Meet Moringa: A Specialty Crop for Improved Health & Nutrition in California

Moringa Awareness Training: Part 1 of 3

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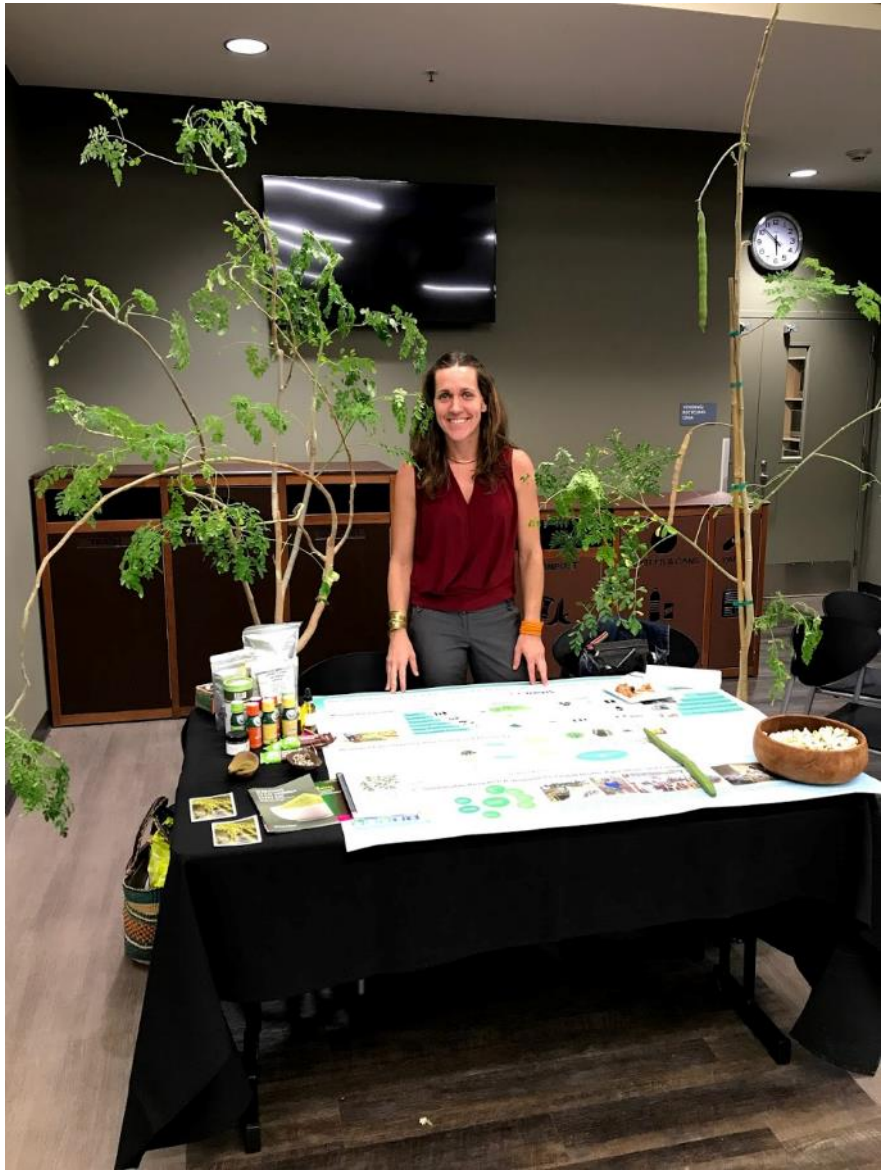
What is Moringa	Define the *Moringa oleifera* (moringa) species
	History & Uses
Why we should eat moringa	Nutrition
	Health
Making Global Solutions Local	Expanding moringa cultivation & consumption in CA for sustainable social, environmental and economic outcomes



Moringa oleifera (moringa)

Order: Brassicales

Family: Moringaceae

Common names: Drumstick tree, Horseradish tree

Grows in semiarid, tropical, and subtropical areas

Thrives in poor sandy soils, is drought tolerant & fast growing

Moringa oleifera (moringa)

Temp	25-30°C ideal for leaf production
Altitude	0 – 2000 m; <600 ideal
Rainfall	250 – 3000 mm *Irrigation needed for leaf production if rainfall < 800 mm
Soil Type	Loamy, sandy, or sandy-loam
Soil pH	~7 but can endure pH 5 – 9
US Zone	9-11

http://cagardenweb.ucanr.edu/Your_Climate_Zone/

Nutrition

- **~27% protein by dry weight**
- All essential amino acids –including high levels of lysine and methionine
- Recommended 1 tablespoon per day
- **A 10 g serving provide approximately 3 g of protein, or ~4.3% of the daily requirement for protein for a 70 kg person.**
- Severely malnourished children (aged 6 months–5 years) given 10g daily, in addition to the regular nutrition intervention, gained more weight and recovered faster compared to the control group.*

*Zongo U, et al. Nutritional and clinical rehabilitation of severely malnourished children with Moringa oleifera Lam. leaf powder in Ouagadougou (Burkina Faso). Food and Nutrition Sciences. 2013 Aug 19;4(09):991.

Nutrition

- School children consuming moringa-fortified snack foods with 3g of moringa exhibited increased hemoglobin (an indicator for anemia), Vitamin A, and folic acid levels.**
- Analysis of 6 randomized controlled studies concluded moringa consumption increased breast milk supply in nursing mothers by day 7 and increased weight gain of moringa-breastfeed infants compared to controls.***
- All consulted studies found moringa to be safe and acceptable for consumption at dosages delivered.

**Serafico ME, et al. Efficacy of Malunggay (*Moringa oleifera*) leaves in improving the iron and vitamins A and B status of Filipino schoolchildren. International Symposium on Moringa 1158 2015 Nov 15 (pp. 293-302).
***Raguindin PF, et al. *Moringa oleifera* as a Galactagogue. Breastfeeding Medicine. 2014 Jul 1;9(6):323.

Nutrient (per 100 g)	Fresh Leaves	Dried Leaf Powder
Water (g)	78.7	7.4
Energy (kcal)	64	304
Protein (g)	9.4	29.1
Fat (g)	1.4	6
Carbohydrate (g)	8.3	38.2
Fiber (g)	2	19.2
Calcium, Ca (mg)	185	2003
Magnesium, Mg (mg)	42	368
Phosphorus, P (mg)	112	204
Potassium, K (mg)	337	1324
Copper, Cu mg)	0.11	0.57
Iron, Fe (mg)	4	28.2
Zinc, Zn (mg)	0.6	2.4
Sodium, Na (mg)	9	220
Vitamin C (mg)	51.7	172
Thiamin (mg)	0.26	2.6
Niacin (mg)	2.22	8.2
Vitamin B-6 (mg)	1.2	2.4
Folate (µg)	40	540
Vitamin A, RAE (µg)	378	3639

Moringa is considered a nutrient-dense plant, which can be explained by low water content and the accumulation of nutrients and minerals.

These nutrients can be further concentrated by drying and removal of water.

Nutritional content can vary by a number of factors including genetic/geographic origins, production, cultivation techniques, and processing.

This table lists the estimated nutrient content of fresh and dried moringa leaves (Witt, 2014; USDA 2019)

Nutrient	Amount in 10 g dried moringa powder	% of daily recommended value provided by 10 g of moringa	
		19-30 yr old women	1-3 yr old children
Protein (g)	2.91	6%	22%
Fiber (g)	4	16%	21%
Calcium, Ca (mg)	160.47	20%	32%
Magnesium, Mg (mg)	28.34	11%	44%
Potassium, K (mg)	174.5	4%	6%
Iron, Fe (mg)	2.82	35%	94%
Zinc, Zn (mg)	0.29	4%	12%
Vitamin C (mg)	17.2	29%	132%
Thiamin (mg)	0.26	29%	65%
Niacin (mg)	0.82	7%	16%
Vitamin B-6	0.24	22%	60%
Folate (µg)	54	17%	45%
Vitamin A, RAE (µg)	363.9	73%	173%
Riboflavin (mg)	0.53	35%	84%

Thus, **this table shows the estimated and averaged nutritional content in a 10 g serving of dried moringa powder and % or daily recommended value for women and young children.** (Witt, 2014; Food and Nutrition Board; Institute of Medicine; National Academies, 2011)

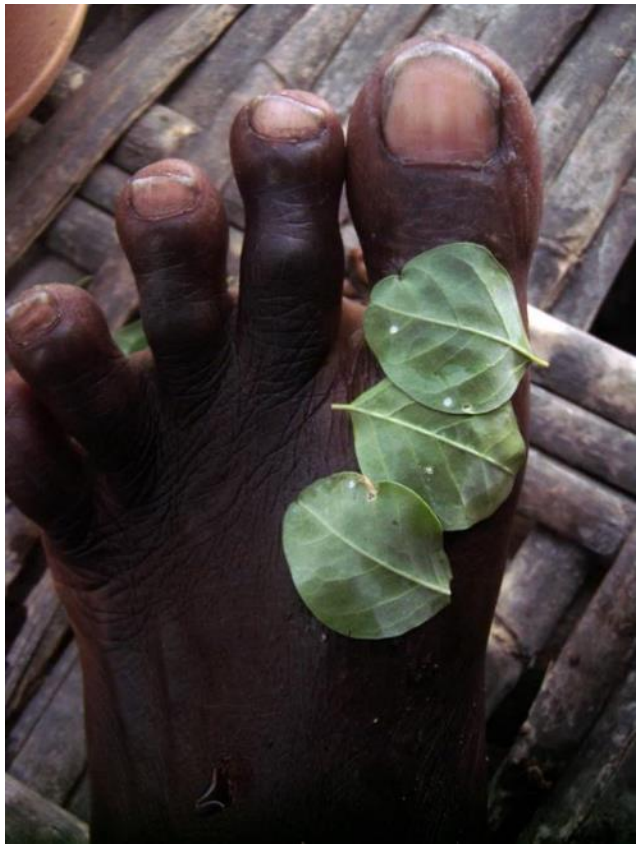
Nutrition Comparison to Spinach

Nutrient	Unit	Moringa per 100 g	Spinach per 100 g
Proximates			
Water	**g**	**78.66**	**91.4**
Energy	kcal	64	23
Energy	kJ	268	97
Protein	g	9.4	2.86
Total lipid (fat)	g	1.4	0.39
Ash	g	2.26	1.72
Carbohydrate, by difference	g	8.28	3.63
Fiber, total dietary	g	2	2.2
Minerals			
Calcium, Ca	mg	185	99
Iron, Fe	mg	4	2.71
Magnesium, Mg	mg	147	79
Phosphorus, P	mg	112	49
Potassium, K	mg	337	558
Sodium, Na	mg	9	79
Zinc, Zn	mg	0.6	0.53
Copper, Cu	mg	0.105	0.13
Manganese, Mn	mg	1.063	0.897
Selenium, Se	µg	0.9	1
Vitamins			
Vitamin C, total ascorbic acid	mg	51.7	28.1
Thiamin	mg	0.257	0.078
Niacin	mg	2.22	0.724
Pantothenic acid	mg	0.125	0.065
Vitamin B-6	mg	1.2	0.195
Folate, total	µg	40	194
Vitamin B-12	µg	0	0
Vitamin A, RAE	µg	378	469
Vitamin A, IU	IU	7564	9377
Amino Acids			
Tryptophan	g	0.144	0.039
Threonine	g	0.411	0.122
Isoleucine	g	0.451	0.147
Leucine	g	0.791	0.223
Lysine	g	0.537	0.174
Methionine	g	0.123	0.053
Cystine	g	0.14	0.035
Phenylalanine	g	0.487	0.129
Tyrosine	g	0.347	0.108
Valine	g	0.611	0.161
Arginine	g	0.532	0.162
Histidine	g	0.196	0.064
Alanine	g	0.705	0.142
Aspartic acid	g	0.92	0.24
Glutamic acid	g	1.035	0.343
Glycine	g	0.517	0.134
Proline	g	0.451	0.112
Serine	g	0.414	0.104
Flavonoids			
Kaempferol	mg	6	6.4
Myricetin	mg	0	0.4
Quercetin	mg	16.6	4

http://ndb.nal.usda.gov/ndb/foods/show/3009?fgcd=&manu=&lfacet=&format=&count=&max=35&offset=&sort=&glookup=moringa

Traditional & Modern Uses

- Inflammation
- Diabetes & cardiovascular diseases
- Gastrointestinal & hepatorenal disorders
- General well being



amanduhinafrica.wordpress.com

Moringa

Potential Health Benefits

Reduces blood pressure and cholesterol levels

Controls blood sugar in prevention and treatment of diabetes

Stabilizes body weight Builds muscle and reduces excess fat

Enhances brain function and memory Reduces anxiety and headaches

Builds strong bones Prevents inflammation Treat arthritis in joints

Boosts immune system helping fight colds and viruses

Provides children with essential vitamins and nutrients

Increases breast milk & nutrition for infants

Increases energy, and body function Improves sleep

Moringa for Hyperglycemia

A. ANIMAL MODELS					
Species	**Inducer**	**Plant part (extract)**	**Protocol[a]**	**Corrective outcomes**	**Reference**
Rat	STZ	Leaf (water)	100–300 mg/kg-bw; p.o., single dose; 8 h	↓FPG; ↑glucose tolerance (OGTT)	Jaiswal et al. (2009)
Rat (GK)	–	Leaf	200 mg/kg-bw; p.o., single dose; 2 h	↑glucose tolerance (OGTT); ↑stomach content	Ndong et al. (2007b)
B. HUMAN T2DM PATIENTS (FPG > 9 mmol/L)					
Exper. N	**Contr. N**	**Plant part (formulation)**	**Protocol**	**Corrective outcomes (in the experimental group)**	**Reference**
6	6	Leaf (meal)	50 g/meal; p.o. single; 1 or 2 h	↓PPPG/FPG	William et al. (1993)
46	9	Leaf (tablet)	8 g/day; p.o., daily; 40 days	↓FPG; ↓PPPG	Kumari (2010)
30	30	Leaf (tablet)	2 tablets/day; p.o., daily; 1, 2, 3 months	↓HbA_{1c}; ↓PPPG	Ghiridhari et al. (2011)

Moringa for Hyperlipidemia

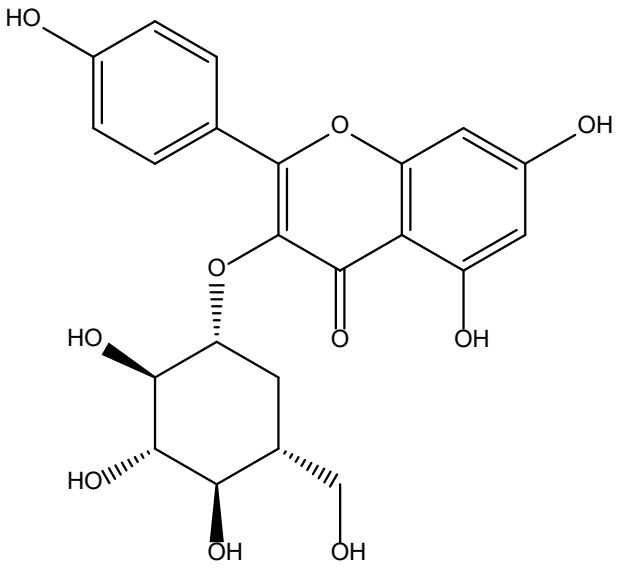
A. ANIMAL MODELS					
Species	**Inducer**	**Plant part (extract)**	**Protocol[a]**	**Corrective outcomes**	**Reference**
Rabbit	HCD	Leaf (water)	5 mg/kg-bw; p.o., daily; 12 weeks	↓TC; ↓LDL; ↓HDL; ↓TG; ↓carotid plaque formation	Chumark et al. (2008)
Rat	HFD	Leaf (water)	1 g/kg-bw; p.o., daily; 30 days	↓TC	Ghasi et al. (2000)
Rat	HFD	Leaf (methanol)	150–600 mg/kg-bw; p.o., daily; 30 days	↓TC; ↓LDL; ↑HDL; ↓VLDL; ↓TG; ↑fecal cholesterol; ↓atherogenic index	Jain et al. (2010)
B. HUMAN HYPERLIPIDEMICS (TC > 180 mg/dL or TG > 140 mg/dL)					
Exper. N	**Contr. N**	**Plant part (formulation)**	**Protocol**	**Corrective outcomes (in the experimental group)**	**Reference**
17	18	Leaf (tablet)	4.6 g/day; p.o., daily; 50 days	↓TC; ↑HDL-C; ↓non-HDL-C	Nambiar et al. (2010)
46	9	Leaf (tablet)	8 g/day; p.o., daily; 40 days	↓TC; ↓LDL-C; ↓VLDL-C	Kumari (2010)

Mbikay, Majambu. "Therapeutic potential of Moringa oleifera leaves in chronic hyperglycemia and dyslipidemia: a review." Frontiers in pharmacology 3 (2012): 24.

Summary of clinical studies and outcomes using moringa leaf powder

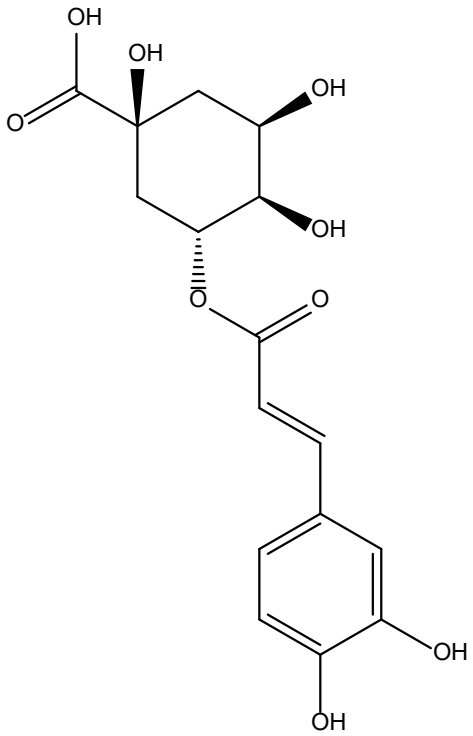
Study design	MO Treatment	Outcomes	Reference
Postmenopausal women (Randomized controlled trial); 30 females; age range 45–55 years	Leaf powder 7 g daily for 3 months	Significant increase in hemoglobin and circulating antioxidant agents.	Kushwaha, 2014
Type 2 DM (Prospective randomized placebo-controlled study) 9 females, 7 males; age range 20–70 years	Leaf powder capsules 4 g daily before breakfast and dinner for 1 month.	Insulin not measured. No significant difference in HbA1C. No changes in BUN, creatinine, ALT or AST.	Taweerutchana, 2017.
DM (Prospective quasi experimental study) 48 females, 12 males; age range 19–65 years	Leaf powder capsules 500 mg capsule (3 times/day) for 12 weeks	Significant reduction in HbA1c in MO-treated patients. Insulin not measured. Significant reduction in high specificity C-Reactive Protein, in MO-treated patients.	Mozo, 2015
Type 2 DM and healthy subjects (Randomized controlled trial) 17 DM (9 females, 8 males); 10 healthy (6 females, 4 males)	Leaf powder 20 g once	Significant reduction in glycaemia up to 150 min after intake of 20 g of moringa leaf powder (268±18 mg/dL) compared with Con (296±17 mg/dL, $p < 0.001$).	Leone, 2018
Type 2 DM controlled trial (36 men and 19 women); age range 30-60 years	Leaf powder 8g daily for 40 days	Significant reduction in fasting blood glucose and post prandial blood glucose levels, total cholesterol and low-density lipoprotein (LDL) compared to control group.	Kumari, 2010
Patients with serum total cholesterol > 180 mg/dl and/ or serum triglycerides > 140 mg/dl (27 men and 9 women); age range 41-60	Leaf powder 4.6 gr daily for 50 days	Significant decrease in total cholesterol and increase in high density lipoprotein. (HDL).	Nambiar, 2010
Systematic analysis of 6 randomized controlled studies concluded moringa consumption and breastmilk supply; pooled 73 patients from all studies		Increased breast milk supply in nursing mothers by day 7 and increased weight gain of moringa-breastfeed infants compared to controls.	Raguindin, 2014

Moringa Phytochemistry: Polyphenols



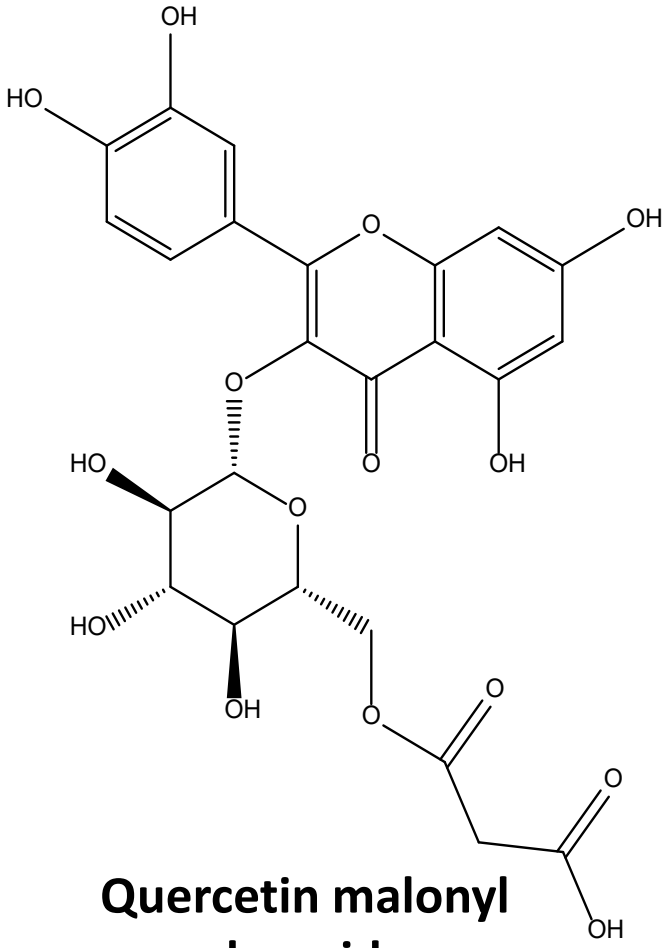
Kaempferol glucoside

- Antioxidant
- Antimicobial
- Anti-hypertensive



Chlorogenic acid

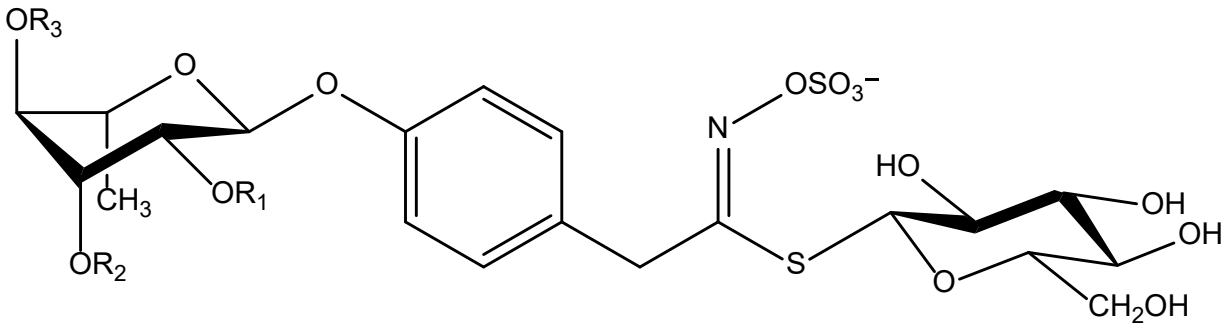
- Improves glucose metabolism and liver function



Quercetin malonyl glucoside

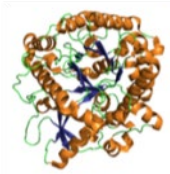
- Potent antioxidant
- Reduces lipid formation
- Hypotensive

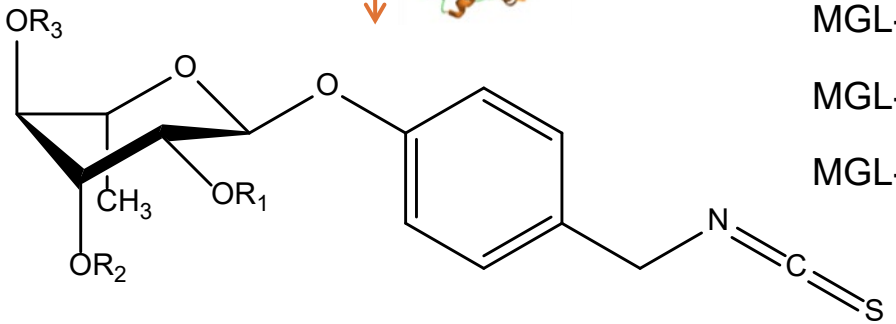
Moringa Phytochemistry: Isothiocyanates (MICs)



Moringa glucosinolates (MGLs)

Myrosinase



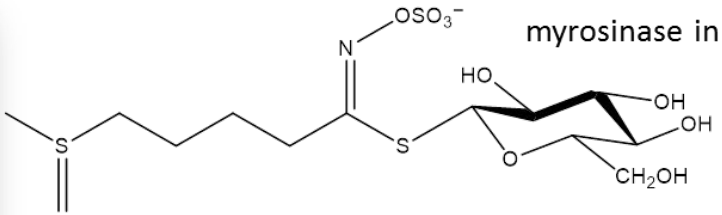


Moringa isothiocyanates (MICs)

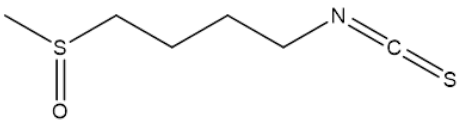
Compounds	R1	R2	R3
MGL-1 & MIC-1	H	H	H
MGL-2 & MIC-2	Ac	H	H
MGL-3 & MIC-3	H	Ac	H
MGL-4 & MIC-4	H	H	Ac

MICs are unique motifs of common isothiocyanates

Broccoli → Glucoraphanin → Sulforaphane (SF)



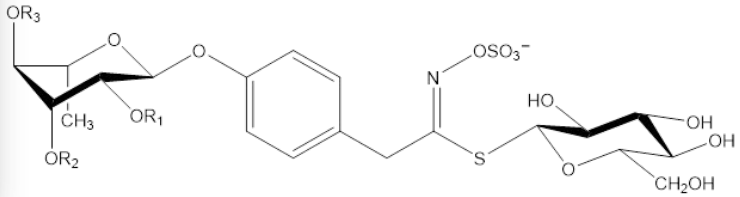
Variable conversion by myrosinase in microflora.

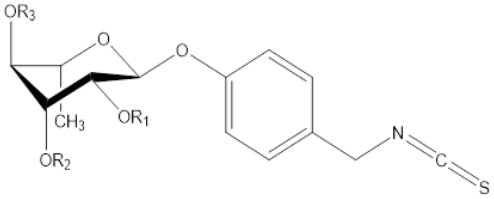


- Volatile Oil
- Very Unstable
- Rapid degradation

Moringa → Glucomoringinins (MGLs) → Moringa Isothiocyanates (MICs)

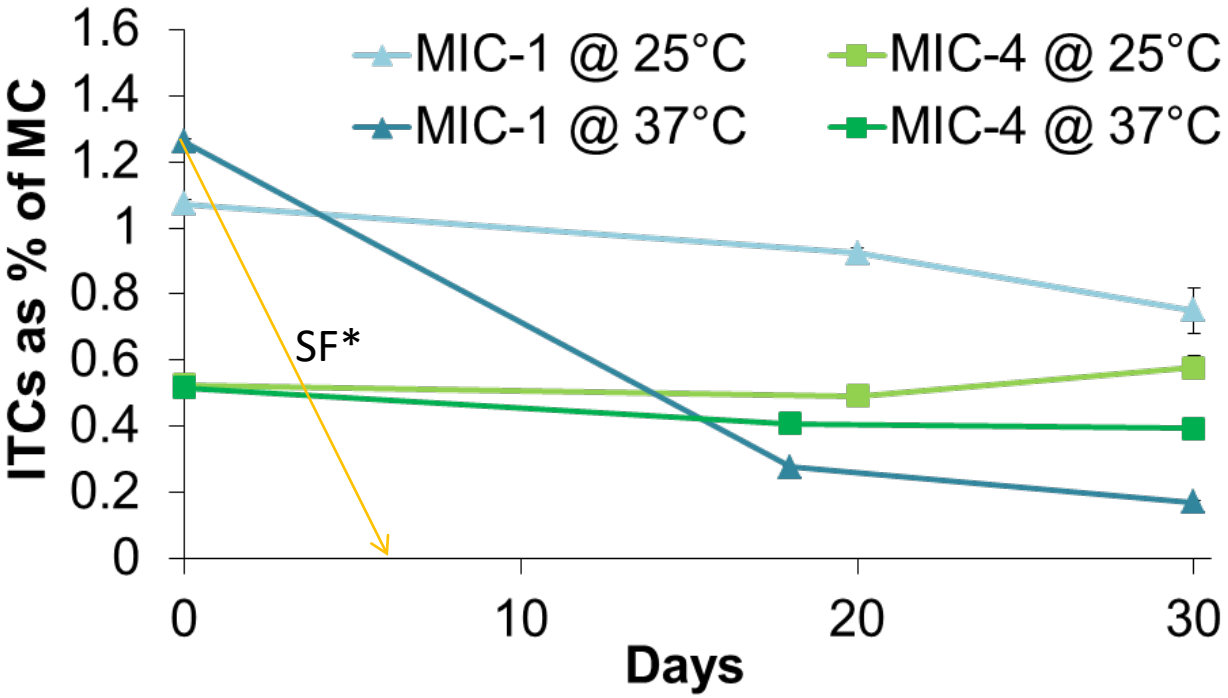
Controlled conversion by myrosinase in extraction.





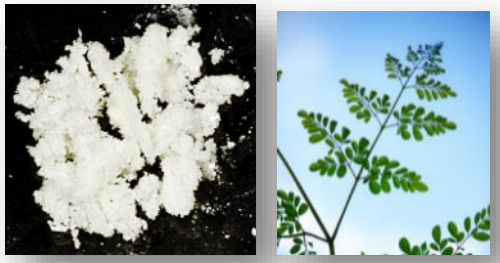
- Sugar moiety on aglygone
- Solid and stable

MICs are chemically stable



*Reported stability of sulforaphane (SF)

Sulforaphane (SF)



MIC-4

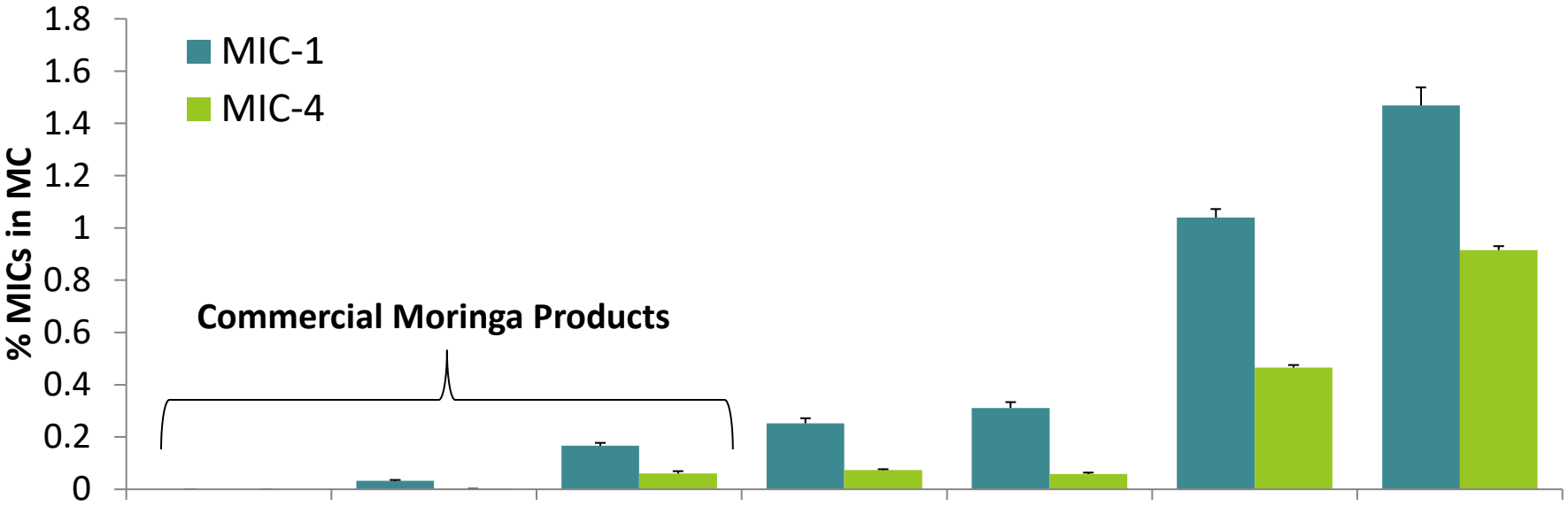
Waterman, C., Cheng, D.M., Rojas-Silva, P., Poulev, A., Dreifus, J., Lila, M.A., Raskin, I. **2014**. Stable, water extractable isothiocyanates from *Moringa oleifera* leaves mediate inflammation *in vitro. Phytochemistry.* http://dx.doi.org/10.1016/j.phytochem.2014.03.28

Cellular and animal studies on activity of MICs

Activity	Description	Reference
Anti-inflammatory	Reduced expression of inflammatory cytokines IL-1β, iNOS, TNFα and COX-2 and nitric oxide (NO) production	Waterman, 2014; Jaj-Chimedza, 2017; Graft, 2017; Park, 2011; Giacoppo, 2017
Blood sugar regulation	Reduced production of glucose and GP6 expression in liver cells. Delay in onset of T2DM in rat model	Waterman, 2015; Waterman 2020
Indirect antioxidant	Stimulate the Nrf-2 Keap pathway involved in detoxification and cellular protection	Tumer, 2015
Anti-cancer	Reduced NF-κB expression and myeloma growth in mice. Induction of apoptosis and Inhibition of prostate cell (PC-3) growth	Brunelli, 2010; Jaafaru, 2018
Cognitive health	Reduced motor deficits in mice with subacute Parkinson's disease	Giacoppo, 2017
Digestive health	Alleviated ulcerative colitis symptoms and inflammation in mice	Kim, 2017
Neurological and immune health	Reduced inflammatory and biomarkers of multiple sclerosis, amyotrophic lateral sclerosis (ALS), and decreased secondary damage in a model of spinal cord injury	Galuppo, 2014; Galuppo, 2015; Giacoppo, 2015

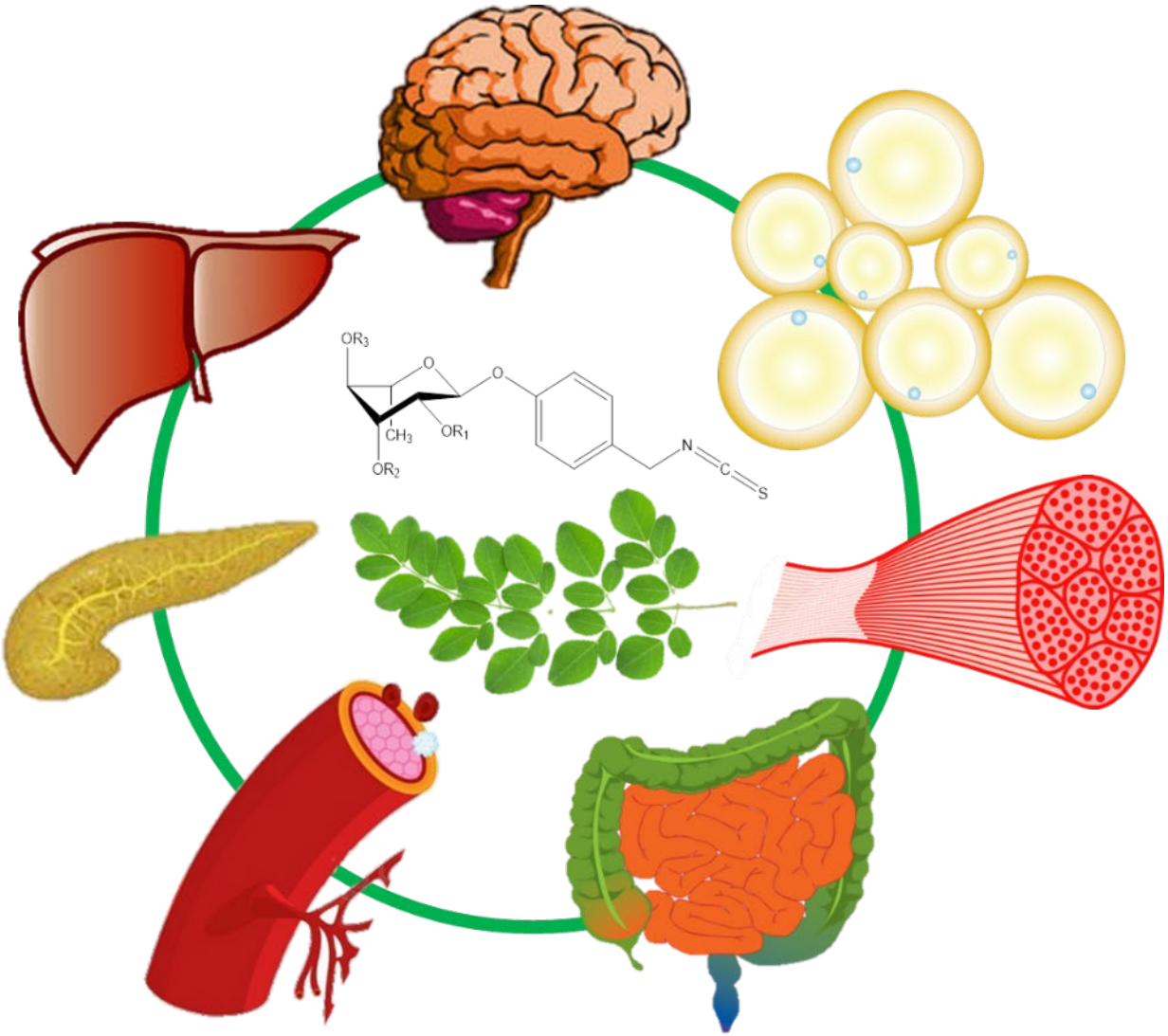
Commercial Moringa Production – Dry and Crush

Concentrating MICs – Crush THEN Dry

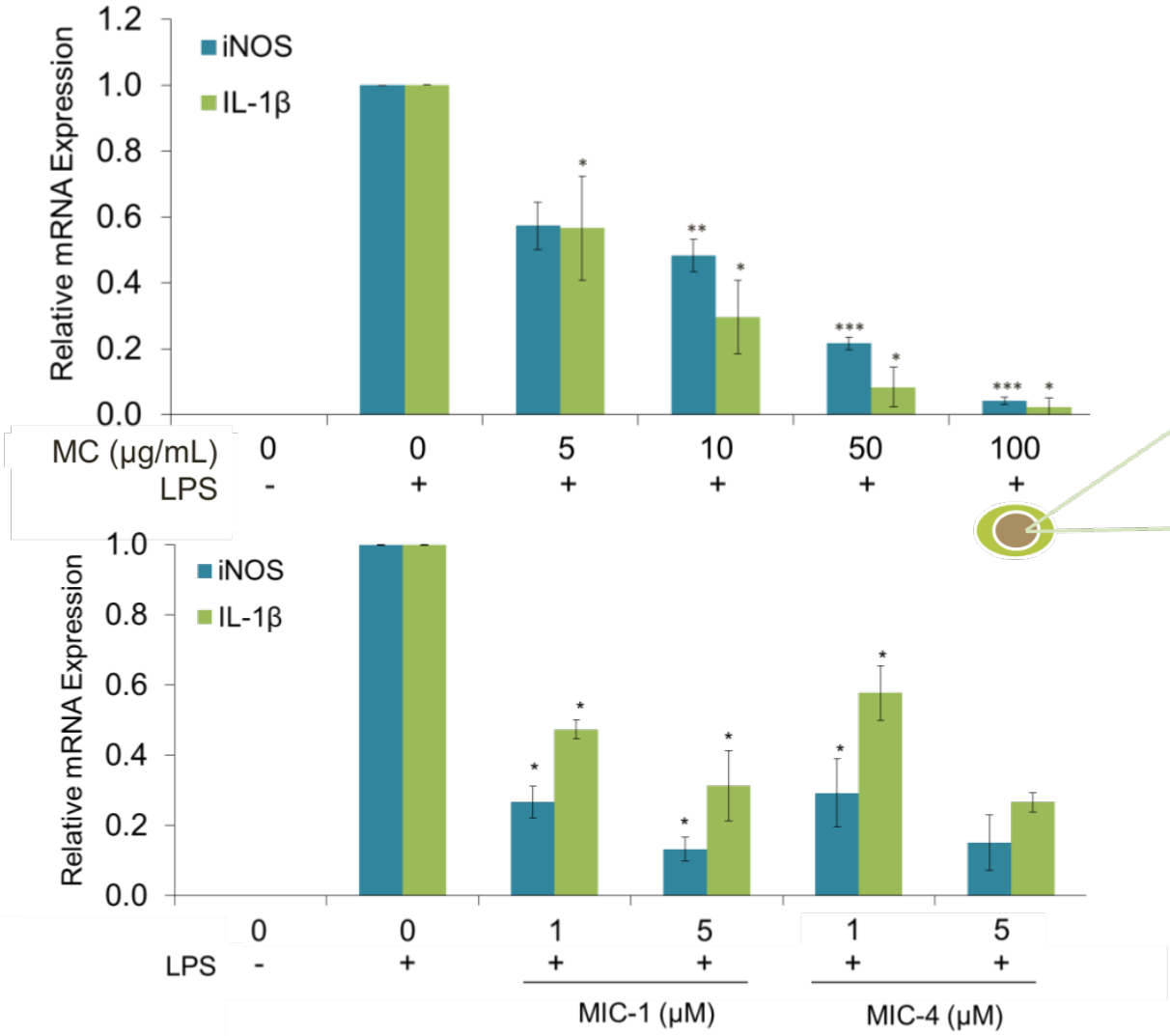


Zija | Moringa Farms | Imagine Zambia | Blended | Rolled | Extracted, Filtered & Centrifuged (MC) | Extracted & Filtered

Biological activity of Moringa and MICs



Moringa Concentrate (MC) & MICs reduced inflammatory markers in vitro



3.53 µM MIC-1

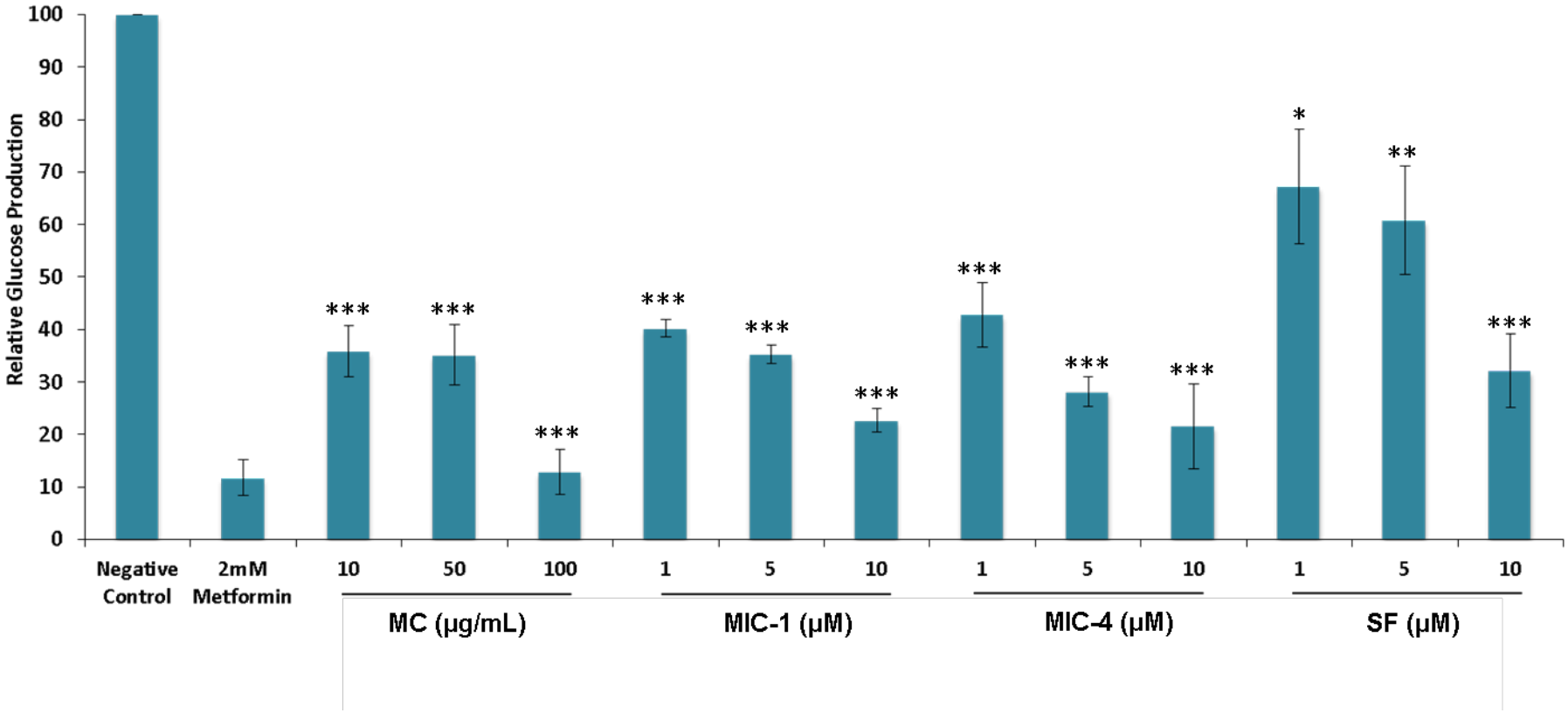
1.43 µM MIC-4

Wilcoxon test. Bars +SEM, (n = 4). *: p<.05,**: p<.01,***: p<.001.

RAW macrophages induced with LPS

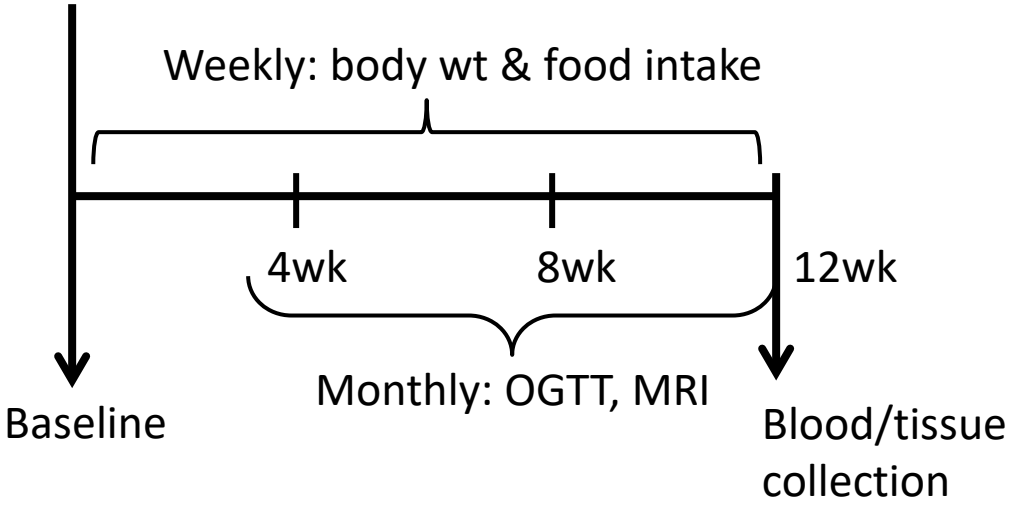
Waterman, C., Cheng, D.M., Rojas-Silva, P., Poulev, A., Dreifus, J., Lila, M.A., Raskin, I. **2014**. Stable, water extractable isothiocyanates from *Moringa oleifera* leaves mediate inflammation *in vitro*. *Phytochemistry.* In Press. http://dx.doi.org/10.1016/j.phytochem.2014.03.28

MICs and MC inhibited gluconeogenesis and expression of G6P and PEPCK in H4IIE liver cells



Waterman C, Rojas-Silva P, Tumer TB, Kuhn P, Richard AJ, Wicks S, Stephens JM, Wang Z, Mynatt R, Cefalu W, Raskin I. **2014**. Isothiocyanates from *Moringa oleifera* reduce weight gain, insulin resistance and hepatic gluconeogenesis in mice. *Molecular Nutrition & Food Research*. DOI: 10.1002/mnfr.201400679

5% MC supplementation reduced pathologies of diabetes in diet-induced obese C57 mice.



	VHFD D12492	5% MC
protein, g	179.0	179.0
CHO, g	203.8	203.8
fat, g	270.0	270.0
protein, kcal	716.0	716.0
CHO, kcal	815.2	815.2
fat, kcal	2430.0	2430.0
total	3961.2	3961.2
protein, kcal%	18.1%	18.1%
CHO, kcal	20.6%	20.6%
fat, kcal%	61.3%	61.3%

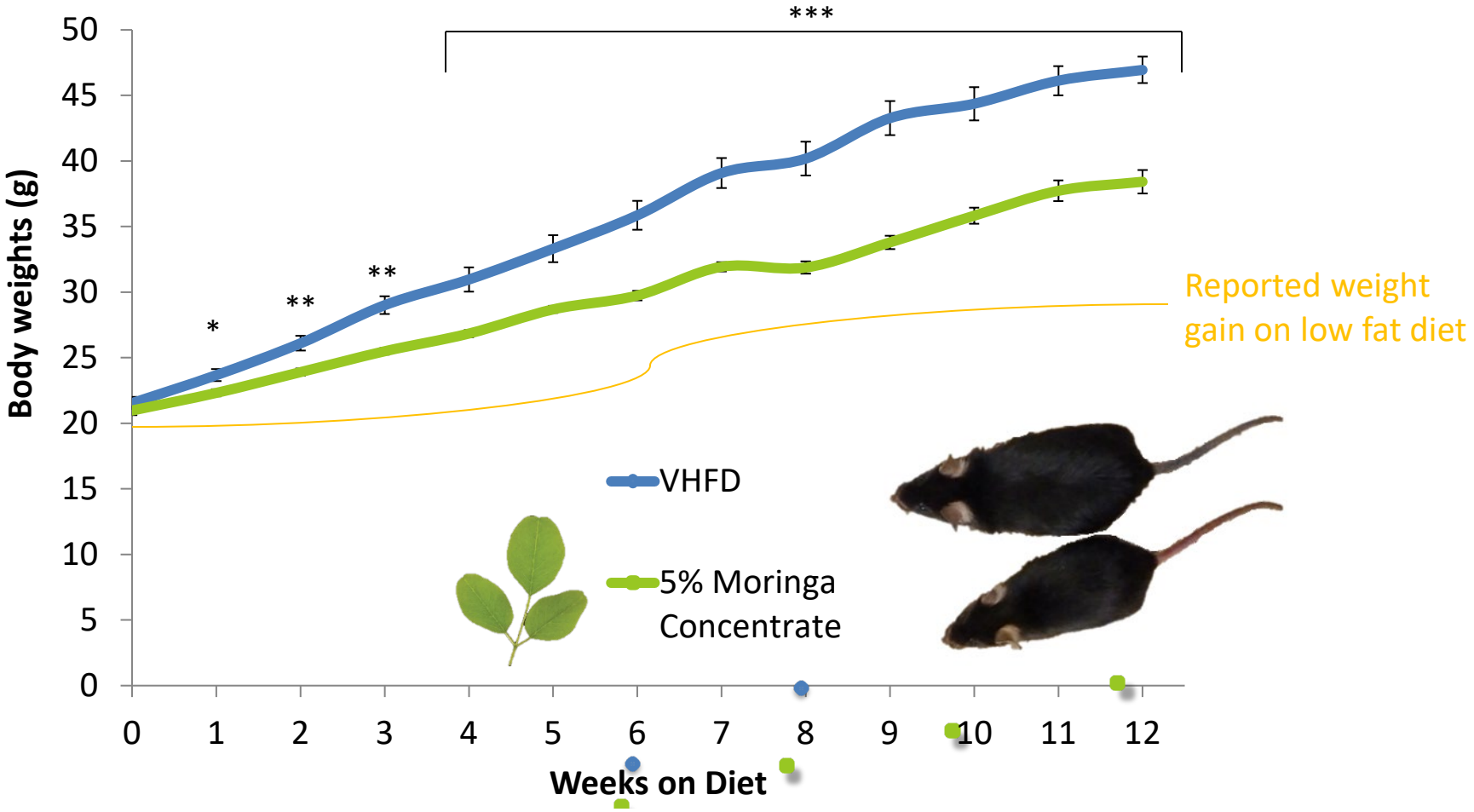
5% MC supplementation delivers:

125 mg of MC per day (4 g/kg/day)

2 mg of MICs per day (66 mg/kg/day)

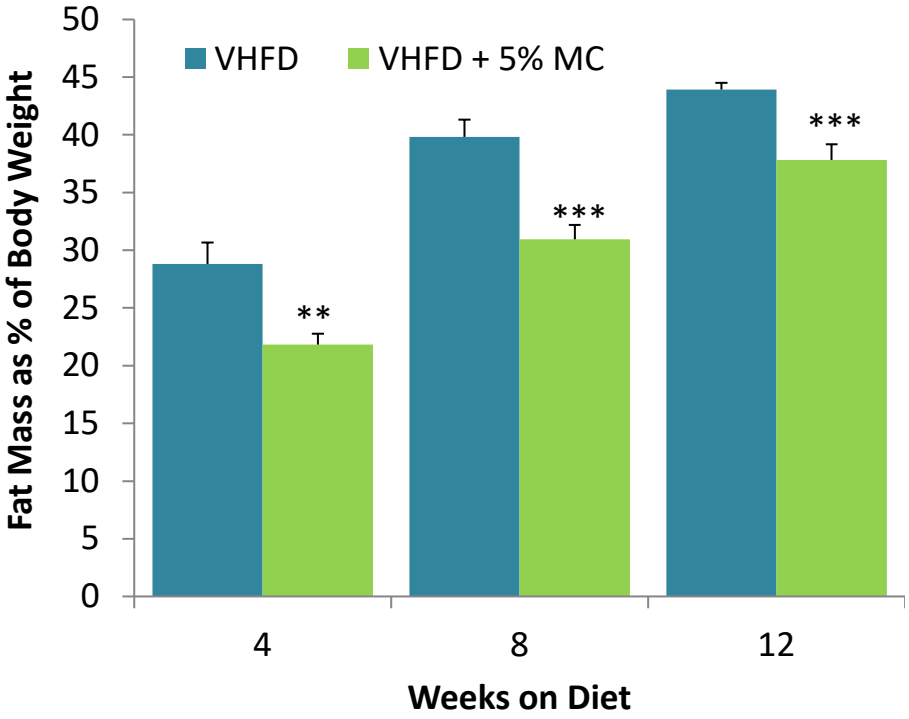
Waterman C, Rojas-Silva P, Tumer TB, Kuhn P, Richard AJ, Wicks S, Stephens JM, Wang Z, Mynatt R, Cefalu W, Raskin I. **2014**. Isothiocyanates from Moringa oleifera reduce weight gain, insulin resistance and hepatic gluconeogenesis in mice. *Molecular Nutrition & Food Research*. DOI: 10.1002/mnfr.201400679

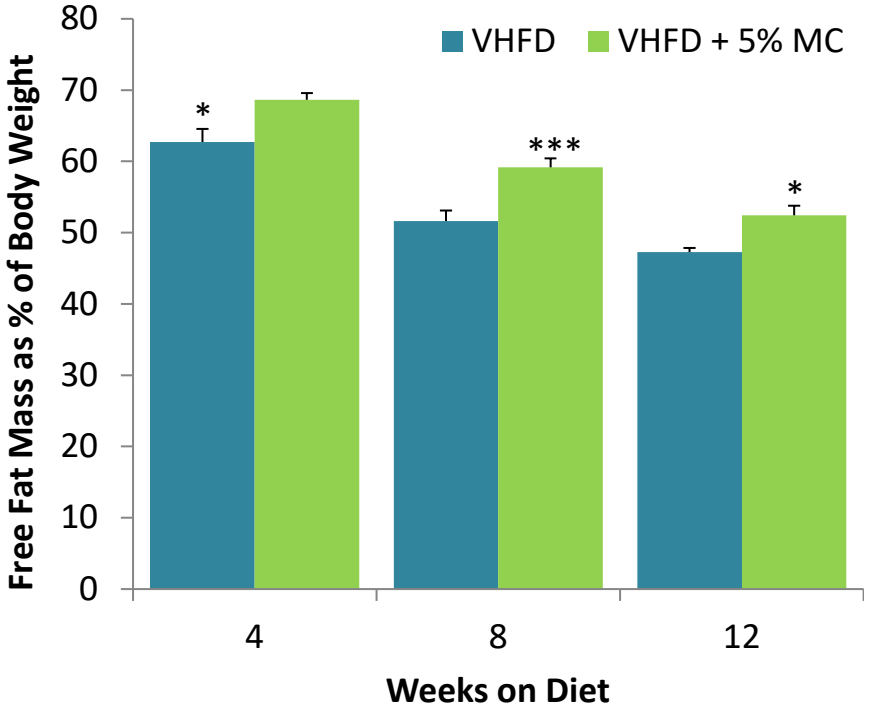
MC-fed mice exhibited reduced weight gain



n=12 mice per group. Comparisons to controls were made by Welch's test. Data are means ± SEM. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

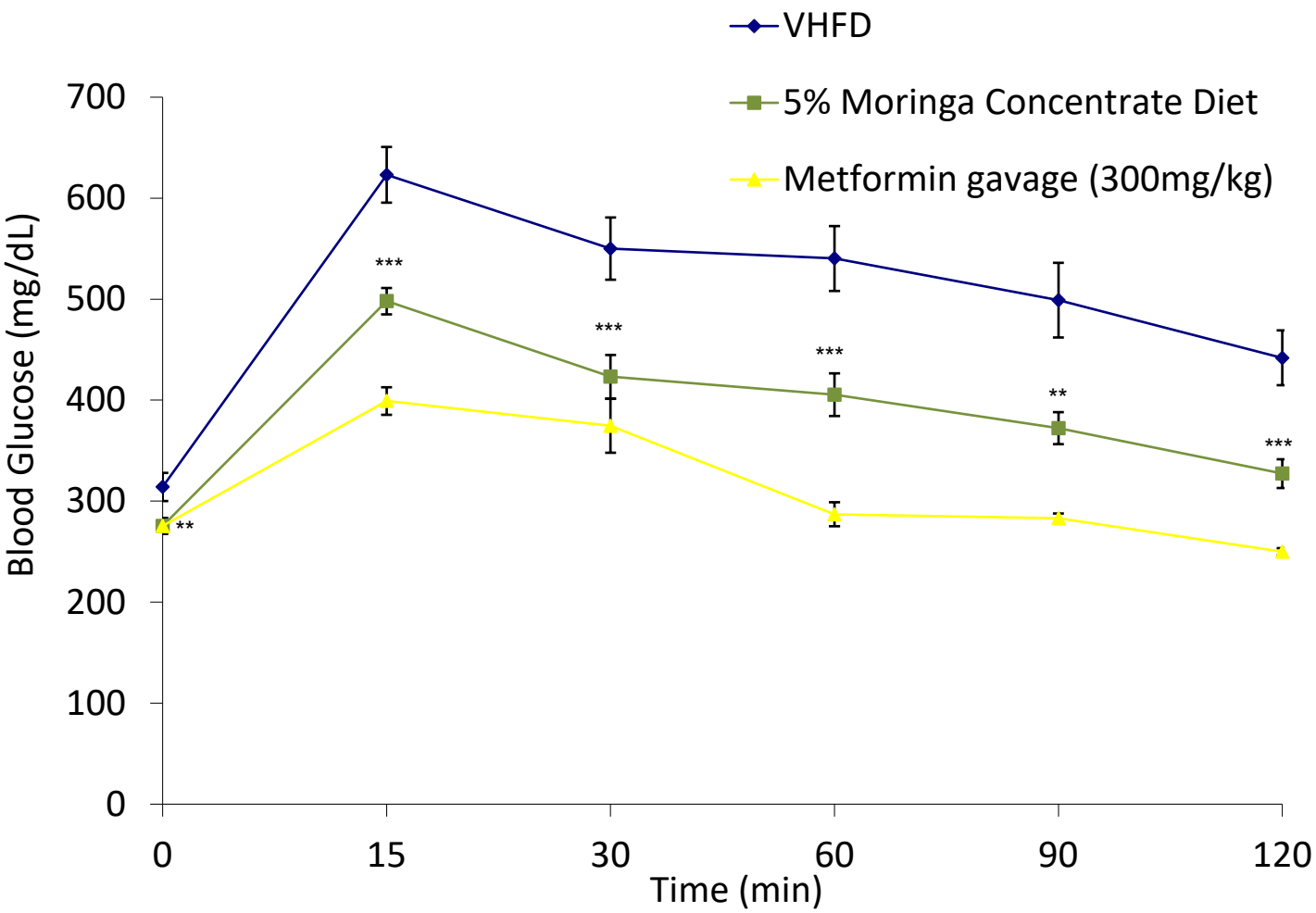
MC-fed mice exhibited reduced fat mass accumulation



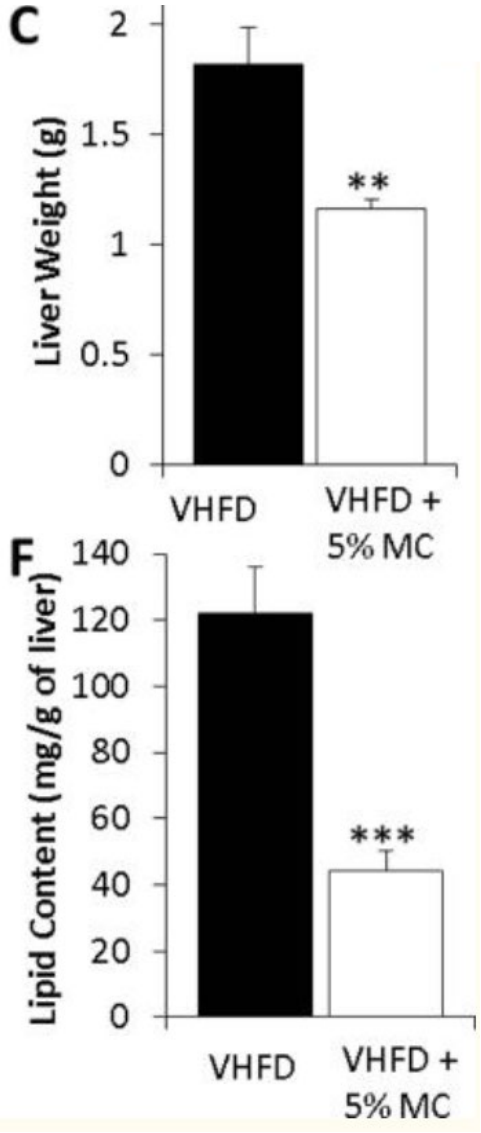


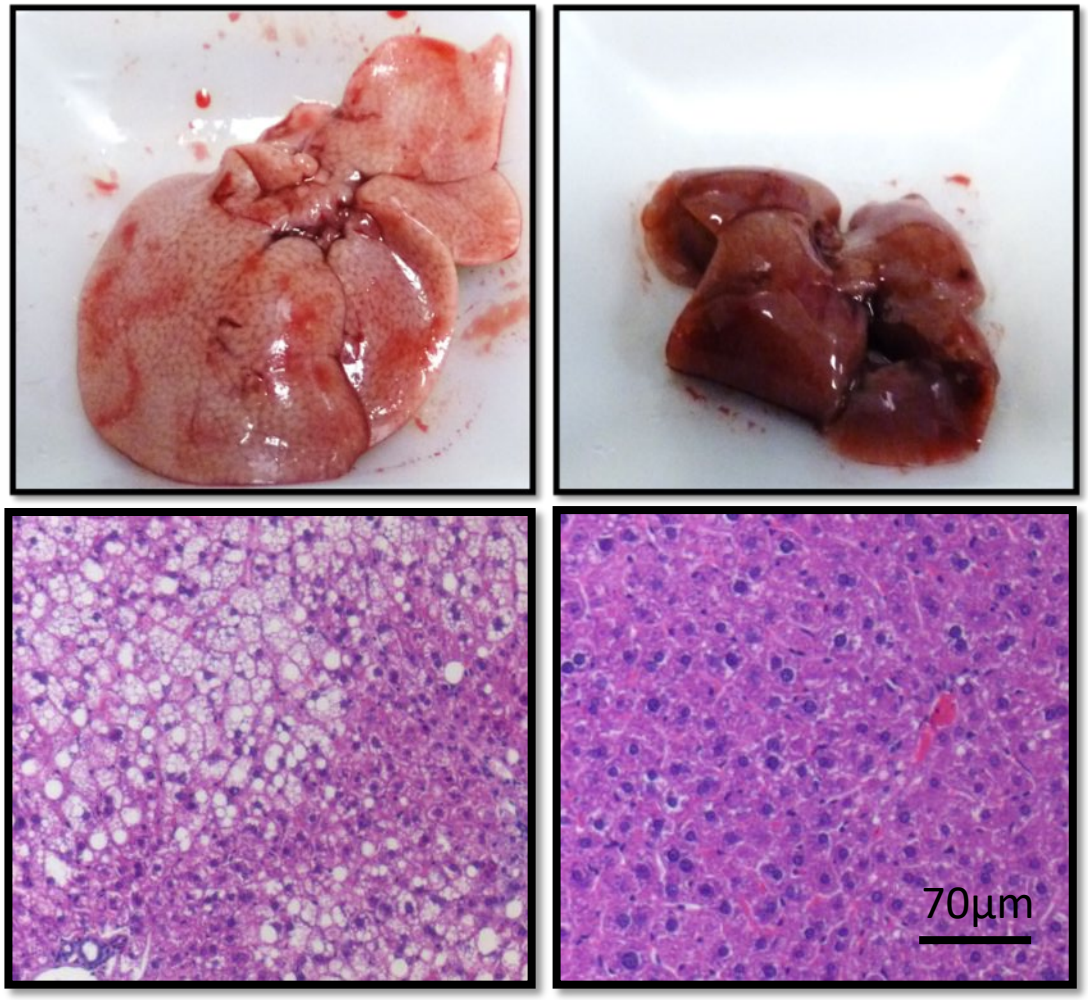
n=12 mice per group. Comparisons to controls were made by Welch's test. Data are means ± SEM. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

MC-fed mice showed improved oral glucose tolerance at 2 weeks



MC-fed mice did not develop fatty liver disease

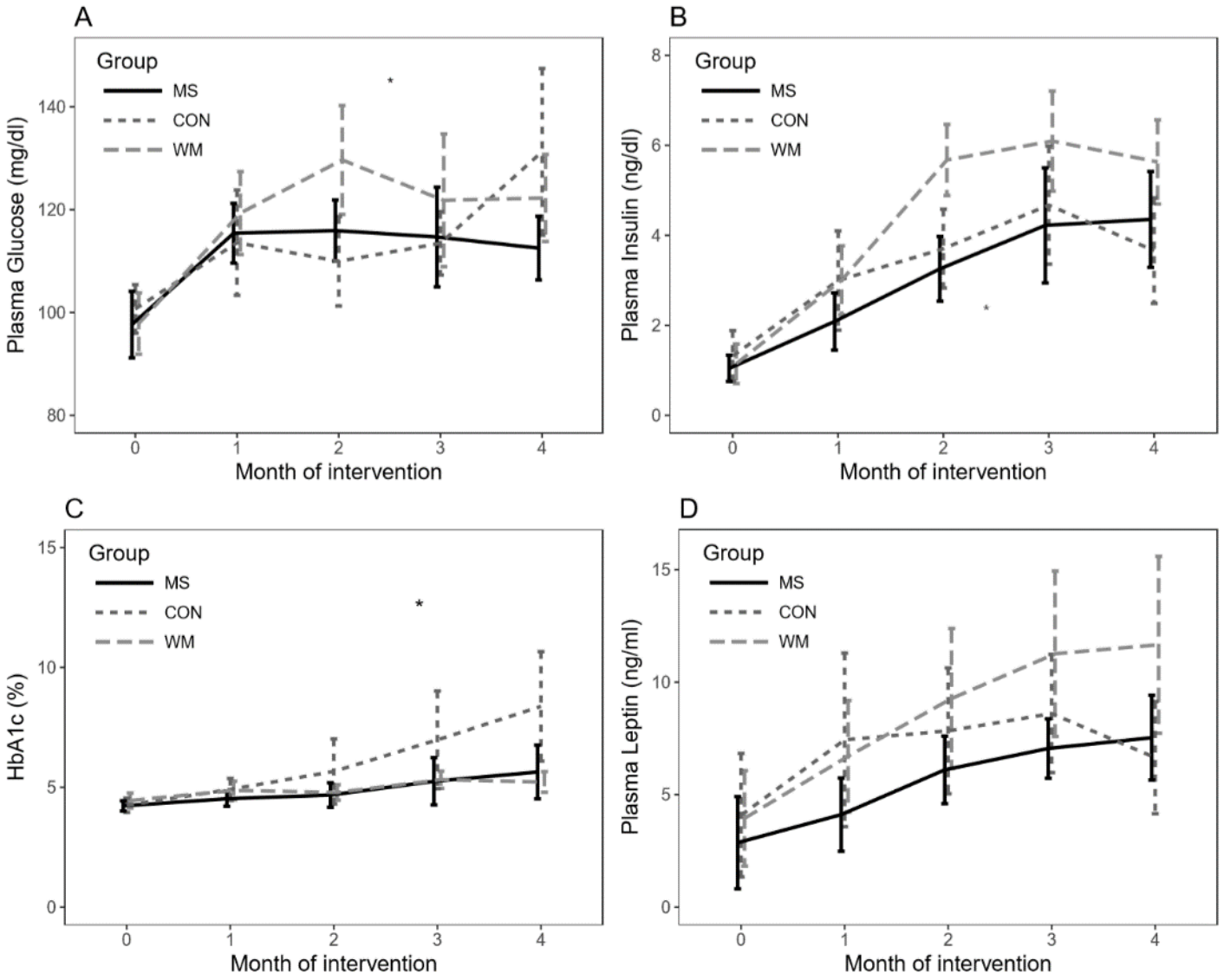




VHFD

5% MC

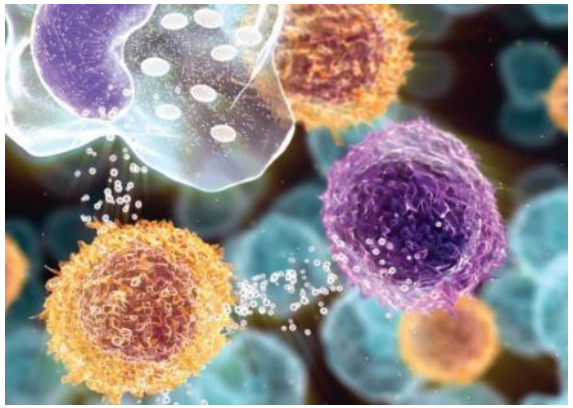
MS significantly decreased plasma glucose, plasma insulin, and HbA1c compared to control rats



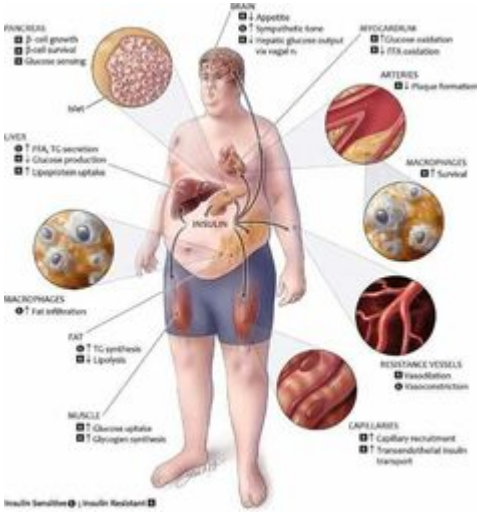
COVID-19	Conditions	Moringa/ITCs
Cytokine storm • Hyper-inflammatory response observed in ICU patients with elevated TNF-α & IL-6 levels.[30] • TNF-α & IL-6 inhibitors are suggested anti-inflammatory agents for clinical trials & use (ex. Sarilumab).[31–33]	Inflammation	**Anti-inflammatory activity** • Reduced expression of TNF-α, IL-6, COX 2 & NF-Kβ in vitro and in vivo.[1–4] • Catalyzes NRF-2 pathway (stimulating antiviral and cytoprotective expression).[5]
Difficulty Breathing • Shortness of breath & cough are significant symptom of patients entering the pulmonary stages of the disease.[8,9] • Cytokine storm known to cause damage to lung tissue.[10]	Respiratory Complications	Anti-asthmatic activity • Clinical study showed moringa seeds (3g/ day for 3 weeks) significantly decreased shortness of breath and coughing in patients with asthma.[6] • Animal study suggested moringa improves vaccine uptake response for Respiratory Syncytial Virus.[7]
Elevated Enzymes & Organ Damage • Brain, kidney, and liver organ function have been compromised in critical care patients.[9] • Higher frequency of AKI with patience admittance with COVID-19.[21]	Organ Complications	**Hepatoprotective activity** • Numerous studies with moringa extracts in animals showed protective effects on the liver and decreased enzyme levels of AST, ALT, and ALP.[27–29] • Moringa ITCs reduced liver GP6 expression-related to glucose production and regulation.[3]
Higher Risk Factors • Hyper-inflammatory response observed in patients in ICU, a condition persisting in patients with metabolic syndrome.[10] • Higher risk of ICU admittance and death among those with diabetes/CVD risk/ and obesity.[16]	Metabolic Syndrome	**Anti-diabetic/obesity/CVD activity** and cholesterol w/ moringa in patients' w/ diabetes.[24–26] • Animal studies showed extracts had significant impact on metabolic markers of obesity and diabetes and reduced NAFLD incidence.[24,26]
Viral Infection • ACE2 receptors present in liver/kidney/CV play a critical role in viral cell entrance.[16–19] • Studies see a correlation with viral infection and disease like diabetes and suggest glucose metabolism plays a role in flu infection.[20]	Viral Susceptibility	**Anti-viral activity** • Modeled protein-ligand docking of bioactive compounds from moringa demonstrated strong affinity for ACE receptors.[22] • Multiple activity reported against HIV, HSV, HBV, EBV, and NDV infection, replication, and treatment[23]
Restricted Food Access • COVID-19 has significantly exacerbated rates of food access & security which will impact existing malnutrition, stunting, and micronutrient deficiencies.[11]	Food Security Nutrition	**Nutrient-density** • A tablespoon of dried moringa leaf powder delivers a significant portion of daily required nutrients (Vit-A, iron, calcium, zinc) and essential amino acids.[12,13] • Clinical studies in children have shown increased hemoglobin, Vitamin A, and folic acid levels along with weight gain in malnourished children.[14,15]

Reducing the burden of chronic inflammation through dietary integration of *Moringa oleifera (NIH Fogarty K01 2015-2021)*

1. Develop a cost-effective moringa supplement concentrated with nutrients and phytoactives.



2. Investigate the mechanism of action of MICs and MC in pathways of cellular protection, inflammation, and metabolism.



3. Evaluate ability of MC to alleviate chronic inflammation/metabolic syndrome.

Moringa Community Development Trainings

- Recipes
- Uses
- Processing & Construction of dryers
- Agricultural best practices
- Cost/benefit analysis

GROWING MORINGA

STEP 1


Soak Seeds
in water for
24 hours

STEP 2


Plant Seeds
5cm deep

STEP 3


Space Seeds
10–20cm apart
Plant Rows
20–30cm apart

STEP 4


Harvest Leaves
Every 40 days

STEP 5


Eat Fresh or
Dry and Store

MORINGA INTENSIVE BED PLANTING/HARVESTING TIMELINE

Prepare double-dug bed with 60% soil, 20% sand, 20% compost.
A well-drained sandy-loam to loam soil is preferred.
Other soil recipes can be used depending on location)

Day 0
Soak seeds in water overnight

Day 1
Plant Seeds in bed at 5cm deep
10-15cm apart in rows that are
15-20cm apart.

Beds are usually 1 meter wide
and can be 1-3m long

Water Seeds, make sure all are
covered by soil

Day 2
Water Seeds -continue to water
every other day as plants need
and depending on rainfall

Day 8–12
Moringa Seeds should germinate.

Replacement seeds can be added to
spots that did not sprout.

Continue to water and weed as needed.

Organic compost can fertilizer may be
added once seedling are established.

Day 60
Moringa should be ready
for first harvest.

Leaves/can be cut back -
to a 10–20cm stem.

Day 95
Regrowth from stems should be ready
for second harvest and continued
harvests can be made every 30-40 days.

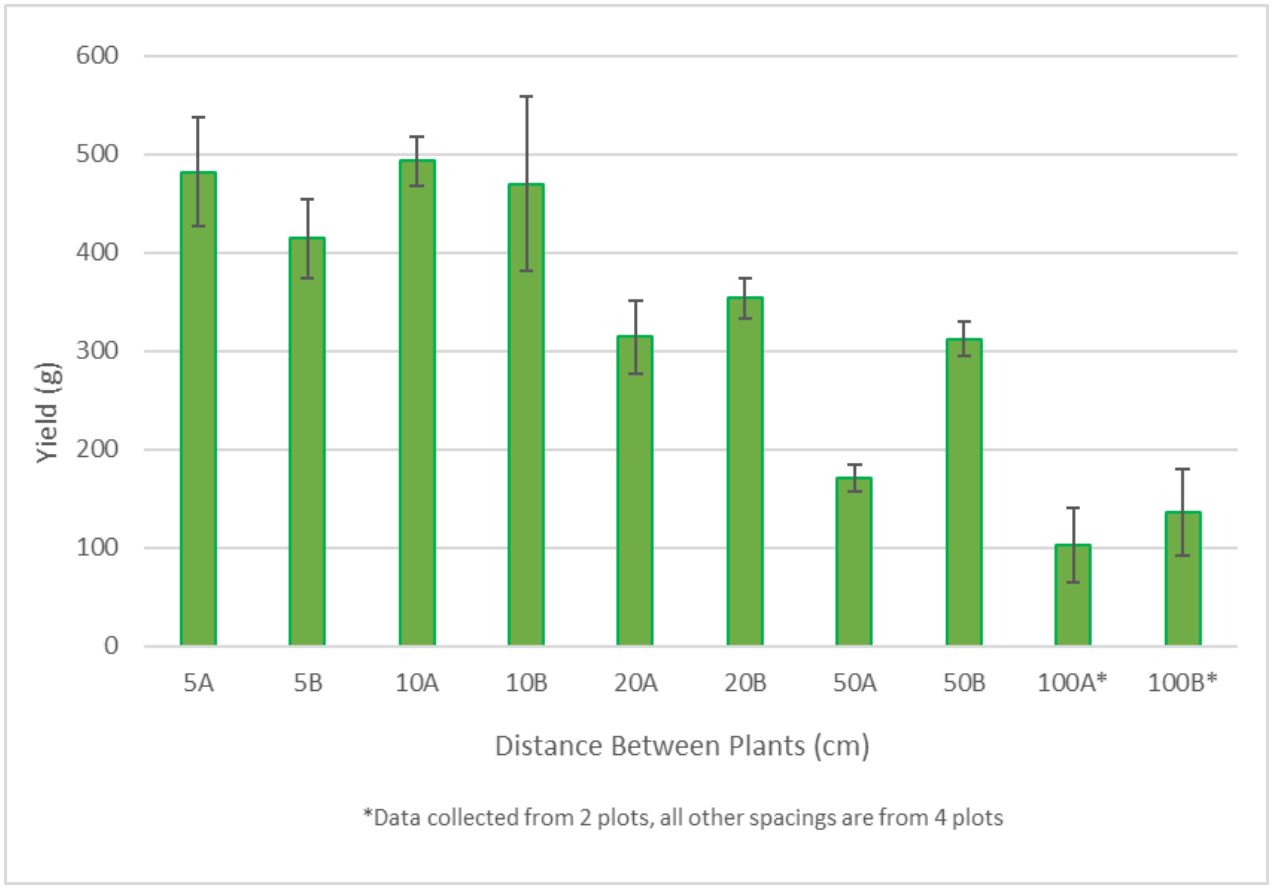
* Depending on location, seed variety, watering, and weather, these recommendations and timing may need to be adjusted.

Drying structure in Meru. From top left clockwise: a) previous drying structure, b) improved structure, c) ventilation fan installed, d) concrete floor installed, e) improved mesh material for drying.

Current moringa leaf cultivation in Meru Kenya (1m X 1m)

Images from Foidl, 2001 and google image searches. May be subject to copyright.

Dry weight yield of moringa leaves at various planting densities in 100 X 300 cm plots.



Capacity building and trainings from top left clockwise: a) Kisumu farmers visit Meru for training on intensive cultivation and irrigation, b) trying new foods with moringa powder in Meru and demonstrating value added products, c) cooking fresh moringa leaves in Matuga with other local indigenous vegetable, d) Samuel Mturuchiu, myself, and Collins Mwenda in Meru, e) density trial review in Meru, f) community farmer visit in Kisumu, g) density and fertilizer trials in Matuga, h) testing moringa powder produced my farmers in Kisumu.

Economic Potential of Moringa Production

- In Nicaragua, planting 1 million plant/ha (with 9 harvests/yr) produced 580 tons fresh material per ha/yr (~99 tons of dry matter and ~16.8 tons of complete protein)
- For comparison ave yield of maize in Kenya is 1.6 metric tons per ha/year

Images from Foidl, 2001 and google image searches. May be subject to copyright.

Economic Potential of Moringa Production in Kenya

- Cost of 10g serving size of dried moringa powder ~ $US 2 cents.
- Current production practices in Meru, Kenya generate a NPV of US$8,049 [ha-1] and average daily returns to family labor 1.6X prevailing local daily wage (projected over a 12 yr period).
- Cost benefit analysis predicted a 648% increase in NPV by intensive production.
- Net Production Value of Moringa @ US $1,640/ha vs Maize @ US $191/ha.

Waterman C, Peterson A, Schelle C, Vosti S. Economic viability of commercial moringa production for Kenyan small-scale farmers. *Journal of Agribusiness in Developing and Emerging Economies*, Jan 2021.

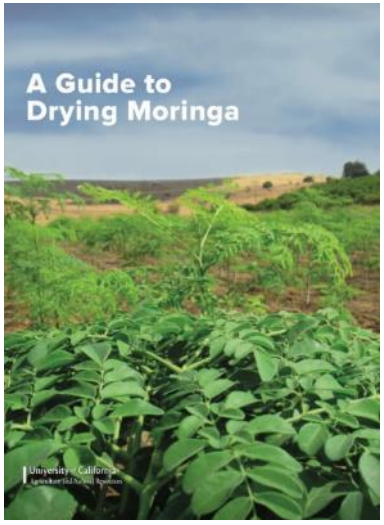
Comparison of US and Kenyan commercial moringa powders

Organic India Kuli Kuli Sprouts

Newly Funded on California State Grant to Promote Moringa

- **Making Global Solutions Local: Increasing Awareness and Consumption of Nutrient-Dense Moringa for All Californians**

- Through presentations and intensive trainings, the project will sequentially increase:
    1. **Awareness of moringa**
    2. **Cultivation and consumption**
    3. **Processing & Preservation**
- We intend to reach to over 25,000 California residents, with a focus on underserved communities.




LUCKY FARM


QUEEN
SHEBA
ETHIOPIAN CUISINE
Moringa

Moringa as animal fodder & growth promotor

Increased milk production **43%** to **65%**

Increased daily weight gain up to **32%**

1.Foidl, N., Makkar, H.P.S. and Becker, K. The potential of *Moringa oleifera* for agricultural and industrial uses. In: L.J. Fuglie (Ed.), *The Miracle Tree: The Multiple Attributes of Moringa* (pp. 45-76). Dakar, Senegal: Church World Service, 2001.

2.Fuglie, L. New Uses of Moringa Studied in Nicaragua. *ECHO Development Notes #68*, June, 2000. <http://www.echotech.org/network/modules.php?name=News&file=article&sid=194>.

3.Reyes, S.N. *Moringa oleifera* and *Cratylia argentea*: potential fodder species for ruminants in Nicaragua. Doctoral thesis, Swedish University of Agricultural Sciences, Uppsala. 2006.

Moringa: Additional Uses- Biodiesel

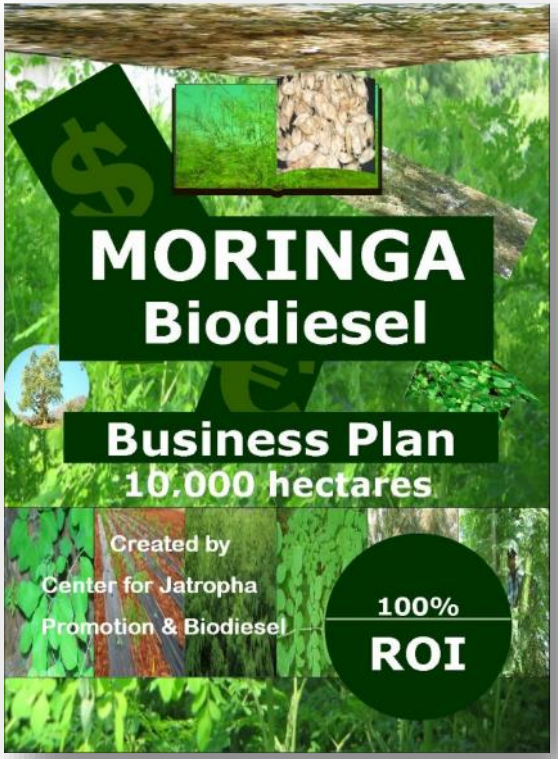


Table 1
Fatty acid profile of *M. oleifera* oil with typical profiles of palm, rapeseed (canola), soybean and sunflower oils shown for comparison purposes

Fatty acid	*Moringa oleifera*	Palm[a]	Rapeseed[a]	Soybean[a]	Sunflower
C16:0	6.5	44.1	3.6	11	6.4
C18:0	6.0	4.4	1.5	4	4.5
C18:1	72.2	39.0	61.6	23.4	24.9
C18:2	1.0	10.6	21.7	53.2	63.8
C18:3	–[b]	0.3	9.6	7.8	–[b]
C20:0	4.0	0.2	–	–	–
C20:1[c]	2.0	–	1.4	–	–
C22:0	7.1	–	–	–	–
other	1	1.1% C14:0, traces of others	0.2% C22:1	Traces	Traces

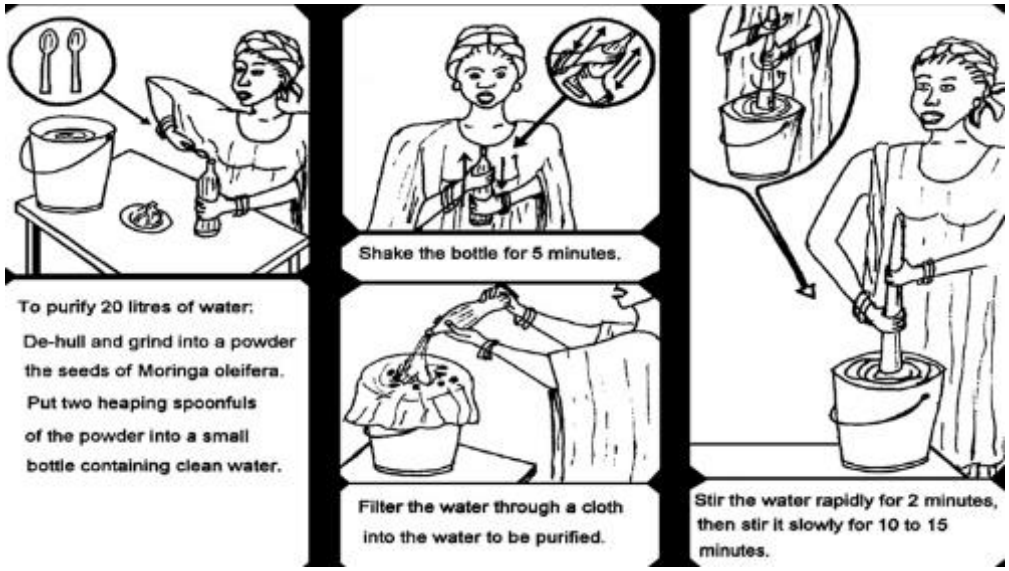
Table 2
Properties of *M. oleifera* methyl esters with comparison to standards

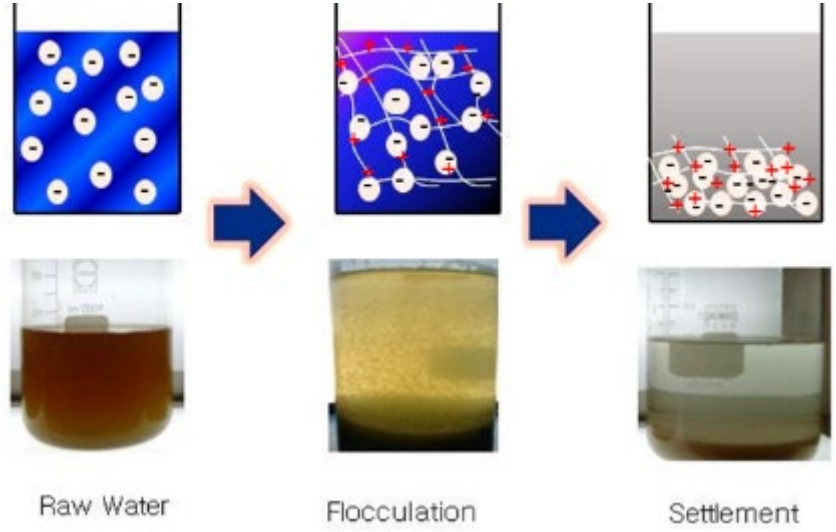
Property	*M. oleifera* methyl esters	ASTM D6751	EN 14214
Cetane number	67.07	47 min	51 min
Kinematic viscosity (mm^2/s; 40 °C)	4.83	1.9–6.0	3.5–5.0
Cloud point (°C)	18	Report	–[b]
Pour point (°C)	17	–[a]	–[b]
Oxidative stability (h)	3.61	3 min	6 min
Lubricity (HFRR; μm)	135, 138.5	–[c]	–[c]

[a] Not specified.
[b] Not specified. EN 14214 uses time- and location-dependent values for the cold-filter plugging point (CFPP) instead.
[c] Not specified. Maximum wear scar values of 460 and 520 μm are prescribed in petrodiesel standards EN 580 and ASTM D975.

U. Rashid et al. / Bioresource Technology 99 (2008) 8175–8179

Moringa seeds for water purification

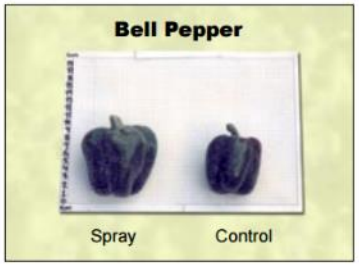


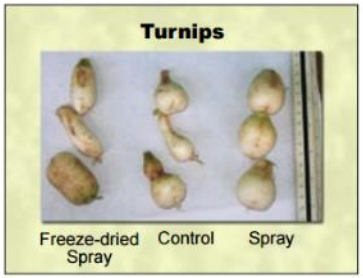


Moringa: Additional Uses- Biofertilizer, nematocide & growth promotor

Several reports note root-knot nematode control with moringa extracts

- Amanda Hodson, Project Scientist in Ed Lewis's Lab (Department of Entomology and Nematology), is conducting testing with moringa seed extract (40% MIC-1).



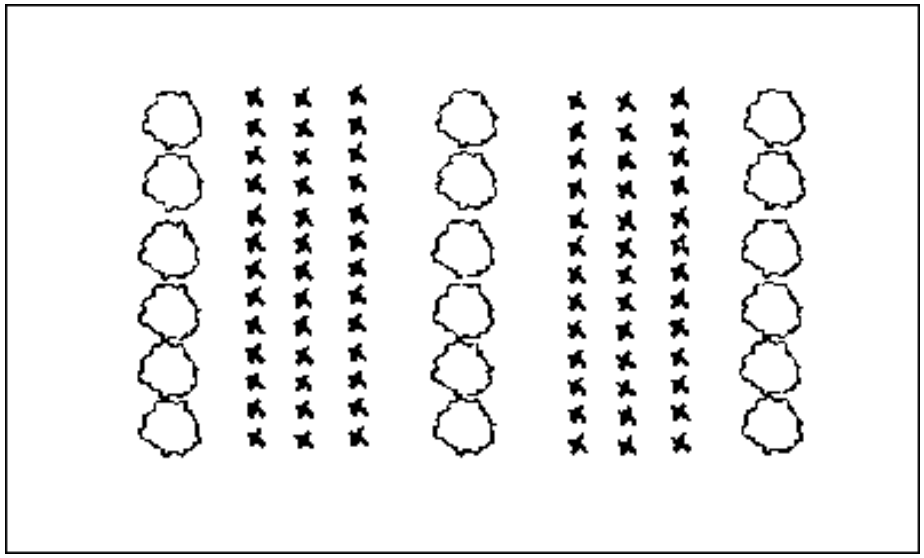


For large-scale farming, Moringa spray was freeze-dried for use at appropriate times.

Foidl et al., found moringa sprayed on crops:

- Accelerated growth of young plants
- Plants are firmer, more resistant to pests and disease
- Longer life-span
- Heavier roots, stems and leaves
- Produce more fruit
- Larger fruit
- Increase in yield 20-35%

Moringa: Additional Uses- Biofertilizer, nematocide & growth promotor



Culver, Mvumi, Tagwira Fanuel, and Albert Z. Chiteka. "**Effect of Moringa extract on growth and yield of tomato**." *Greener J. Agri. Sci* 2 (2012): 207-211.

South African Journal of Botany 119 (2018) 383–389

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journal homepage: www.elsevier.com/locate/sajb

Improving the growth, yield and volatile oil content of *Pelargonium graveolens* L. Herit by foliar application with moringa leaf extract through motivating physiological and biochemical parameters

Agricultural Water Management 193 (2017) 46–54

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Research paper

Moringa leaf extract as biostimulant improves water use efficiency, physio-biochemical attributes of squash plants under deficit irrigation

Taia A. Abd El-Mageed [a,*], Wael M. Semida [b], Mostafa M. Rady [c]

[a] Soil and Water Department, Faculty of Agriculture, Fayoum University, Fayoum, Egypt
[b] Horticulture Department, Faculty of Agriculture, Fayoum University, Fayoum, Egypt

Environ Sci Pollut Res (2017) 24:27601–27612
DOI 10.1007/s11356-017-0336-0

RESEARCH ARTICLE

Growth promoting potential of fresh and stored *Moringa oleifera* leaf extracts in improving seedling vigor, growth and productivity of wheat crop

Shahbaz Khan [1] · Shahzad Maqsood Ahmed Basra [1] · Irfan Afzal [1] · Muhammad Nawaz [2] · Hafeez Ur Rehman [1]

Journal of Horticulture

Thanaa et al., J Hortic 2017, 4:1
DOI: 10.4172/2376-0354.1000193

Research Article — Open Access

Influence of Foliar Application with Moringa (*Moringa oleifera* L.) Leaf Extract on Yield and Fruit Quality of Hollywood Plum Cultivar

Thanaa ShM*, Kassim NE, AbouRayya MS and Abdalla AM

Department of Horticultural Crops Technology, National Research Center, Dokki, Giza, Egypt

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Received date: February 08, 2017; **Accepted date:** February 21, 2017; Published date: February 28, 2017

South African Journal of Botany 129 (2020) 74–81

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Combined application of moringa leaf extract and chemical growth-promoters enhances the plant growth and productivity of wheat crop (*Triticum aestivum* L.)

S. Khan [a,b,*], S.M.A. Basra [b], M. Nawaz [c], I. Hussain [d,e], N. Foidl [f]

South African Journal of Botany xxx (2019) xxx

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Comparative analysis of the antioxidant, antibacterial and plant growth promoting potential of five Indian varieties of *Moringa oleifera* L

B. Farooq, B. Koul *

School of Bioengineering and Biosciences, Lovely Professional University, Phagwara 144411, Punjab, India

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Improvement in growth, productivity and quality of 'Kinnow' mandarin fruit after exogenous application of *Moringa olifera* leaf extract

M. Nasir [a,*], A.S. Khan [b], S.M.A. Basra [c], A.U. Malik [b]

[a] Horticulture Research Institute, Ayub Agriculture Research Institute, Faisalabad, Pakistan
[b] Institute of Horticultural Sciences, University of Agriculture Faisalabad, Faisalabad, Pakistan
[c] Department of Crop Physiology, University of Agriculture Faisalabad, Faisalabad, Pakistan

Potential of Moringa (Moringa oleifera) Leaf Extract as Priming Agent for Hybrid Maize Seeds

Article in International Journal of Agriculture and Biology · January 2011

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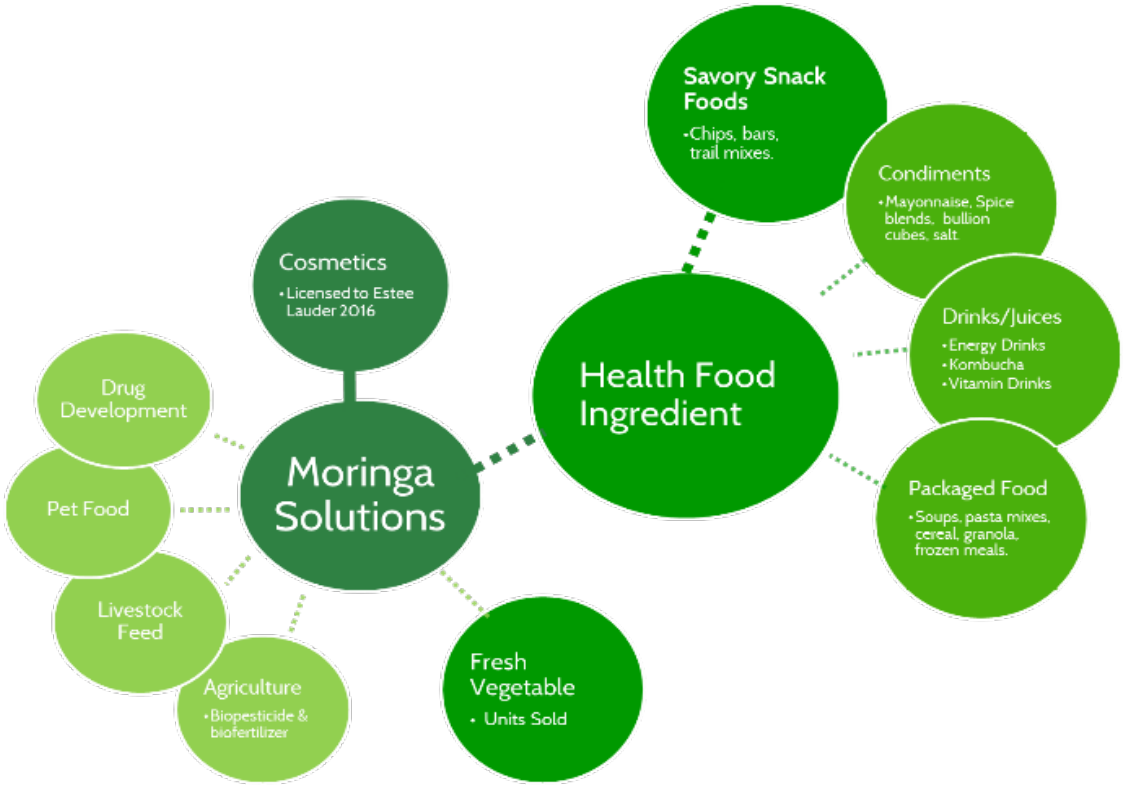
Positioning Academic, Government & Industrial Collaborations for Moringa and More…

- Foster Interaction & Internships
- Promote Public/Private Partnerships
- Investigate & Innovate
- Translate Research to Feasible Solutions
- Improve the lives of Africans

Business Opportunities

- Current patent on moringa processing to capture MICs exclusively licensed to Estee Lauder for their skin care products (US20160243176A1).
- UC Business Development Fellows Program to explore additional business opportunities.
- Consultant for Kuli Blossom and other moringa companies in Africa.



Moringa

- Nutrition/Health
- Agriculture
- Water Purification
- Livestock
- Economic Growth
- Climate Action

1) **Waterman C**, Peterson A, Schelle C, Vosti S. **2021**. Economic viability of commercial moringa production for Kenyan small-scale farmers. *Journal of Agribusiness in Developing and Emerging Economies*, Jan 7.

2) Islam, MA, Sheikh, A, **Waterman C**., Hosenuzzaman, M. **2020**. Morphology, pod yield, and nutritional quality of two cultivars of moringa (*Moringa oleifera*) in Bangladesh. *Indian Journal of Science and Technology*, 13, 3725-3735.

3) **Waterman C**, Graham JL, Arnold C, Stanhope KL, Tong JH, Havel, PJ. 2020. Moringa isothiocyanate-rich seed extract delays the onset of diabetes in UC Davis type-2 diabetes mellitus rats. *Scientific Reports, 10.1*, 1-7.

4) Wolff K, Jaja-Chimedza A, Kim Y, **Waterman C**, Poulev A, Raskin, I, Ribnicky D. **2020**. Moringa isothiocyanate-1 is bioaccessible and bioavailable as a stable unmodified compound. *Phytochemistry Letters*, *33*, 33-38.

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7) **Waterman C**, Rojas-Silva P, Tumer TB, Kuhn P, Richard AJ, et al. **2014**. Isothiocyanates from *Moringa oleifera* reduce weight gain, insulin resistance and hepatic gluconeogenesis in mice. *Molecular Nutrition & Food Research*, *59*, 1013–1024.

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- Ramni Jamnadass
- Prasad Hendre
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NIH - NCCAM & UCD

- BRC- P50AT002776-01
- BRC Pilot Grant Sub award 5P50AT002776-08 S12-50318.
- T32: 5T32AT004094-04
- UC Davis Global Affairs Seed Grant
- K01: TW 009987-05