Moringa and other highly nutritious plant resources: Strategies, standards and markets for a better impact on nutrition in Africa. Accra, Ghana, November 16-18, 2006

International Workshop on Moringa and Nutrition

Accra, Ghana
November 16-18, 2006

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Nutritional Benefits, Toxicology, and Health Effects of Moringa Leaf Powder vis-à-vis Treatment of Malnutrition

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Cultivar Effect on *Moringa oleifera* Glucosinolate Content, Taste, and Performance Characteristics: A Pilot Study

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General Moringa Reviews, by:

Julia Morton

Lowell Fuglie

Manuel Palada

Martin Price

Trees for Life

National Academy of Sciences U.S.A. (just published)

LOST CROPS of AFRICA

volume II Vegetables

Development, Security, and Cooperation
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Overview

Nutritional Benefits, Toxicology, and Health Effects of Moringa Leaf Powder vis-à-vis Treatment of Malnutrition

1. Some risks?
   - In mice
   - In tilapia (a widely aquacultured species of fish)
   - In human beings
2. Some benefits?
   - Cancer protection
   - Combating *Helicobacter pylori* infection

Cultivar Effect on *Moringa oleifera* Glucosinolate Content, Taste, and Performance Characteristics: A Pilot Study

3. Variability
   - Taste
   - Phytochemical (glucosinolate) content

Framing the discussion:

GHANA: Children < 5 years old*

mortality rate = 111 for every 1,000 live births (11.1%)*

30% stunted (11% severe stunting)**

7% wasted (1% severe wasting)**

22% underweight (5% severe underweight)**

**Ghana* Accelerated Child Survival and Development approach (ACSD); www.unicef.org

***Ghana Demographic Health Survey (2003)

Framing the discussion:

Primary Food Source

vs.

Nutritional Supplementation

While not mutually exclusive, these 2 strategies for using *Moringa* leaves address very different usage patterns and sets of needs.

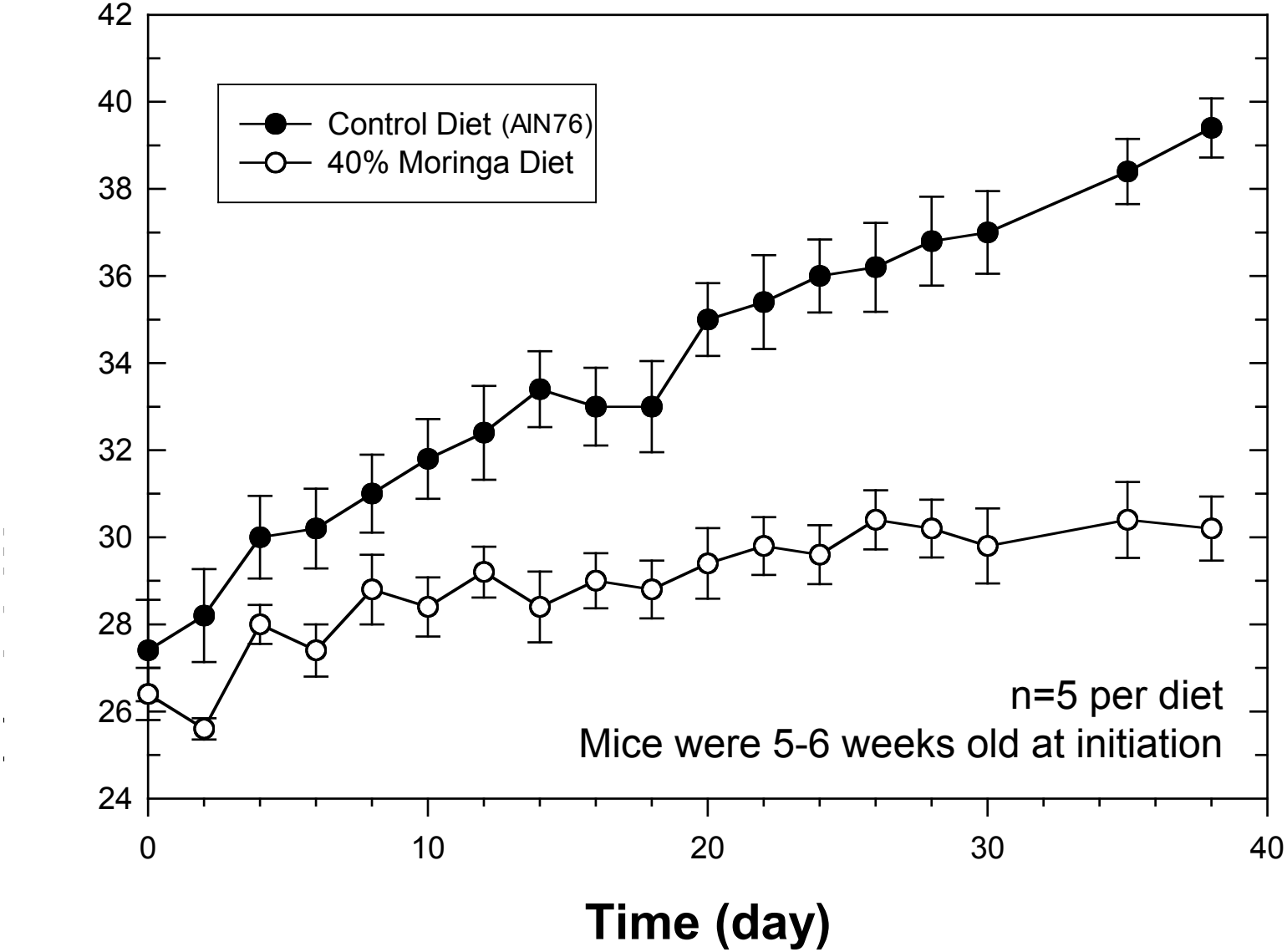
They both require additional, rigorous, scientific research.

Moringa Leaf Powder vs. Malnutrition

- **As A Primary Food Source**
  - Dietary *replacement*
    - (substituting Moringa for something else)
    - high rate substitution (>10% of diet)
  - Famine food
    - when nothing else is available
- **Treating Acute Malnutrition (Nutritional Supplementation)**
  - Relief of vitamin, mineral deficiencies
  - Treating Protein-Energy Malnutrition
  - Combating stunting, wasting and failure-to-thrive in infants & children
  - Combating chronic infectious diseases

Out research interest in high rate supplementation grew out of cancer prevention experiments in which we had to administer very high rates of leaf powder to animals, to get the desired glucosinolate levels.

Effect of 40% *Moringa oleifera* leaf powder amended diet on weight gain in female ICR mice



Effect of high rate *Moringa* leaf powder supplementation for 38 days, on female ICR mouse organ development

	AIN76		40% Moringa	
	Mean	S.E.M.	Mean	S.E.M.
Liver Ratio (g liver/g BW)	0.058	0.004	0.059	0.003
Colon (cm)	8.6	0.4	11	0.5
Norm. colon (cm/g)	0.22	0.01	0.36	0.02
Cecum (cm)	2.8	0.1	3.7	0.2
Cecum – Normalized (cm/g)	0.072	0.005	0.12	0.01
Colon:cecum ratio	3.1	0.1	3	0.1

Aquaculture Research, 2003, **34**, 1147–1159

Comparative nutritional evaluation of raw, methanol extracted residues and methanol extracts of moringa (*Moringa oleifera* Lam.) leaves on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus* L.)

W Afuang, P Siddhuraju & K Becker

Department of Aquaculture Systems and Animal Nutrition, Institute for Animal Production in the Tropics and Subtropics, University of Hohenheim, Stuttgart, Germany

Growth performance and nutrient utilization of tilapia fed 40% dry moringa leaf powder enriched diet vs control diet.

	Control	Moringa (40%)
initial body weight (g)	16.9 ± 4.5	16.3 ± 4.5
body weight gain (g)	38.1 ± 4.5	14.5 ± 4.5

Data from: W Afuang, P Siddhuraju & K Becker (2003) Comparative nutritional evaluation of raw, methanol extracted residues and methanol extracts of moringa (*Moringa oleifera* Lam.) leaves on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus* L.). *Aquaculture Research* 34: 1147-1159

Diet composition (%, dry matter basis)

Proximate composition	Control 1	4
Dry matter	93.4	93.0
Crude protein	36.2	35.0
Crude lipid	8.9	9.9
Ash	10.6	12.1
Crude fibre	1.5	4.0
NFE	42.8	39.0
Gross energy (MJ kg^{-1})	19.9	20.4
NDF	4.1	13.4
ADF		1.8
ADL		0.6
Total phenols		1.7
Tannins		0.5
Phytates		0.6
Saponins		3.1

Data from: W Afuang, P Siddhuraju & K Becker (2003) Comparative nutritional evaluation of raw, methanol extracted residues and methanol extracts of moringa (*Moringa oleifera* Lam.) leaves on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus* L.). *Aquaculture Research* 34: 1147-1159

•Saponins (for example)

- **Broad class of phytochemicals:**
  - **effects on livestock production well documented**
  - **effects on humans complex and contradictory**
  - **some useful for controlling cholesterol**
  - **others toxic or cause urticaria (skin rash)**

- **Moringa saponins**
  - **occur at substantial levels (1-5%) in *Moringa oleifera* leaves.***
  - **don't appear to be toxic at levels that are being consumed by people**
  - **might they be toxic when consumed as a large percentage of the diet?**

Makkar & Becker (1996) *Animal Feed Science Technology* 63: 211-228

Mekkonen et al. demonstrated cytotoxicity at a high level of extract (500 µg/ml).

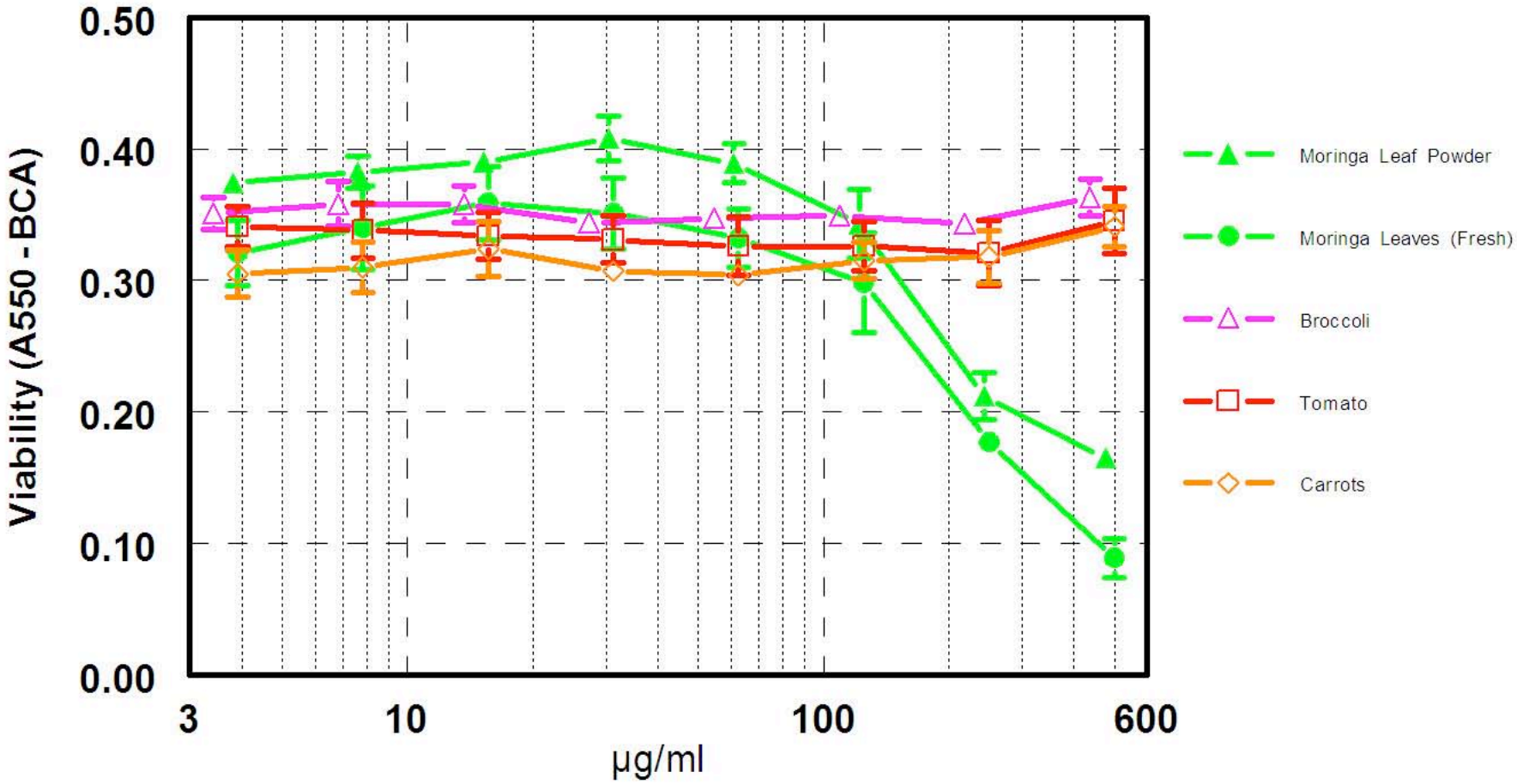
> **". . .a highly significant . . . decrease in the percentage of viable hepatocytes was found after incubating the cells with the highest concentration (500 µg/ml) of the ethanol leaf and seed extracts of *Moringa stenopetala*. . ."**
> [Mekonnen et al., (2005) *Phytotherapy Research* 19: 870-875]

<u>?????</u>
Is this a problem vis-à-vis supplementary feeding of human beings?

At some level, all plant extracts will have a deleterious effect on cultured cells.

How does this cytotoxicity relate to pathology and to the human condition?
(ug extract / ml of culture medium vs. grams of intake of food or food product per day)?

Effects of plant extracts on cultured Hepa1c1c7 cells



?? Goitrogenicity ??

Cross sectional study

Consumption of >2x/day helleko (*Moringa stenopetala*):

- **significantly associated goitre in Gamo-Gofa, Ethiopia ($p<0.005$)**
- **4.57 times more likely to have goitre than other groups**

Prevalence of goitre (597 children and their parents), 51.7%, with 21.7% visible goitre.

Highly significant familial tendency for goitre ($p<0.001$).

“Isothiocyanate is a known goitrogenic chemical substance”

Abuye et al. (1999) East African Medical Journal 76: 447-451

?? Goitrogenicity ??

". . . The presence of a small amount of cyanogenic glucosides in *M. stenopetala* leaves may have a health risk in areas of high incidence of endemic goitre as an exacerbating factor if consumed for a long period of time."

79–89 mg cyanogenic glucosides / 100 g

Abuye et al. (2003) East African Medical Journal 80(5): 247-252

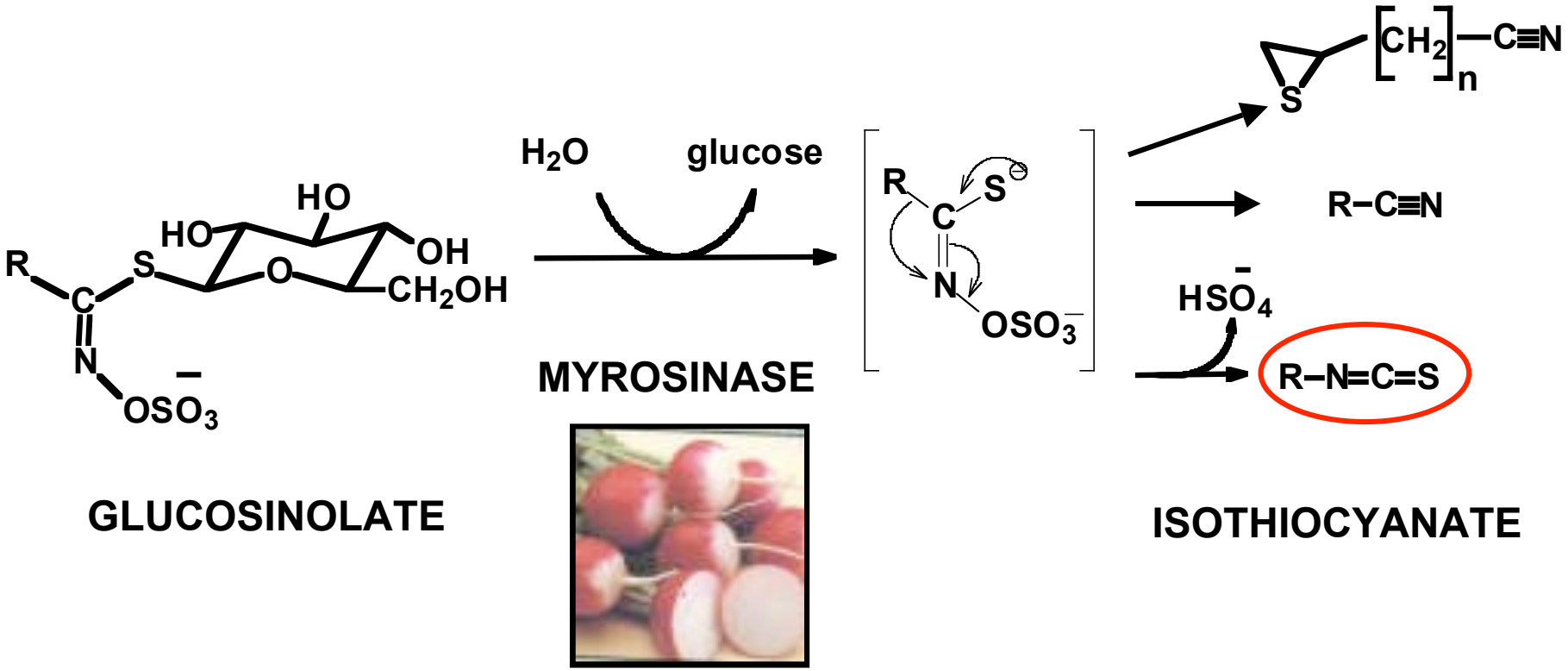
?? Goitrogenicity ??

However . . .

- **Indeed, progoitrin (a glucosinolate) produces goitrin (an isothiocyanate), which upon breakdown produces an oxazolidonethione, that is goitrogenic.**

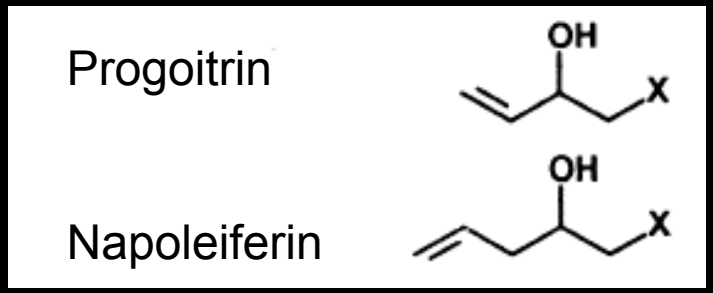
- **Indole glucosinolates are thought to have goitrogenic potential.**

- ***Moringa* spp. have neither progoitrin, nor significant levels of indole glucosinolates. They do, however, have thiocyanates which should be more intensively examined for their goitrogenicity (Ref. Faizi, Sidiqui, Guevera, et al.)**



Fahey et al (2001) *Phytochemistry* 56(1): 5-51

Hydrolysis of β-hydroxyalkenyl glucosinolates (e.g. progoitrin & napoleiferin), gives rise to β-hydroxyalkenyl isothiocyanates.

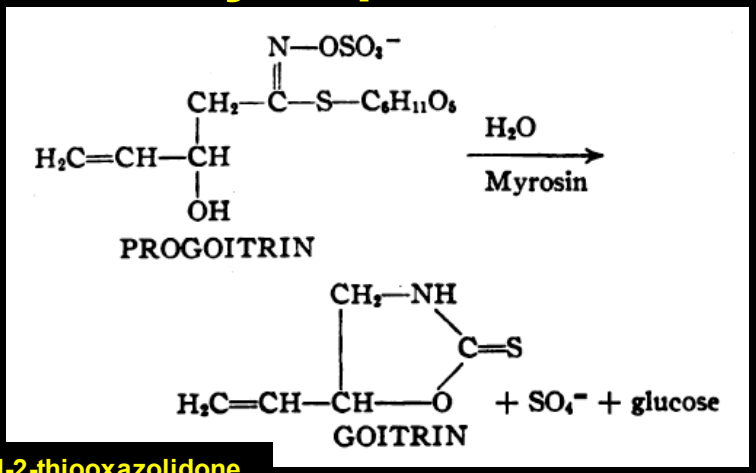


These compounds cyclize to oxazolidine-2-thiones which may have goitrogenic effects in mammals -- first observed in rabbits and designated ``cabbage'' goiter by Webster and Chesney (1930).

The ``antinutritional'' nature of the β-hydroxyalkenyl glucosinolates is discussed in a variety of published works.

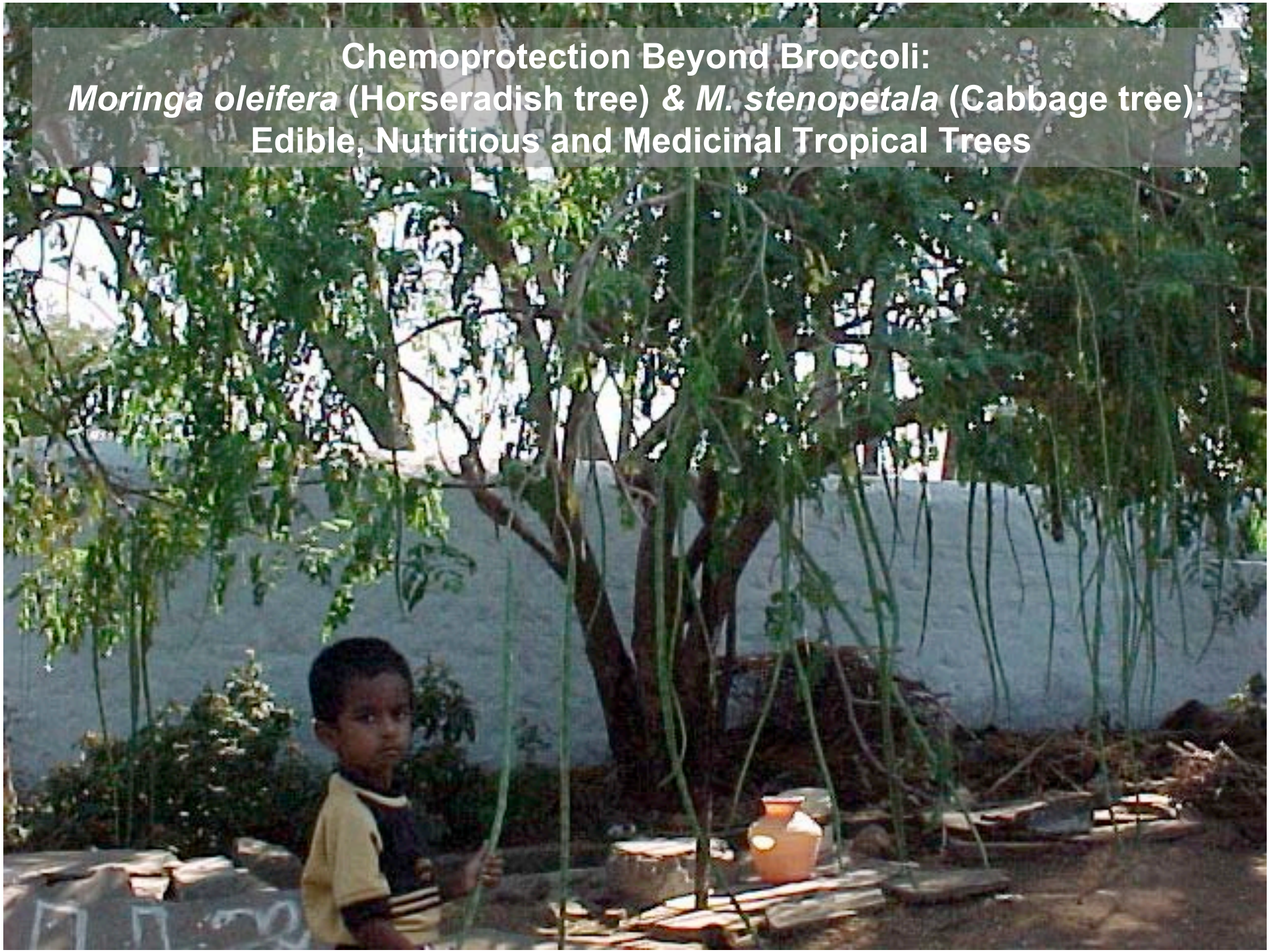
Chesney, A. M., Clawson, T. A., and Webster, B. Endemic goitre in rabbits. I. Incidence and characteristics. Bull. Johns Hopk. Hosp. 1928, **43**, 261.

Greer, M. A. Nutrition and goiter. Physiol. Rev. 1950, **30**, 513.

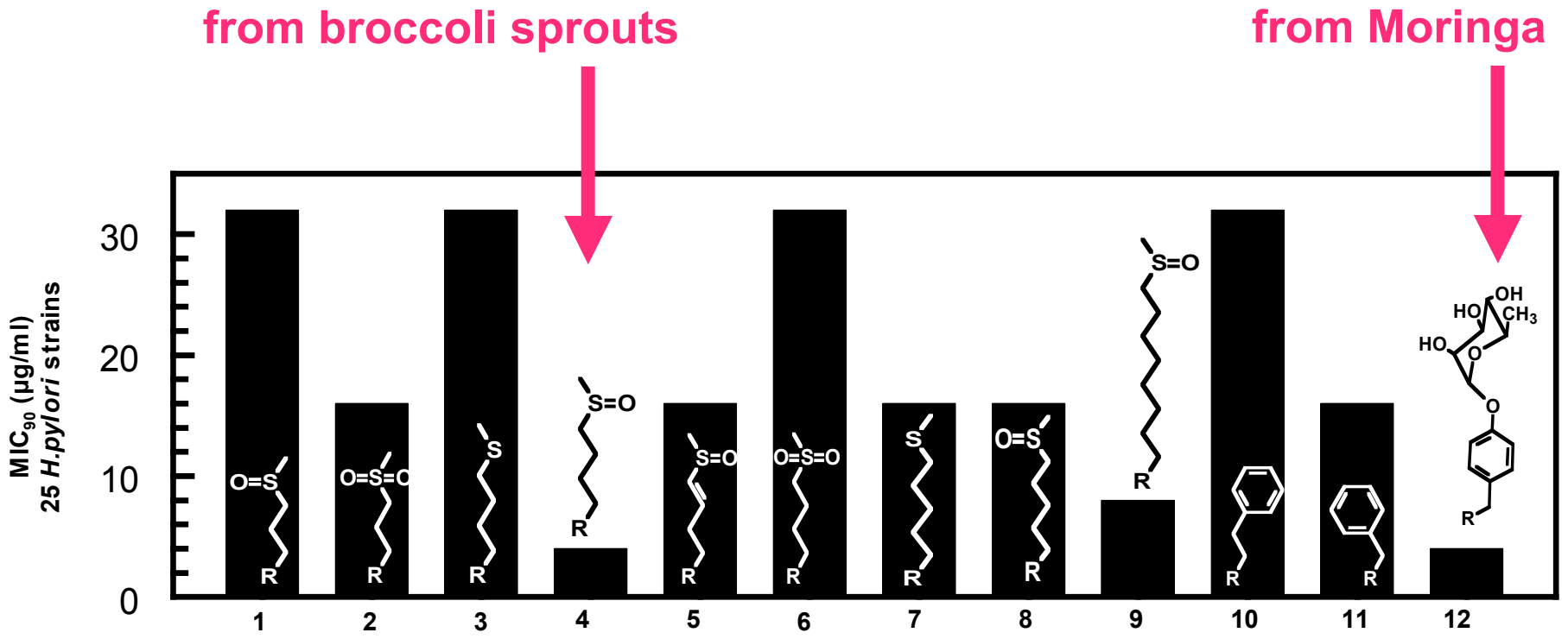


1-5-vinyl-2-thiooxazolidone

Chemoprotection Beyond Broccoli:
Moringa oleifera (Horseradish tree) *& M. stenopetala* (Cabbage tree):
Edible, Nutritious and Medicinal Tropical Trees



Antibacterial potency of a variety of plant-derived isothiocyanates against *Helicobacter pylori*



Redrawn from: Haristoy, Fahey, Scholtus, Lozniewski (2005) *Planta Medica* 71: 326-330.

International Consensus Conference (Feb 05):
Why an edible plant-based approach to *H. pylori* treatment?

- Inexpensive
- Underserved populations ± indigenous plants
- May be effective where synthetic antibiotics are not
- Anti-inflammatory activity of ITCs may have 2° benefit against gastritis
- Prevent or ameliorate symptoms of gastritis, peptic ulcer or stomach cancer vs. complete cure?

On the one hand, the fact that many ethnic groups have consumed Moringa leaves and leaf powder for many generations is a very positive indication . . . After all, tolerance, safety, and toxicology studies are not performed on corn, wheat, squash, and groundnuts.

On the other hand, performing a safety and tolerance study like the following (just completed with broccoli sprouts) would be a reasonable undertaking. Funding must be developed for such a trial, which would then facilitate a variety of nutritional efficacy studies that global funding agencies have seemed reluctant to back so far.

For example, one could readily substitute *Moringa* leaf powder in an experimental design like the following, which we have just published

NUTRITION AND CANCER, *55*(1), 53–62

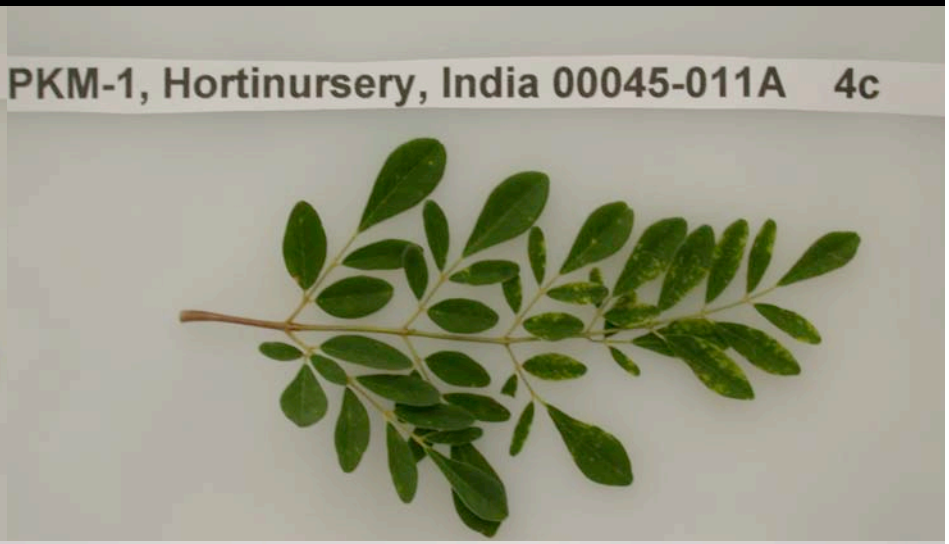
Safety, Tolerance, and Metabolism of Broccoli Sprout Glucosinolates and Isothiocyanates: A Clinical Phase I Study

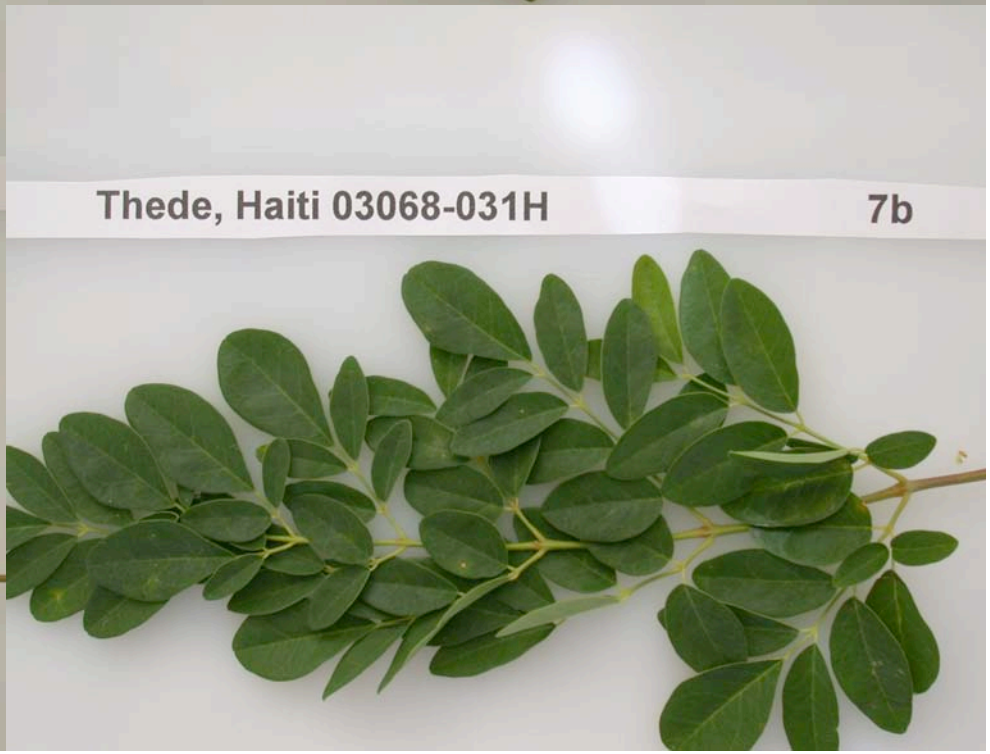
Theresa A. Shapiro, Jed W. Fahey, Albena T. Dinkova-Kostova, W. David Holtzclaw, Katherine K. Stephenson, Kristina L. Wade, Lingxiang Ye, and Paul Talalay

"Widely consumed in many parts of the world, and have not caused any concern with respect to their tolerance and safety in humans. Nevertheless, a formal Phase I study of safety, tolerance, and pharmacokinetics appeared justified"

- *Placebo-controlled, double blind, randomized clinical study*
- *Healthy volunteers -- inpatients on our clinical research unit*
- *5-day acclimatization period on a crucifer-free diet*
- *Oral intake of standardized broccoli sprout extract*
- *8-h intervals for 7 days (21 doses)*
- *32 types of hematology or chemistry tests (before, during, and after dosing)*
- *Liver (transaminases) and thyroid (TSH, T3, and T4) function examined in detail*
- *No significant or consistent subjective or objective abnormal events or toxicities*

30 Accessions; 3 Harvest Dates; 10 Taste Testers





30 Accessions; 3 Harvest Dates; 10 Taste Testers

Moringa **leaves being promoted as nutritional supplement for weaning infants and nursing mothers.**

Adoption as a nutritious supplement may hinge upon taste.

Taste can vary greatly amongst cultivars, from quite mild, to exceptionally pungent, astringent, and “radishy".

Widely assumed to be germplasm-dependent (i.e. the breeding line or cultivar dictates taste).

Prior knowledge of one of the major phytochemical components of *Moringa*, the glucosinolates, suggests that they might be a component of this harshness of taste.

These glucosinolates, and their breakdown products (isothiocyanates), are also implicated in many of the medicinal properties of *M. oleifera*.

- Regional preferences regarding taste and other organoleptic, horticultural, and agronomic characteristics vary greatly.

- The taste of fresh leaves is known to vary greatly -- some of them are quite “radishy”, hot, and pungent, while others are very mild.

- To the extent that the leaves (typically dried and powdered) are suggested for use in weaning porridges, it would seem to be important to be able to suggest or provide sources of less harsh or less radishy tasting leaves.

- Although the potential aversion of infants to a very pungent gruel has not been tested scientifically, from a commonsense standpoint it would seem logical that having taste options would be beneficial.

Since at least two breeding lines (designated PKM1 and PKM2) have now been developed, and the potential health benefits that *Moringa* offers is widely recognized, we undertook a pilot study to investigate the association between pungent taste and glucosinolate levels of the leaves of this plant.

283 trees, representing 30 accessions, were grown in a randomized field plot at a single site in central Florida, USA

Sampled three times over the course of a year.

Taste was assessed by 9 or 10 individuals in a masked protocol.

In addition:

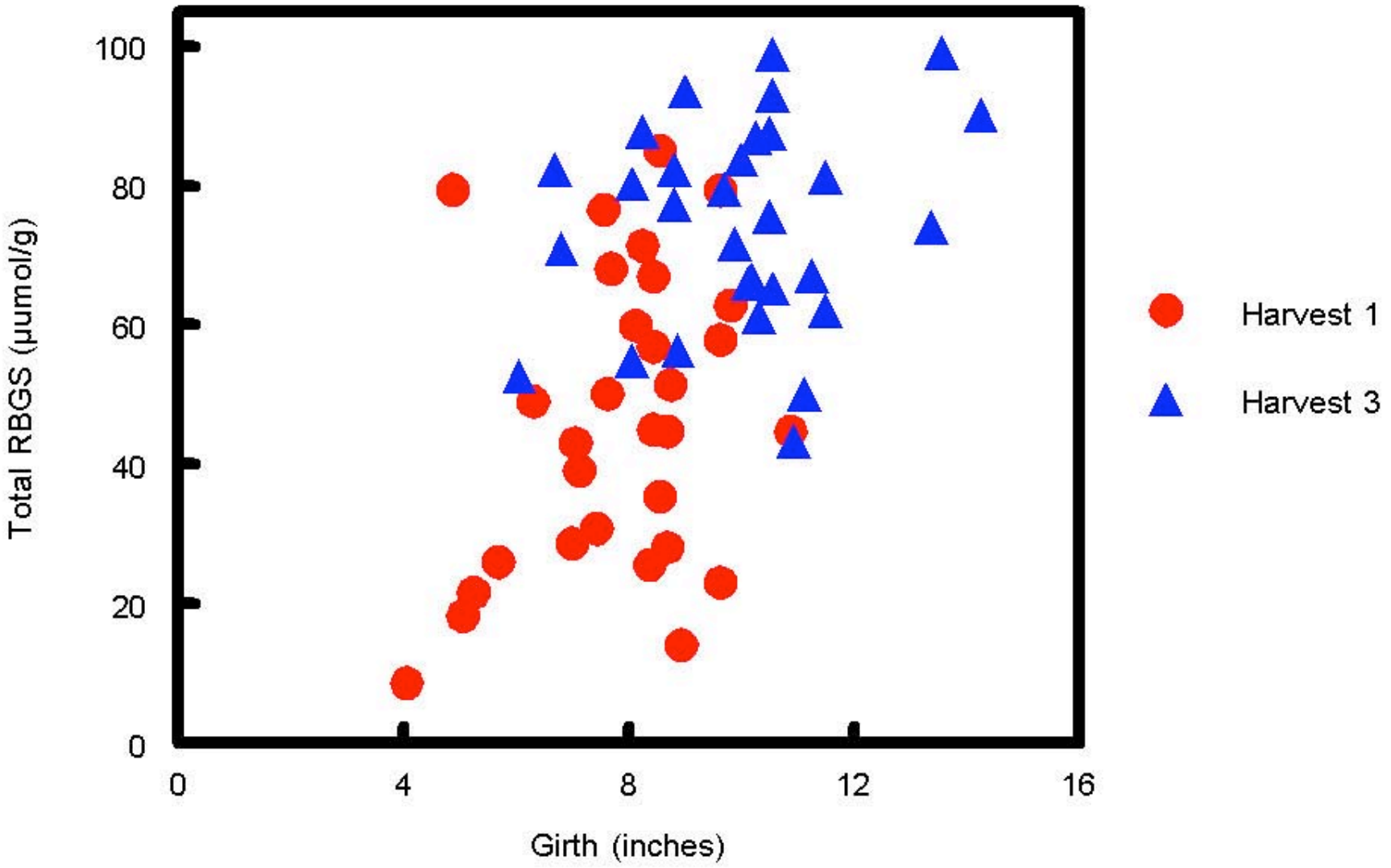
- glucosinolate content was measured

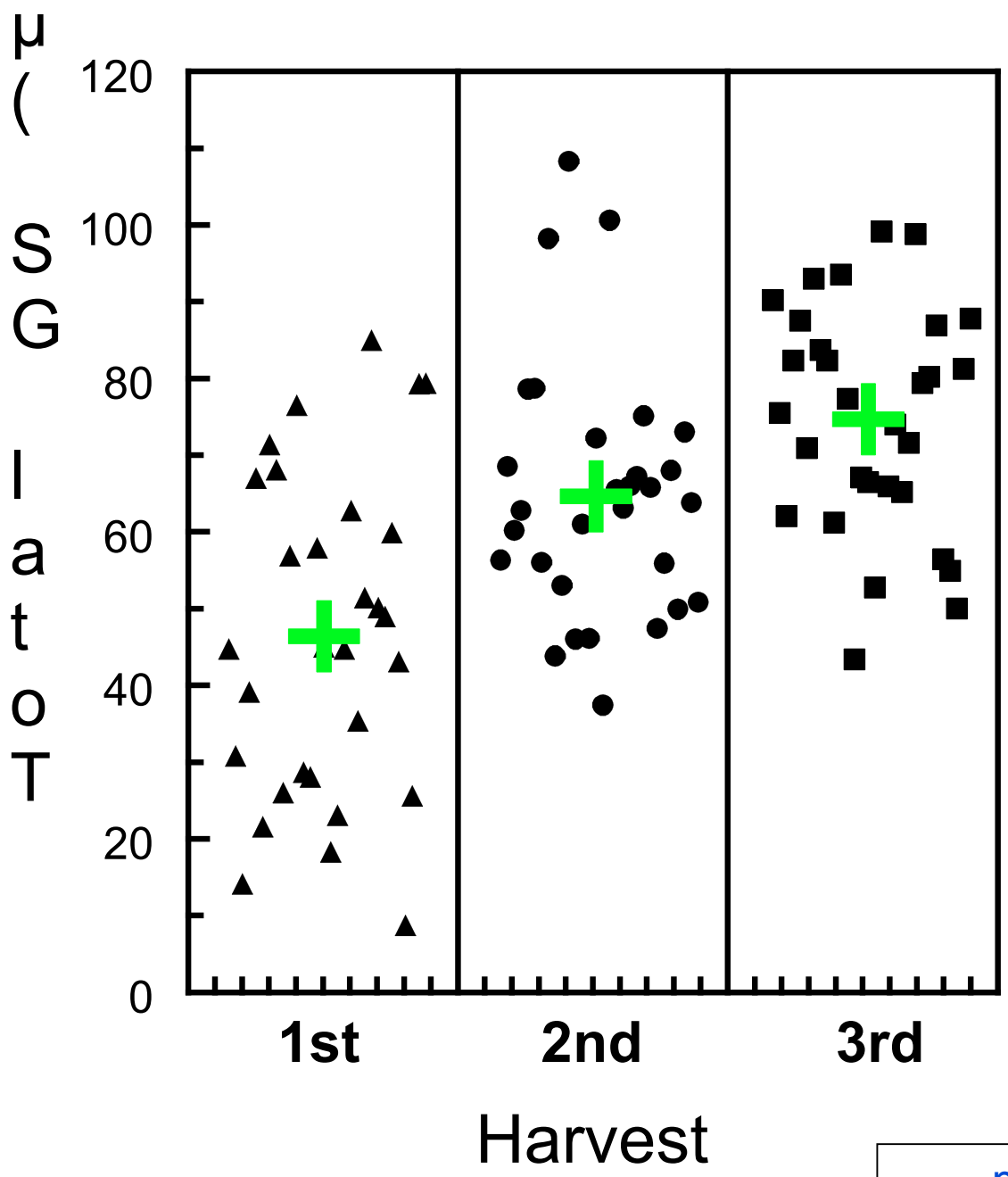
- performance was assessed and compared:
  - number of branches
  - horizontal-to-vertical branching
  - leaf size
  - tree height
  - tree girth
  - canopy biomass

Accession designations

Source	Accession Designation No.
North America	
Bradenton, Florida	02099-021D
ECHO Farm	92028-991E
Fort Myers	92026
N. Wood, Florida	00099-001D
Central America	
Villoria, Belize	03051-031D
Mexico	01084-011D
Caribbean	
K. Flanagan, Haiti	01046-011A
Bohoc, Haiti	02055-021H
La Gonave, Haiti	02073-021H
Les Cayes, Haiti	02057-021H
Port Au Prince, Haiti	02056-021H
C. Thede, Haiti	03064-031H
C. Thede, Haiti	03065-031H
C. Thede, Haiti	03067-031H
C. Thede, Haiti	03068-031H
C. Thede, Haiti	03069-031H
Archai, Haiti	03070-031H
C. Thede, Haiti	03071-031H
Titayen, Haiti	02058-021H

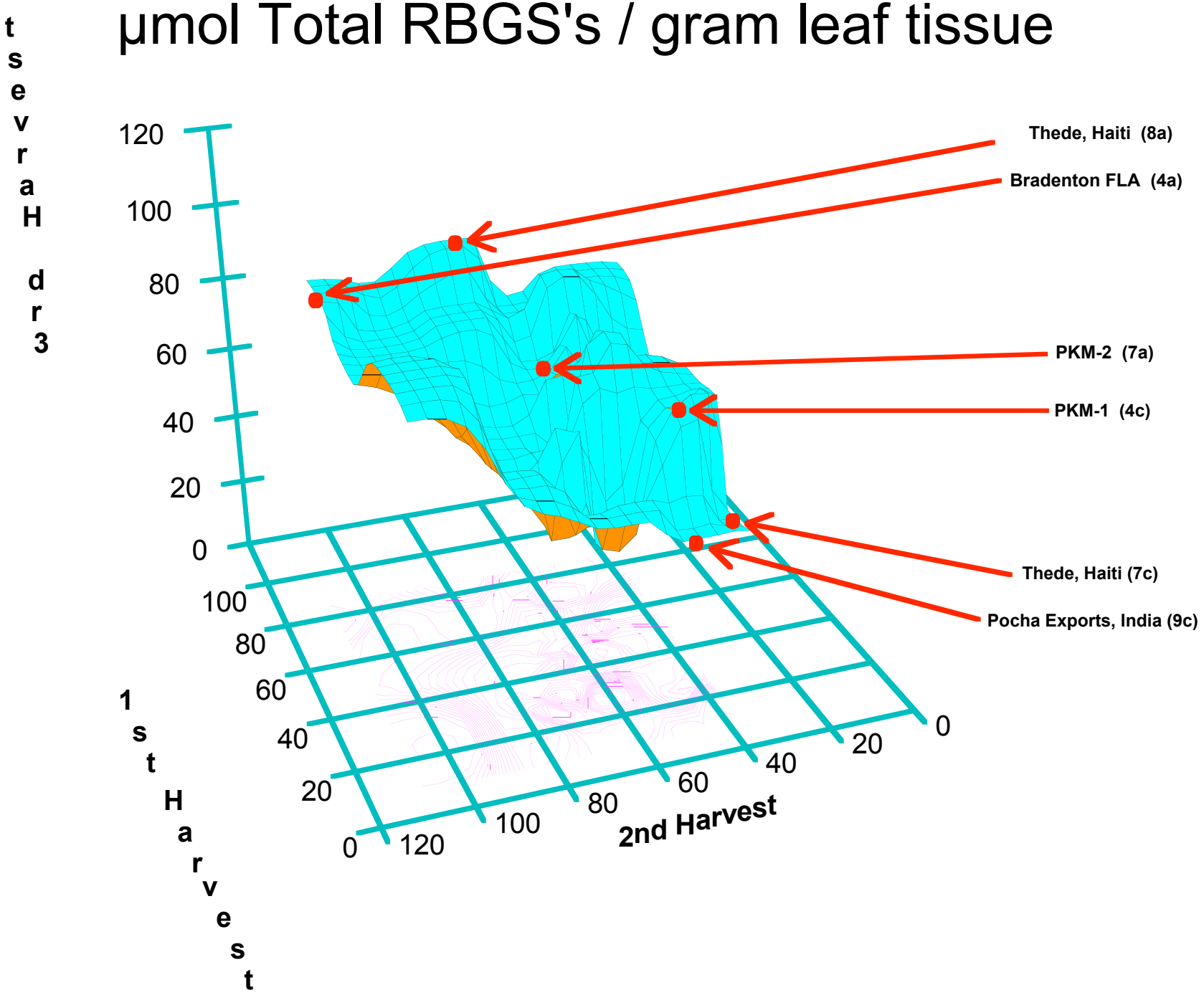
Source	Accession Designation No.
South Asia	
PKM-1 Horti, India	00045-011A
PKM-2 U.Asmar, India	03005-031A
Pocha Exports, India	91070
Trust Hospital, India	03056-031D
Africa	
CWS Senegal	03052-031D
Tanzania/Malawi	98018
Msingi, Tanzania	03034-031D
Optima, Tanzania	01088-011D
Optima, Tanzania	03066-031H
Groves, Mozambique	03055-031D
Binga Trees, Zimbabwe	03053-031D


Total RBGS (µmol/g)
100
80
60
40
20
0
0
4
8
12
16
Girth (inches)
Harvest 1
Harvest 3



p for trend by harvest date was highly significant ($p < 0.001$)

µmol Total RBGS's / gram leaf tissue



- These findings suggest that deliberate selection for agronomic, taste, or quality factors can be made without jeopardizing the content of one of the more important phytochemicals in *Moringa*.

- However, this field trial has not been replicated across multiple soil types, climates, or geographic environments.

- If intelligent efforts are to be directed towards producing and disseminating plants with a specific taste (e.g. mild) for specific purposes (e.g. weaning food), baseline information on these qualities must first be developed.

- Ultimately, it will be necessary to determine the degree to which harshness of taste is controlled by the genetics of a cultivar, variety, or accession, and by the environmental conditions in which the plants are grown (soil type, water status, amount of heat, drought, and pathogen stress, etc.).

- Leaf or foliage production (e.g. biomass) must also be better characterized.

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Trees for Life Journal
a forum on beneficial trees and plants

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Reviews

Moringa oleifera: A Review of the Medical Evidence for Its Nutritional, Therapeutic, and Prophylactic Properties. Part 1.

Jed W. Fahey, Sc.D.
Johns Hopkins School of Medicine, Department of Pharmacology and Molecular Sciences, Lewis B. and Dorothy Cullman Cancer Chemoprotection Center, 725 N. Wolfe Street, 406 WBSB, Baltimore, Maryland, USA 21205-2185

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