
Moringa as a Source of Minerals?
A Comparison with Corn and Soybean

By Donald D. Job, Ph.D.

BACKGROUND

Moringa oleifera (also known as the Drumstick tree) is a well known plant in sub-tropical and tropical climates. Also known as a "miracle tree" it has been credited with many healing properties as well as providing other practical uses (such as in purifying water) [Witt, 2013; Price, 1985; Aslam, 2005]. The leaves are dried and made into a tea. A tea or "meal" can also be made from seeds. There have been a number of studies on the nutrient content of Moringa leaves and seeds; but the emphasis has been on concentration levels more than on a total mineral profile. The focus of the present study was to examine the mineral profile of the Moringa leaves and see how that compares to two other common sources of food; namely corn meal and soybean meal. As a justification for looking at leaves only, the mineral properties of both leaves and pods from soybeans were analyzed to determine whether leaf profile might be predictive of minerals in seed pods.

Of particular interest was whether the mineral profile could account for some of the claimed health benefits [Price, 1985]. It is recognized that there are numerous other biochemicals in the Moringa plants such as antioxidants that could provide health benefits; but those were not identified in the present study.

There have been other studies of the nutrients found in Moringa (see for example references in Witt, 2013; Price, 1985). There have been fewer studies making direct comparisons with other food sources. Furthermore, most of the studies have been carried out on plants grown in the wild. To our knowledge, this is the first study in which a complete mineral profile has been done on plants grown under controlled conditions in the temperate climate of southern United States (North Carolina at latitude/longitude in decimal degrees format 35.400351, -79.111720). See companion papers exploring further details of feasibility of growing Moringa in a temperate climate (Job, 2018b) and of electrolyte interactions (Job, 2018c).

For comparing the Moringa to other food sources, an important reference article comes from Batal, [Batal, et al. 2010]. Remus (2010a, b) has also provided a survey of phosphorus, phytic acid, phytate P and calcium in common United States feedstuffs.

Batal et al. summarize their work thusly:

> "Levels of several nutritionally significant minerals (P, K, Ca, Mg, Mn, Fe, Al, Cu, Zn, and Na) were determined in 16 samples of yellow corn and 16 samples of soybean meal from the 2009 U.S. harvest. … An effort was made to ensure a geographic diversity in the origin of these samples. However, no attempt was made to identify the exact area where the respective crops had been cultivated. Phosphorus content of yellow corn averaged 0.23%, which was slightly lower than listed by the NRC but in agreement with other recent studies. The P content of soybean meal (0.67%) was slightly higher than that reported by the NRC [NRC. 1994]."

They concluded:

"1. A survey of corn and soybean meal from the 2009 US harvest found the P content of corn to be lower and the P content of soybean meal to be higher than listed by the NRC [NRC. 1994].
2. Levels of other macro and microminerals (K, Ca, Mg, Mn, Fe, Al, Cu, Zn, and Na) generally agreed with those reported by the NRC [NRC. 1994]". Resulting data is found in Tables 1-4.

Another line of investigation is to study the genome of Moringa to identify genes that may contribute to the high protein content, fast-growth, heat and stress tolerance [Yang Tian , 2005]. Along with such a study is a consideration for the nutrient profile although thus far that has not included genes that are involved in mineral metabolism.

METHODS

The Moringa oleifera plants were grown from seeds provided by ECHO, a global initiative promoting sustainable food production throughout the world (17391 Durrance Road, North Fort Myers, FL 33917 USA www.ECHOcommunity.org). Tissue samples were taken from plants grown between Spring and Fall of 2016 and again in 2017 after a winter dormancy period in central North Carolina.

Soybeans were grown outdoors in North Carolina in potted containers (starting with Jiffy pots) in most cases and in one case from a local farmer's field. The potted plants variety was one popular for commerical use: Dyna-Gro seeds 36RY68. This variety is claimed to be a "very good over-all disease package" and is "RoundUp ready." The potted soybeans were watered and fertilized hydroponically using a Miracle-Gro water soluble Plant Food formulation 24-8-16 (1 Tablespoon/gallon) which in some instances was supplemented by a solution enriched by magnesium sulfate at a concentration of 1 teaspoon per gallon of Epsom salts (hydrated magnesium sulfate).

The Miracle Gro Potting Soil formulation (N-P-K) also included the minerals B, Cu, Fe, Mn, Mo, Zn. However, it does not contain Magnesium, Calcium nor Sulfur as seen in the composition table in the Appendix. The water source (other than natural rain) was from the City of Sanford which draws its water from the Cape Fear River and two deep wells. An analysis of that water is provided in the Appendix.

Mineral analysis was performed by the NCDA & CS Agronomic Division of NC State University in Raleigh, NC. The method for analysis of mineral is a variation of the US Environmental Protection Agency. 1994. Method 200.7 - "Determination of metals and trace elements in water and wastes by inductively coupled plasma-atomic emission spectrometry" [US EPA, 1994].

The NCDA&CS tissue analysis measures crop levels of up to 13 essential nutrients required for normal plant growth and development. Primary nutrients (N, P, K) are needed in greatest quantities, secondary nutrients (Ca, Mg, S) in lesser quantities, and micronutrients (Fe, Mn, Zn, Cu, B, Mo, Cl) in very small amounts. Concentrations of primary and secondary nutrients and Cl are measured as a percentage and other micronutrients in parts per million (ppm), all on a dry-weight basis. Resulting data appears below.

A soil analysis was made toward the end of the first year of the old soil and the new soil after transplanting into a larger pot. The older soil had a pH of 5.8, a high Phosphate Index (116), and a slightly elevated Potassium Index. The Agricultural Service recommended additional nitrogen. The top layer of soil in the new pot after transplanting the tree had a pH of 4.9, a very high Phosphate Index (212) and a very high Potassium Index (419). They recommended Nitrogen and lime additions. The new "topsoil" (top 2 inches) was mostly all Miracle Gro Potting Soil which in retrospect may have not been the best choice since it was higher in phosphorous and potassium than one would normally encounter.

RESULTS

Results from the Batal, et al. (2010) study are given in Tables 1-2. Downloaded from https://academic.oup.com/japr/article-abstract/19/4/361/734478 by guest on 07 January 2018

Table 1 Mineral composition (%) of corn (as-fed basis)

Item	P	K	Ca	Mg
Samples (16)				
Average	0.23	0.33	<0.001	0.08
Minimum	0.18	0.28		0.07
Maximum	0.26	0.4		0.09

Table 1b Mineral composition (mg/kg) of corn (as-fed basis)

Item	Mn	Fe	Al	Cu	Zn	Na
Samples (16)						
Average	4.5	25	5.1	2.9	20	92
Minimum	3	18	2.4	1.7	14	26
Maximum	6.9	36	10.3	6.3	28	193

Table 2 Mineral composition (%) of soybean meal (as-fed basis)

Item	P	K	Ca	Mg
Samples (16)				
Average	0.67	2.05	0.31	0.28
Minimum	0.6	1.82	0.21	0.25
Maximum	0.72	2.24	0.42	0.33

Table 2b Mineral composition (mg/kg) of soybean meal (as-fed basis)

Item	Mn	Fe	Al	Cu	Zn	Na
Samples (16)						
Average	41	172	88	15	48	127
Minimum	29	79	21	13	38	39
Maximum	57	443	484	18	58	329

The results from our studies appear in the following tables. The minerals presented are an extract from those obtained and are displayed to match the order given in the Batal et al. study. Charts are also provided in addition to the tables.

Table 3. Mineral Composition of Soybean pods

Sample	Condition	N %	P %	K %	Ca %	Mg %
Pod analysis						
SYP1- plant 1 of 2 - pods	untreated	4.2	0.43	2.19	0.24	0.38
SYP2 plant 2 or 2	untreated	3.83	0.41	2.16	0.33	0.48
SYP3	treated w Mg	3.74	0.45	2.26	0.39	0.39
SYP4	treated w Mg	3.67	0.47	2.15	0.35	0.38
Average		3.86	0.44	2.19	0.3275	0.4075

Table 3b. Mineral Composition of Soybean pods

Sample	Mn ppm	Fe ppm	Al	Cu	Zn	Na %
Pod analysis						
SYP1- plant 1 of 2 - pods	49.7	50.3	6.29	13.5	37.9	0
SYP2 plant 2 or 2	61.9	61.5	9.21	13.2	42.3	0.01
SYP3	65.7	56.5	5.44	12.1	40.6	0.01
SYP4	66.5	64.6	4.63	13.9	42	0
Average	60.95	58.225	6.3925	13.175	40.7	0.005

Table 4 Mineral composition of Soybean leaves

Sample	Condition	N %	P %	K %	Ca %	Mg %
Soy 1	MirGro+ Mg suppl	4.26	0.46	2.19	1.64	0.71
Soy 2	MirGro-only	3.77	0.43	1.96	1.66	0.6
SOYN1	leaves	3.74	0.4	1.11	1.48	0.64
SOYN2		3.76	0.36	1.09	1.33	0.64
SOYN3 - treated	treated w Mg	3.77	0.43	1.61	1.78	0.48
SOYN4 - treated	treated w Mg	2.93	0.33	1.33	1.67	0.41
Average		3.705	0.401667	1.548333	1.593333	0.58

Table 4b Mineral composition of Soybean leaves

Sample	Mn ppm	Fe ppm	Al	Cu	Zn	Na %
Soy 1	155	115	14.1	9.52	146	0
Soy 2	136	222	25.9	8.05	129	0
SOYN1	205	90.4	47.4	6.92	121	0
SOYN2	179	92.1	40.8	6.09	118	0.01
SOYN3 - treated	248	104	58.2	13.6	162	0.02
SOYN4 - treated	235	83.4	38.3	5.98	141	0.01

Average	193	117.81	37.45	8.36	136.16	0.0066

Table 5 Mineral Composition of Moringa Leaves

Moringa		N %	P %	K %	Ca %	Mg %
M-H1		2.02	0.24	1.31	2.96	0.42
MH-2		4.54	0.30	1.16	2.72	0.53
MH3		6.04	0.32	1.41	1.56	0.32
MHN1		3.05	0.29	1.32	3.04	0.45
MHN2		5.48	0.31	1.27	2.27	0.46
MHN3		5.92	0.31	1.19	1.12	0.34
Average		4.51	0.30	1.28	2.28	0.42

Table 5b Mineral Composition of Moringa Leaves

Moringa	Mn ppm	Fe ppm	Al	Cu	Zn	Na %
M-H1	159.00	86.10	25.10	2.45	12.70	0.01
MH-2	173.00	84.70	12.70	4.46	17.40	0.01
MH3	127	90.7	4.68	5.44	25.3	0.03
MHN1	191	114	22.3	2.73	12.6	0.01
MHN2	155	88.8	6.31	5.19	21.5	0.02
MHN3	105	85.5	1.91	5.03	35.3	0.02
Average	151.67	91.63	12.17	4.22	20.80	0.02

The growing conditions for the Soybeans is indicated in the photographs below (Image 1-2).

Image 1. Soybeans grown hydroponically in Miracle Gro solution. The ones on the right have a Mg supplemented solution.

Image 1
Test Soybeans without Mg and With Supplement

Image 2. Pods on soybean plants grown hydroponically in a Micracle Gro solution.

Image 2
Soybeans Grown Hydroponically

Image 3 - Field grown soybean plant showing pods. Grown during the summer of 2017 in the sandhills region of North Carolina (latitude-longitude 35.396898, -79.088358). ID: Oct27-Farm-pods.

Image 3
Field Grown Soybeans

Image 4 Pot grown Moringa. Year 1 mid-season. Photo taken August 14, 2016

Image 4
Year 1 - Mid-Season

Image 5. Moringa - in second year of growth following a winter dormant period and die-back. The original plant was repotted and developed new shoots as shown. The yard sticks are shown end-to-end against the white backdrop.- The main stem had reached a height of 109 inches at the time of photo. Some branches were removed for tissue analysis during this period. Photo taken August 31, 2017.

Image 5
Second Year Growth

Image 6. Moringa near end of second growing season - October 24, 2017. Samples were taken for tissue analysis. Other branches were removed and dried for use as a tea. The top growing peak at this point was 10 feet tall.

Image 6
End of Second Growing Seasong

The following section provides the mineral profiles in a uniform manner. The code for the minerals in the charts are as follows.

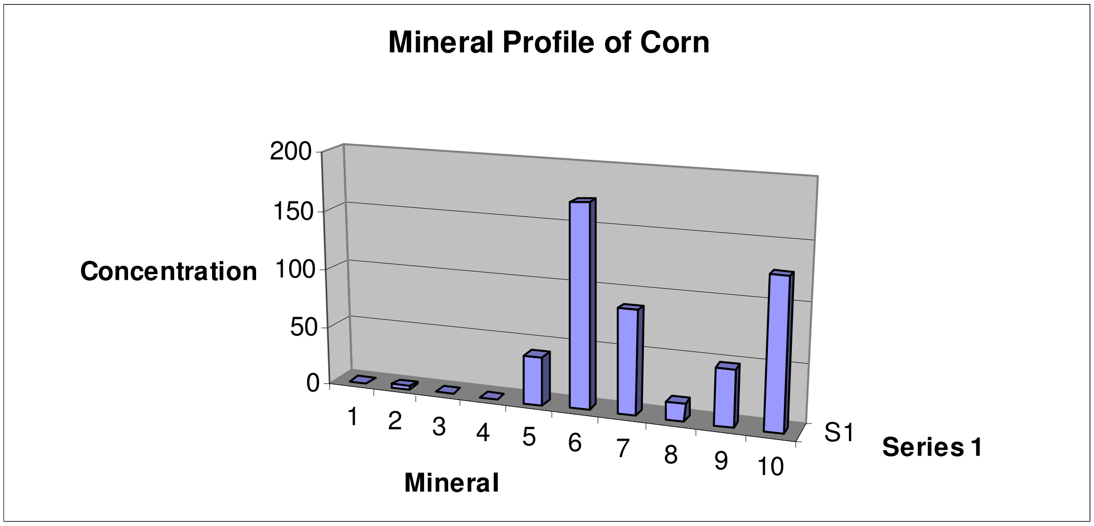
The Codes for Minerals in following Charts:

1- Phosphorous -	P
2- Potassium -	K
3- Calcium -	Ca
4- Magnesium -	Mg
5- Manganese -	Mn
6- Iron -	Fe
7- Aluminum-	Al

8- Copper - Cu
9- Zinc - Zn
10- Sodium- Na

The concentrations are given either as % of the total (elements 1-4) or as mg/kilogram or parts per million (ppm) for minerals 5-9. Sodium may be expressed as either % (Tables 3-5) or as mg/Kgm (Tables 1-2). The first 4 minerals are uniformly expressed in % (of dry weight).

Chart 1. Broad Profile for Corn (see data in Tables 1, 1b)



Note that the scale for the mineral profile of corn is different from that of the other samples. See the details of the first four minerals in Charts 6 to 10.

Chart 2 - Broad Profile for Soy Meal (see data in Tables 2, 2b)

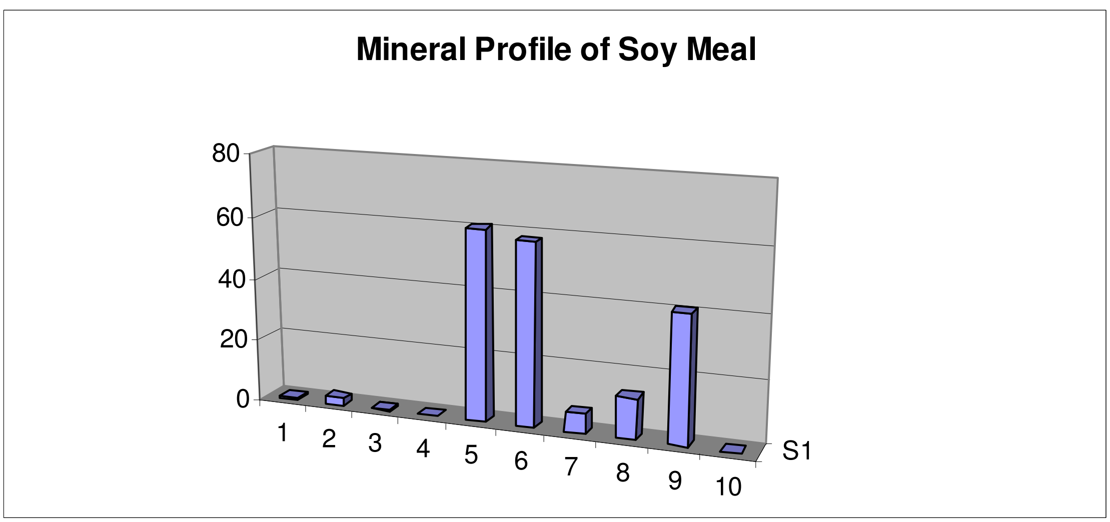
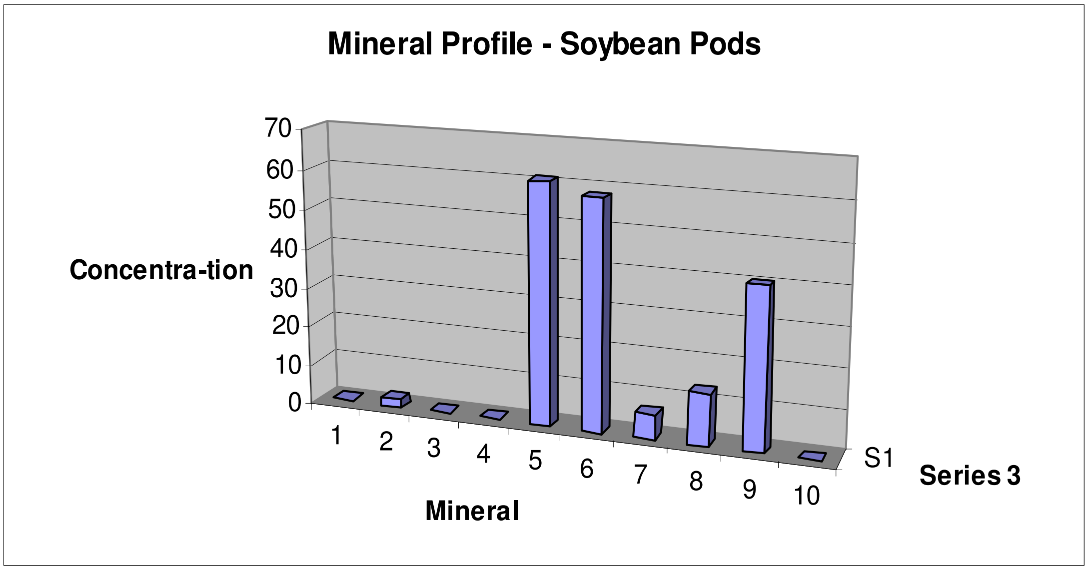
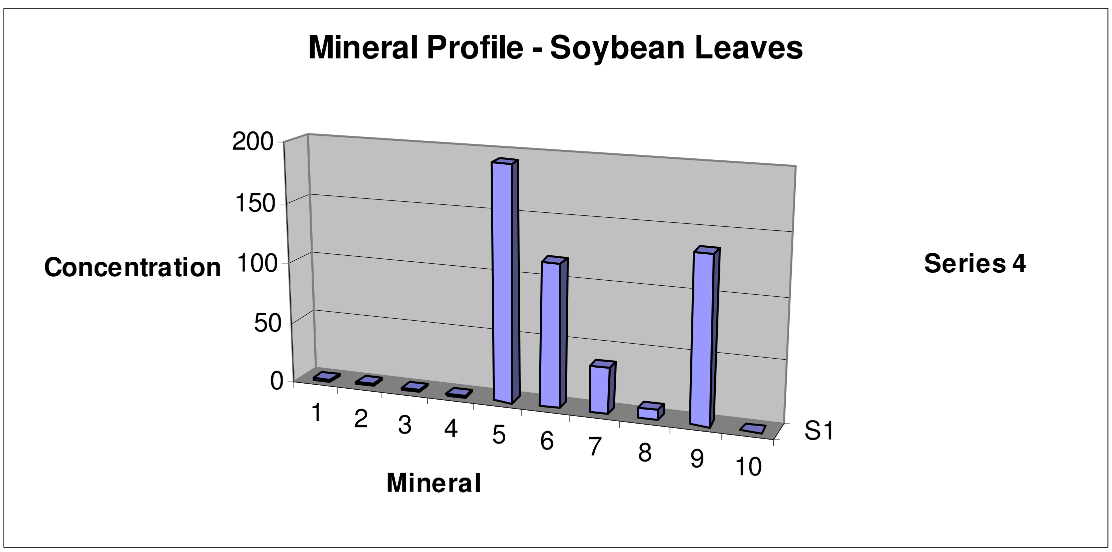


Chart 3 - Broad Profile for Soybean Pods



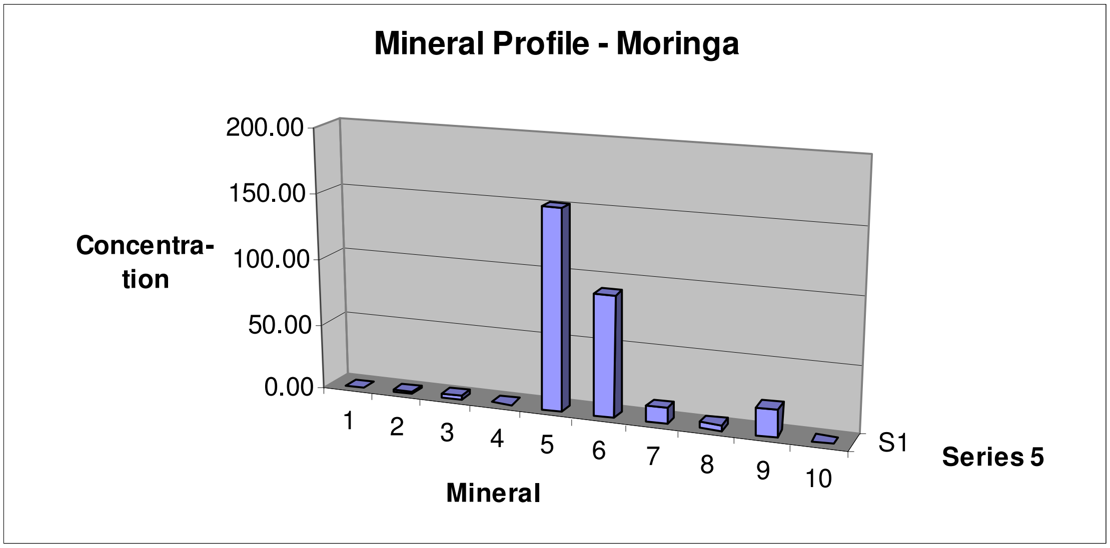
Note that the general profile is similar between pods and the meal from pods as would be expected.

Chart 4. Broad Profile for Soybean Leaves



Most of the elements are more concentrated in leaves than in pods (note the scale difference). It is seen that the profile of the leaves is similar to (but with some apparent differences) the profile of the pods and meal. Iron (6) and aluminum (7) are proportionately higher and copper (8) lower in leaves than in the pods.

Chart 5. Broad profile for Moringa Leaves



The profile in Moringa leaves has greater similarity to soybeans than to corn. In fact, except for the less prevalent Zinc, the profile could be nearly identical.

Detailed look at major minerals.

The Code for Minerals in the following Charts:

1- Phosphorous P
2- Potassium K
3- Calcium Ca
4- Magnesium Mg

Note that the scale for corn meal is only 16% of that for other minerals indicated below. In other words, corn is not a good source of these minerals compared to soybeans (leaves or pods) or Moringa leaves.

Chart 6. Macro Profile for Corn

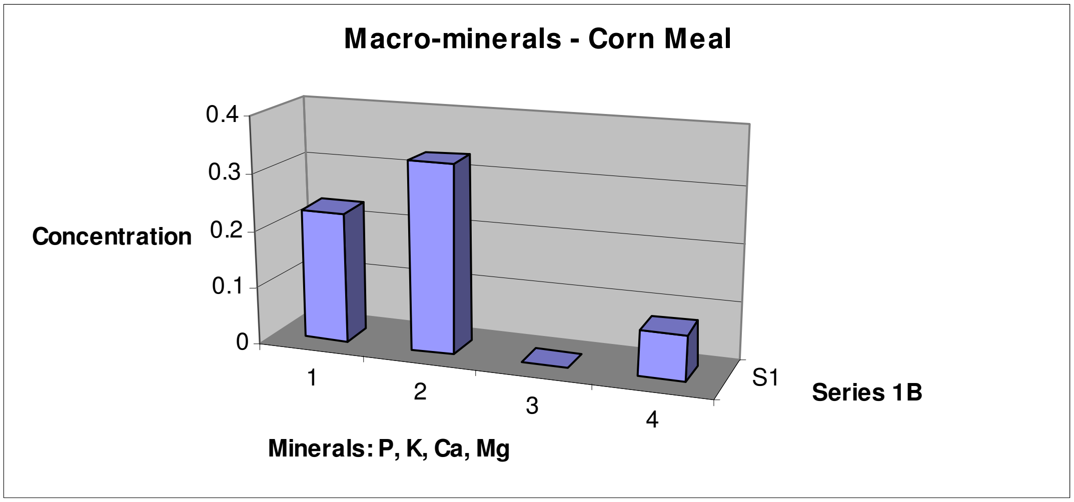
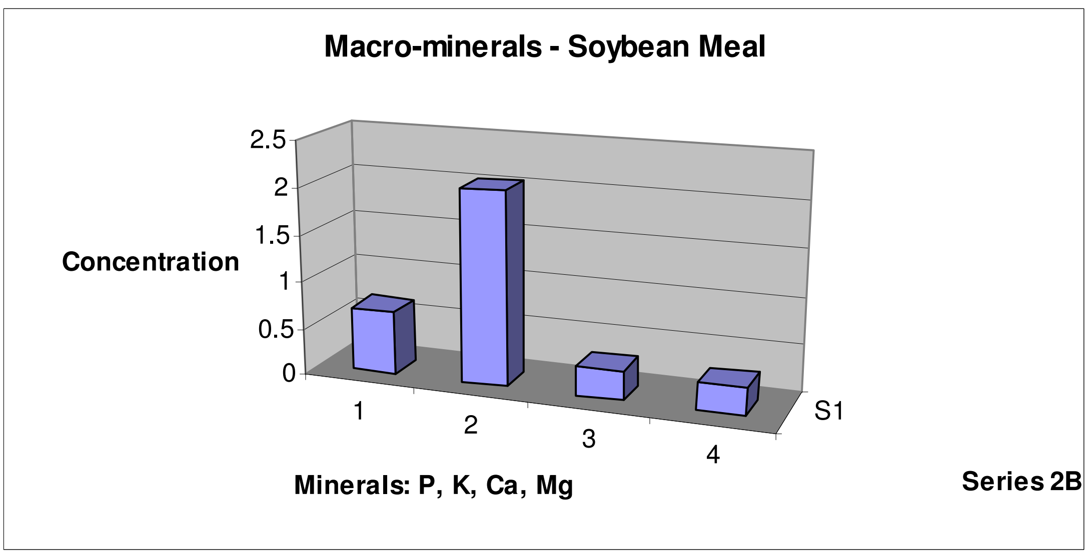


Chart 7. Macro profile for Soybean Meal



Note that the soybean pods mineral profile is similar to that found in the soybean meal and with the exception of calcium, similar to soybean leaves for which calcium is approximately 300% higher.

Chart 8. Macro Profile for Soybean Pods

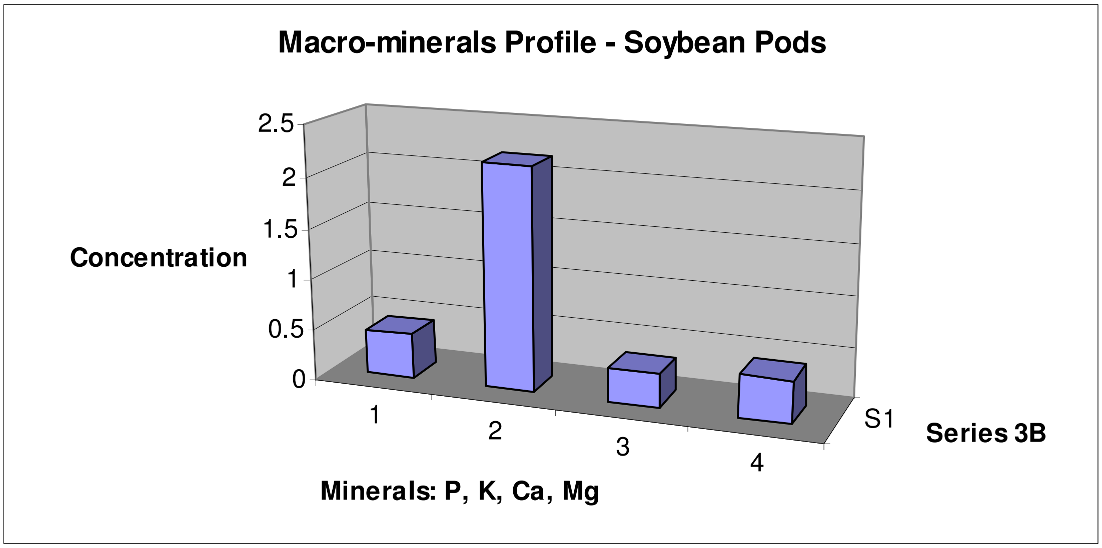


Chart 9. Macro profile for Soybean Leaves

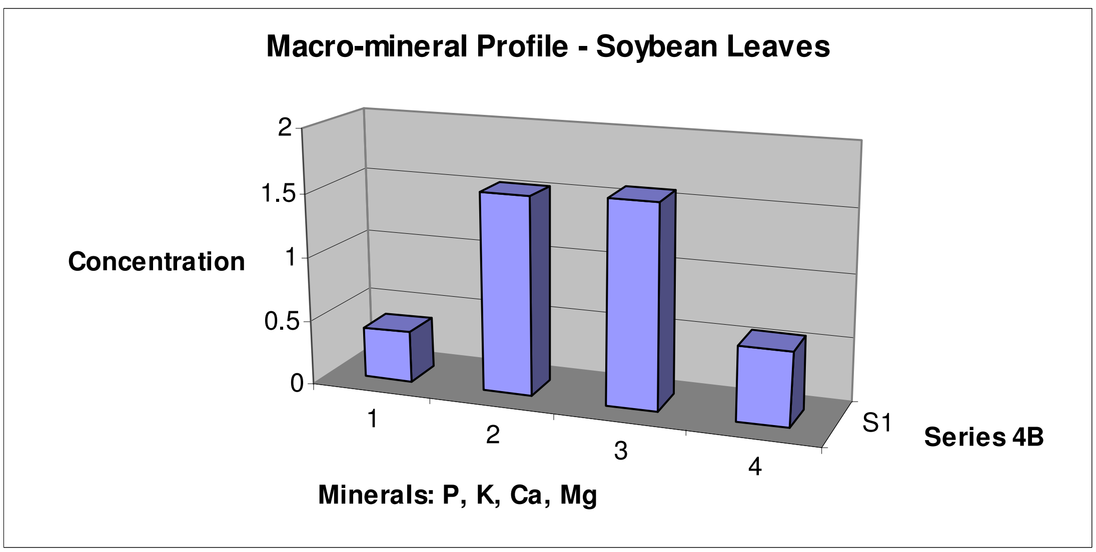
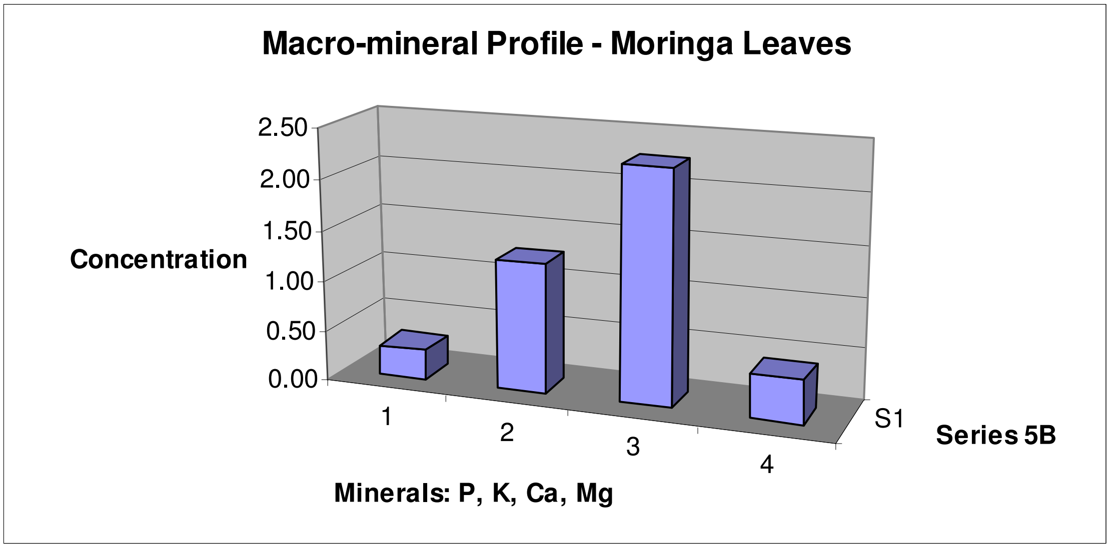


Chart 10. Macro Profile for Moringa Leaves



Note that Moringa leaves are similar to soybean leaves except they are somewhat higher in calcium, lower in potassium and a little lower in magnesium.

CONCLUSIONS

The leaves of the Moringa tree provide a broad range of important minerals for the human diet [Witt, 2013; Covance, 2011; Aslam, 2005; Price, 1985]. In comparison to other common food staples [Batal, 2010], the profile appears superior to corn and is at least comparable to soybeans.

One of the objectives was to compare minerals in leaves and in pods to see if the leaf profile might be predictive of the pod profile. In comparing Charts 3 and 4 for total mineral profile for soybeans it is noted that the leaves have higher concentrations of minerals and the profile is very similar for all but three minerals iron, aluminum and copper. . Iron (6) and aluminum (7) are proportionately higher and copper (8) lower in leaves than in the pods. In comparing Charts 8 and 9 the leaves have a similar profile and concentration as the pods with the exception of calcium in which the leaves were significantly higher than calciuim in the pods. We conclude that the proportional amounts of minerals in the leaves is similar to the proportional amounts in the pods but may be different in quantity. Thus, a leaf analysis may be used (albeit with some caveats) as an early indicator of mineral nutrients in the pods or beans. This correlation is yet to be confirmed in Moringa and other species.

It is not possible at present to assert that the level or proportionate amounts of minerals may account for particular health benefits; benefits that could be achieved by other means such as having a diet containing fruits, vegetables, grains, dairy products, et al. If however one is living in an area lacking such fresh produce, then supplementing one's diet with Moringa extracts would provide an excellent source of the basic minerals along with vitamins, proteins and other nutrients. In at least one analysis, Moringa was found to be rich in anti-oxidants, substances that have known health benefits [ORAC]. More study is required to be able to trace health benefits to plant leaves composition.

REFERENCES AND NOTES

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_________ ORAC Values. The Moringa Source company retained Brunswick Laboratories to test its Moringa samples to determine Oxygen Radical Absorbance Capacity (or ORAC value score). The ORAC value score is an accepted measurement of antioxidants in foods and supplements. It scored very high. https://www.moringasource.com/pages/moringa-sources-orac-test

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Remus, J. C., M. Hruby, and M. Cunha. 2010b. Phosphorus and phytate phosphorus levels in harvest year 2008 corn from Brazil and United States. Poult. Sci. 89 (Suppl. 1):209. (Abstr.)

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July 2015, Volume 58, Issue 7, pp 627–638 . https://link.springer.com/article/10.1007%2Fs11427-015-4872-x

WEBSITES RELATING TO MORINGA THAT CITE OTHER STUDIES

Note: The following sites are commercial sites that extol the virtues of Moringa, their ingredients and related products. However, there are some references made to studies that we presume are less self-serving.

http://moringatrees.org/
22 Shelter Rock Lane 261, Unit 3 Danbury, CT 06810, USA
https://miracletrees.org/#moringadocuments

Moringa Source LLC
22 Shelter Rock Lane #3, Danbury CT, 06810
https://www.moringasource.com/pages/moringa-product-data
https://www.moringasource.com/pages/moringa-sources-orac-test

_________ "Moringa Nutrition Data. What Makes Moringa a Superfood" from Moringa Source: https://www.moringasource.com/pages/moringa-product-data

IMAGE INFORMATION

Image 1. Soybeans grown hydroponically in Miracle Gro™ solution. The ones on the right have a Mg supplemented solution. 2017-Oct27-duo-019sc.

Image 2. Pods on soybean plants grown hydroponically in a Micracle Gro™ solution. 2017 Oct27-pods.

Image 3 - Field grown soybean plant showing pods. Grown during the summer of 2017 in the sandhills region of North Carolina. Image name: 2017-Oct27-Farm-pods-052sc.jpg.

Image 4 Pot grown Moringa Year 1 mid-season, August 14, 2016.

Image 5. Moringa - in second year of growth following a winter dormant period and die-back. The original plant was repotted and developed new shoots as shown. The yard sticks are shown end-to-end against the white backdrop. Some branches were removed for tissue analysis during this period. Photo taken August 31, 2017 - Over-all height is 109 inches. Image ID 2017-Oct 021crp.jpg.

Image 6. Moringa near end of second growing season - October 24, 2017. Samples were taken for tissue analysis. Other branches were removed and dried for use as a tea. Photo ID (from Moringa 2017 folder) 2017-Oct24-004-sc.jpg.

ACKNOWLEDGMENT

The author gratefully acknowledges the support of Gary Maddox who provided the field grown samples of soybeans that were locally raised in Harnett County of North Carolina.

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http://www.iprsinc.org and http://www.enbede.com

IPRS is a non-profit corporation holding a 501(c)(3) IRS tax exemption.

Appendix

Product: Miracle-Gro Potting Mix 0.21-0.11-0.16
Product #:0698-0126

GUARANTEED ANALYSIS	(%)	REPORTED METALS	(ppm)
Total Nitrogen (N)	**0.2100**	Arsenic	**0.9740**
Available Phosphoric Acid (P_2O_5)	**0.1100**	Cadmium	**0.4860**
Soluble Potash (K_2O)	**0.1600**	Cobalt	**4.7400**
Calcium (Ca)		Mercury	**0.0334**
Magnesium (Mg)		Molybdenum	**1.4600**
Sulfur (S)		Nickel	**1.8500**
Boron (B)		Lead	**3.7900**
Chlorine (Cl)		Selenium	**1.4600**
Cobalt (Co)		Zinc	**18.3000**

State of Washington Fertilizer Product Registration site
https://agr.wa.gov/PestFert/Fertilizers/FertDB/prodinfo.aspx?pname=2882

The Potting Mix product is formulated from (one or more of the following: processed forest products, peat, coir, and/or compost), and sphagnum peat moss, perlite, fertilizer (as above), and a wetting agent.

Product Miracle Gro 24-8-16 Water Soluble All Purpose Plant Food
Scotts Miracle-Gro Products Inc - Marysville, Oh

Heavy Metals (in Parts Per Million)		
Arsenic: < 0.63	**Cadmium:** < 0.315	**Mercury:** < 0.0283
Nickel: < 0.479	**Lead:** 4.15	
Guaranteed Analysis		
Total Nitrogen: 24%	**Avail. Phosphate:** 8%	**Sol. Potash:** 16%
Calcium:	**Magnesium:**	**Sulfur:**
Boron: 0.02%	**Chlorine:**	**Cobalt:**
Copper: 0.07%	**Iron:** 0.15%	**Manganese:** 0.05%
Molybdenum: 0.0005%	**Sodium:**	**Zinc:** 0.06%

State of Oregon Fertilizer Product Registration site ss of: 2/28/2018
http://oda.state.or.us/dbs/heavy_metal/detail.lasso?-op=eq&product_id=4552

Quality of Water Used for Watering Plants and Making up Fertilizer Solutions

Substance (Unit of Measure	**Amount Detected**	**Range Low-High**
Alkalinity (ppm)	42	NA
Hardness (ppm)	35	NA
Iron (ppm)	.01	NA
Manganese (ppm)	.02	NA
pH (units)	8	6.5-8.5
Raw Total organic Carbon (ppm)	7.3	6.3-8.8
Sodium (ppm)	32.3	NA
Regulated Substances		
Sulfate (ppm)	41.6	NA
Nitrate (as Nitrogen) (ppm)	1.41	ND-1.41

City of Sanford Water Treatment Plant: Unregulated and Other Substances from CCR-49, Sampled 2008 (old report). Data for hardness measured throughout the year of 2017 was also obtained with comparable results. Water from Cape Fear River and two wells.

Water Hardness is measured according to Standard Methods: 2340C: EDTA Titrimetric Method (Hardness). Standard Methods Online -- Standard Methods for the Examination of Water and Wastewater. http://standardmethods.org/

Manganese is measured according to the *Direct Air-Acetylene Flame Method. See* NEMI Method Summary - 3111B at *https://www.nemi.gov/methods/method_summary/5703/.*