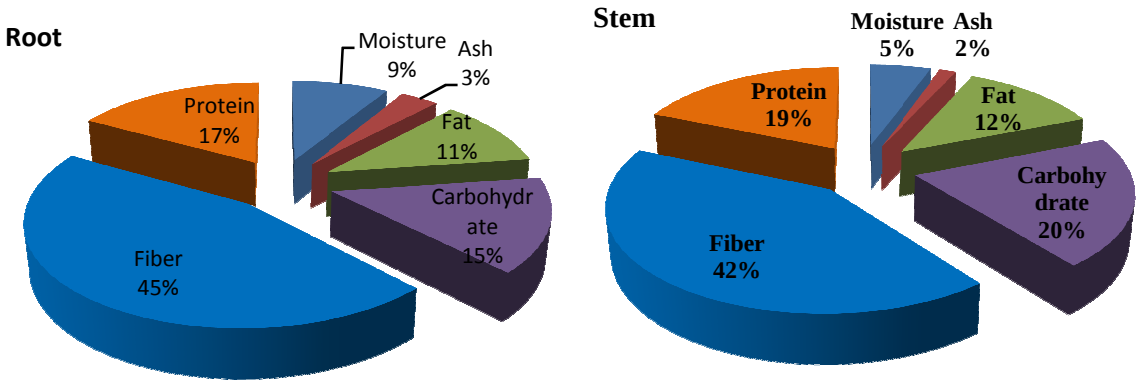
RESULTS

Moringa oleifera different plant parts proximate analyses were done with three independent replicates and the data are presented as mean standard deviation which is shows in Table 1. Analysis showed that there was not much difference in moisture content in different plant parts which ranged from 5.36 to 8.6%. Stem of *Moringa oleifera* showed lower ash percentage (1.44 ± 0.18%) where leaf showed highest ash percentage (12.23 ± 0.70 %). Although highest fiber percentage found in root (16.27 ± 0.25%) and seed showed lowest (45.43 ± 0.56 %).

Carbohydrate content was measured in terms of available glucose by comparing with the standard curve of D-glucose (R^2 =0.950).The carbohydrate percentage was lowest in leaf (7.4 ± 0.20) followed by seed (24.74 ± 0.02).Bark showed highest amount of total lipid (17.47 ± 0.35) while root and fruit showed lower lipid percentage. The protein content was found to be very high (54.30 ± 1.00 %) in fruit and leaf and seed showed similar protein content.

Table 1: Proximate analysis of different plant parts of *Moringa oleifera*. The results are presented as mean ± SD.

Sample	Moisture	Ash	Fiber	Carbohydrate	Lipid	Protein
Root	8.6± 0.3	3.37±0.32	45.43±0.56	14.92±0.02	10.8±0.10	16.87±0.71
Stem	5.36±0.20	1.44±0.18	41.603±0.60	20.4±0.20	12.2±0.26	18.66±0.70
Leaf	6.43±0.23	12.23±0.70	22.90±0.25	7.4±0.02	16.07±0.15	34.93±1.10
Fruit	7.56±0.30	2.53±0.25	28.03±0.90	20.92±0.02	10.2±0.79	54.30±1.00
Bark	8.56±0.25	1.5±0.20	25.73±0.15	12.33±0.01	17.47±0.35	23.95±2.03
Seed	6.63±0.37	1.56±0.35	16.27±0.25	24.74±0.02	16.07±0.25	34.73±0.68



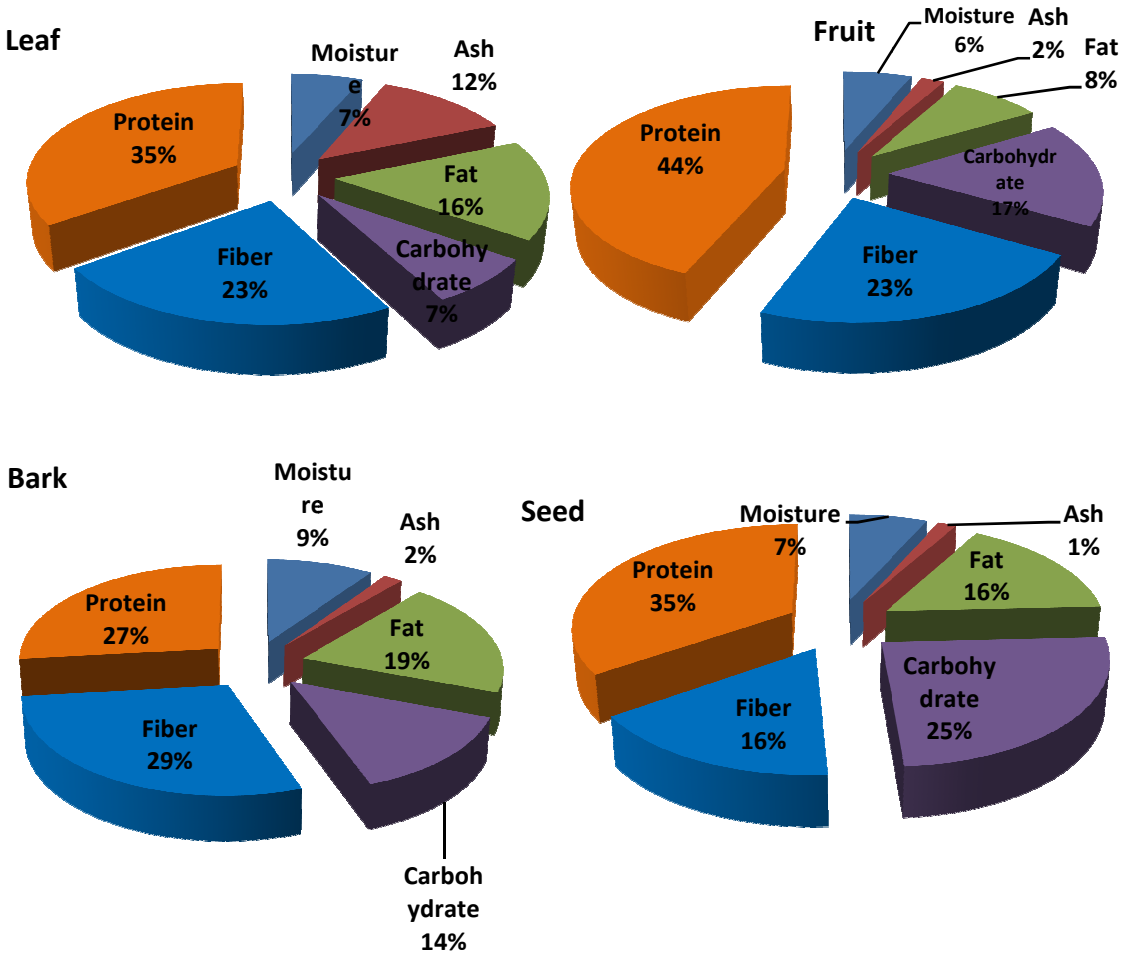


Fig 1 represents the percent values of major nutrients in different plant parts of *Moringa oleifera.*

Table 2 represents that when the nutrient value was calculated for all three replicates independently,fruit showed highest calorific value as 392.71 ± 3.23 Kcal per 100 g dry weight followed by root (224.36 ± 2.39 Kcal per 100 g dry weight).Other plant parts showed less calorific value.

Table 2: Nutritive value of different plant parts of *Moringa oleifera*. The results are presented as mean ± SD.

S.no.	Plant Part	Replicates (%)			Mean (%)	SD(±)
		1	*2*	*3*		
1.	Root	221.92	224.46	226.7	224.36	2.39
2.	Stem	266.04	269.94	262.1	266.03	3.92
3.	Leaf	312.1	317.5	312.2	313.93	3.09
4.	Fruits	388.98	394.36	394.78	392.71	3.23
5.	Bark	314.04	297.58	295.3	302.31	10.23
6.	Seed	382.3	379.4	385.7	382.47	3.15

Table 3 represents the nutritionally important mineral content in different plant parts of *M. oleifera* as analyzed through Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP AES). among nutritionally important minerals, zinc content varied greatly among plant parts. Low zinc content was found in *M. oleifera* seed (3.43 ppm), moderate in stem, leaf, fruit and bark (13.22, 15.96, 15.89 and 11.16ppm) and highest in root (47.84 ppm).

Iron content varied a lot among the different plant parts. Low iron (2.18 and 2.84 ppm) was found in *M. oleifera* seed and stem, moderate in root and leaf (5.04, 4.11 ppm) and much higher in bark and seed (22.53, 19.44 ppm).

As far as calcium is concerned, the highest amount was found in *M. oleifera* fruit (375.95 ppm), and the seed showed lowest calcium content 67.07 ppm. The leaf, stem, root and bark showed moderate calcium content as 141.42, 125.49, 286.07 and 264.12 ppm respectively.

Higher amount of potassium was found in all six plant parts ranging from 902.67 ppm (fruit) to 259.83 ppm (bark). Leaf, stem, root and seed showed moderate potassium content as 700.83, 829.79, 860.59 and 523.89 ppm respectively.

Na was found in the range of 17.17 ppm (in root), 19.61 ppm (in stem), 16.93 ppm (in leaf), 19.54 ppm (in fruit), 34.79 ppm (in leaf), 34.79 ppm (in bark) and 13.20 ppm (in seed) in *M. oleifera*. Not much difference among different plants was found as far as the sodium content is concerned.

Magnesium was found to be highest in root of *M. oleifera*. Other plant parts showed only moderate amount of Mg as 12.95, 15.26, 14.85, 10.94 and 10.94 in stem, leaf, fruit, bark and seed respectively.

Table 3: Estimation of nutritionally important minerals in different plant parts of *Moringa oleifera* using Inductively Coupled Plasma Atomic Emission Spectroscopy (values are in ppm).

S. No.	Sample	Minerals					
		Zn	**Fe**	**Ca**	**K**	**Na**	**Mg**
1	**Root**	47.84	5.04	286.07	860.59	17.17	43.79
2	**Stem**	13.22	2.84	125.49	829.79	19.61	12.95
3	**Leaf**	15.96	4.11	141.42	700.83	16.93	15.26
4	**Fruit**	15.89	19.44	375.95	902.67	19.54	14.85
5	**Bark**	11.16	22.53	264.12	259.83	34.79	10.94
6.	**Seed**	3.43	2.18	67.01	523.89	13.20	4.66

The amount of heavy metals in different plant parts of the *Moringa oleifera* as analyzed with ICP AES method. Selenium, mercury and arsenic were not detectable in all plant parts of *Moringa oleifera*. Lead was found in very low quantity (less than 1 ppm) and the values were 0.19, 0.083, 0.036, 0.132, 0.025 and 0.032 for root, stem, leaf, fruit, bark and seed respectively.

Table 4.: Estimation of heavy metals in different plant parts of *M. oleifera* using Inductively Coupled Plasma Atomic Emission Spectroscopy (values are in ppm).

S. No.	**Sample**	**Heavy metals**			
		Pb	**Se**	**Hg**	**As**
1	**Root**	0.19	ND	ND	ND
2	**Stem**	0.083	ND	ND	ND
3	**Leaf**	0.036	ND	ND	ND
4	**Fruit**	0.132	ND	ND	ND
5	**Bark**	0.025	ND	ND	ND
6	**Seed**	0.032	ND	ND	ND

DISCUSSION

Moringa oleifera is an important food source in some parts of the world. Because it can be grown cheaply and easily, and the leaves retain lots of vitamins and minerals when dried, Moringa is used in India and Africa in feeding programs to fight malnutrition [10]. *Moringa oleifera* also contains proteins, vitamins, and minerals. As an antioxidant, it seems to help protect cells from damage [11].

Proximate analysis of *M. oleifera* showed higher moisture content in bark and fruits. Julinai [12] showed presence of low moisture in leaves of *M. oleifera* though they did not show any information about other parts as far as moisture percent is concerned. Our results show higher amounts of ash in leaf of *M. oleifera*. Aja et al [13] have performed proximate analysis of *M. oleifera* leaf and seed and showed the presence of higher amounts of ash in leaf along with protein, carbohydrate, moisture, crude fibre, fat and mineral i.e. calcium, chlorine and phosphorous. Our results seem to be in-line with the reported literature.

Bark of *M. oleifera* showed higher amount of lipid content. Fruit contained higher amount of carbohydrate and protein. Higher amount of crude fibre was present in root of *M. oleifera*. Apart of that *M. oleifera* fruit contain higher amount of phosphorous, zinc, calcium, Iron, sodium and magnesium minerals.Fruits showed a nutritional value of 392 Kcal per 100g. The value is for dried fruit and may not be applicable to fresh fruit. Fresh fruit contains high amount of water (~90-95%), and hence nutritional value will be low when calculated per 100 g basis.
Fuglie [14] has reported countless instances of lifesaving nutritional rescue that are attributed to *M. oleifera*. Such incidents show the high nutritional value of this miracle tree. Further, our study shows that the *M. oleifera* fruit can be dried up and stored for a long time without losing its nutritional and medicinal qualities.

Internet reports showed that *M. oleifera* leaves have higher amount of minerals like Ca, Mg, Fe, P, Cu and S [15] which were matched to our result also. Ogbe et al. showed the leaves of *Moringa oleifera* harvested from Lafia in Nasarawa State of Nigeria during the rainy season in June 2011 had high crude protein (17.01% ±0.1) and carbohydrate (63.11% ±0.09) [4]. The leaves also contained appreciable amounts of crude fiber (7.09% ±0.11), ash (7.93% ± 0.12), crude fat (2.11% ±0.11) and fatty acid (1.69% ±0.09). The ash showed to contain minerals, Ca (1.91% ±0.08), K (0.97% ±0.01), Na (192.95±4.4), Fe (107.48±8.2), Mn (81.65±2.31), Zn (60.06±0.3) and P (30.15±0.5) parts per million (ppm). Magnesium (0.38% ±0.01) and copper (6.10±0.19) were the least. Mutayoba *et al*. [16] reported values of 57.34, 21.70 and 5.73 parts per million for Mn, Zn and Cu, respectively. However, the value of Fe (318.81), Ca (2.47%), K (1.63%) and Mg (1.03%) reported in their work. The presence of the essential nutrients and minerals implies that apart from fpods, *Moringa oleifera* leaves could be utilized as a source of feed supplement to improve growth performance and health status. More work is needed in this direction and other pharmacological activities should be established with this tree in order to make full and sustainable use of indigenous tree of *Moringa oleifera*.

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