Provitamin A Carotenoids in Bananas? The Surprisingly High Level of Micronutrients in Several Staple Foods from Micronesia

By Lois Englberger

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30th NNDC, September 2006

ISLAND FOOD COMMUNITY OF POHNPEI 2004


Guiyang
Kunming
Fuzhou
(Foochow)
TAIPEI
台北
Okinawa
Ogasawara-guntō
Iwō-Jima
Minami-Tori-Shima (Marcus Is)
(JAPAN)
Miyako-Jima
Ishigaki-Jima
Guangzhou
(Canton)
REPUBLIC OF CHINA
Nanning
Macau
(Aomen)
(PORTUGAL)
KAOHSIUNG
高雄
HONG KONG
香港
(U.K.)
2,770 km
3,273 km
Ha-noi
Hai-phong
LAOS
Viangchan
(Vientiane)
Haikou
Hainan Dao
Gulf of Tonkin
Batan Is.
Babuyan Is.
Aparri
Okino-Tori-Shima
(JAPAN)
Farallon de Pajaros
Agrihan
Pagan
Alamagan
Mariana Is.
SAIPAN
サイパン
Tinian
Rota
GUAM
グアム
(U.S.)
Chiang Mai
THAILAND
Da-nang
VIETNAM
SOUTH CHINA SEA
LUZON
Baguio
Angeles
Quezon
PHILIPPINES
MANILA
マニラ
San Pablo
Philippine Is.
Bangkok
CAMBODIA
Phnom Penh
Qui-nhon
Cam-ranh
Ho Chi Minh
Vinh-long
Rach-gia
Mekong
Gulf of Thailand
Catbalogan
SAMAR
Panay
Iloilo
Negros
Cebu
Leyte
Palawan
SULU SEA
Balabac Strait
MINDANAO
Davao
Zamboanga
Palau Is.
PALAU
パラオ
Ngulu
YAP
ヤップ
Sorol
Lamotrek
Kota Kinabalu
BRUNEI
Bandar Seri Begawan
Kepulauan Talaud
Penang
(George Town)
Kepulauan Bunguran Utara
MALAYSIA
Kuala Lumpur
Johor Baharu
Singapore
SINGAPORE
Kuching
KALIMANTAN
(BORNEO)
CELEBES SEA
Manado
Morotai
HALMAHERA
Angaur
Sonsorol
Pulau Waigeo
Sorong
Kepulauan Schouten
SUMATRA
Singkep
Pontianak
Samarinda
Jambi
Bangka
Palembang
Belitung
Banjarmasin
Telukbetung
Tanjung Selatan
SULAWESI
(CELEBES)
Makasar Strait
Maluku Is.
Kepulauan Sula
Buru
Seram
INDONESIA
Pulau Butung
Kepulauan Kai
Puncak Jaya
5030
NEW GUINEA
Enggano
Jakarta
JAVA SEA
Ujung Pandang
BANDA SEA
Bandung
Semarang
Surabaya
Jogjakarta
Denpasar
JAVA
BALI
Great Sunda Is.
Pulau Wetar
Pulau Alor
Flores
Timor
Sumbawa
Sumba
Lesser Sunda Is.
Christmas
(AUSTRALIA)
Kepulauan Aru
Kepulauan Tanimbar
ARAFURA SEA
Melville Is.
TIMOR SEA
Darwin
Gulf of Carpentaria
MICRONESIA
Enewetak
Bikini
Ujelang
Truk Is.
CHUUK
チューク
(旧トラック)
705 km
POHNPEI
ポンペイ
Palikir
546 km
KOSRAE
コスラエ
Mortlock Is.
MICRONESIA
Nukuoro
Caroline Is.
1,028 km
KWAJALEIN
クワジェリン
Likiep
MARSHALL ISLANDS
MAJURO
マジュロ
Ebon
Wake
(U.S.)
8,113 km
Taongi
Bikar
Lisianski
Laysan
Gardner Pinnacles
Necker
JOHNSTON ISLAND
ジョンストン・アイランド
1,324 km
2,350 km
PACIFIC
Makin
KIRIBATI
Tarawa
Maiana
Gilbert Is.
Abemama
Nonouti
Howland
(U.S.)
Baker (U.S.)
Nauru
NAURU
Ocean
Tamana
Arorae
Canton
Enderbury
Phoenix Is.
CENTRAL PACIFIC BASIN
Admiralty Is.
Manus Is.
Bismarck Archipelago
New Ireland
NEW BRITAIN
MELANESIA
PAPUA NEW GUINEA
SOLOMON SEA
Bougainville
SOLOMON ISLANDS
Malaita
Honiara
San Cristobal
Louisiade Is.
Rennell
Vanikolo
Santa Cruz Is. (U.K.)
Torres Is.
Banks Is.
Espiritu Santo
New Hebrides Is.
VANUATU
Malekula
Port Vila
Erromanga
Tanna
Nanumea
Ellice Is.
Nui
Funafuti
TUVALU
WESTERN SAMOA
Savai'i
Apia
Upolu
American Samoa
Pago Pago
Tutuila
Samoa Is.
Vanua Levu
Viti Levu
Nandi
Suva
Kandavu
FIJI
Fiji Is.
Vavau
TONGA
Nukualofa
Tongatapu
Tonga Is.
Niue
(NEW ZEALAND)
CORAL SEA
Chesterfield Is.
(FRANCE)
NEW CALEDONIA
(FRANCE)
Île Lifou
Nouméa
Cape York Peninsula
Cairns
Wyndham
Daly Waters
Derby
Burketown
Normanton
Townsville
Cloncurry
Hughenden
Winton
Port Hedland
Great Sandy Desert
North West Cape
Onslow
Great Dividing Range
Rockhampton
Carnarvon
Gibson Desert
Alice Springs
AUSTRALIA
Great Artesian Basin
Brisbane
Charleville
Great Victoria Desert
Lake Eyre
Geraldton
Laverton
Mungindi
Cape Byron
Woomera
Kalgoorlie
Eucla
Perth
Cape Leeuwin
Albany
Great Australian Bight
Port Pirie
Adelaide
Newcastle
Sydney
Wollongong
Canberra
2230
Mt. Kosciusko
Geelong
Melbourne
Cape Howe
Wilsons Promontory
King Is.
BASS STRAIT
Furneaux Group
Burnie
Launceston
TASMANIA
Lord Howe
TASMAN SEA
Norfolk Is.
(AUSTRALIA)
Kermadec Is.
(NEW ZEALAND)
North Cape
Auckland
Gisborne
East Cape
NORTH
Cook Strait
Cape Farewell
NEW ZEALAND
Wellington
Nelson
INDIAN OCEAN

	Population
FSM	
Chuuk, Pohnpei, Yap, Kosrae	**107,000**
Marshall Islands	**67,731**
Kiribati	**84,494**

Local Foods – Breadfruit, banana, taro, pandanus, yam, coconut, fish and seafood, meats, fruits, vegetables

Imported Foods - Rice, flour products including bread, donuts, and noodles, sweet/refined foods, tinned fish/meat

The great shift from traditional to imported foods + change in lifestyles has been followed by serious problems of nutritionally-related diseases:

- **Vitamin A deficiency (VAD)– over half of preschool children in all three countries**

- **Chronic diseases:**
  diabetes, heart disease, cancer

80% overweight among older age groups
~ 20% of FSM adults with diabetes

Importance of understanding the nutrient content of the indigenous foods

Known Sources of Vitamin A

Animal/Retinol: egg, liver, milk and dairy foods

Plant/Beta-carotene: orange/yellow fruits & vegetables, dark green leafy vegetables

….how could the shift in diet lead to such problems

Provitamin A Carotenoid Content

–

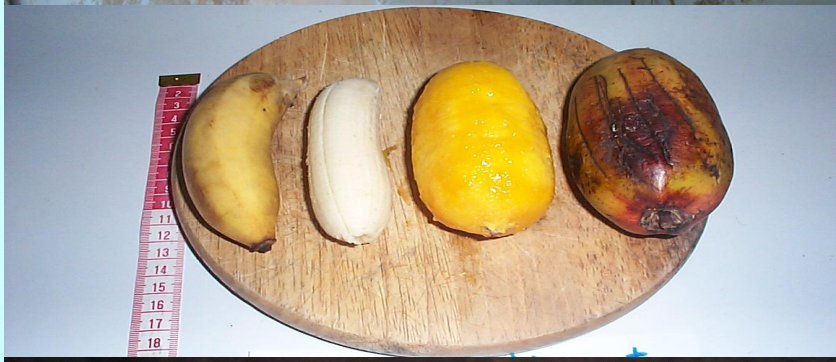
	ug ß-carotene/100 g
Rice	0

Provitamin A carotenoids protect against VAD

Carotenoid-rich foods may help protect against diabetes, heart disease, cancer

Riboflavin: evidence for role in iron absorption/utilization.

Zinc: role in vitamin A metabolism and protection against infection.



There are many cultivars of the staple foods:

55 FSM banana	>48 FSM giant swamp taro
133 FSM breadfruit	>40 FSM pandanus
>100 **Marshalls pandanus**	>100 Kiribati pandanus

Most are not yet analyzed for nutrient content

Many are now rare

Some banana cultivars have been identified with highest provitamin A carotenoid content in the world

Purpose of this project

-Identify foods/cultivars with high micronutrient content and acceptability

-Build partnerships with the community, government and NGOs, laboratories and academic institutions

-Gain insight on how to promote those foods for their health benefits

-Document traditional food system/promote traditional foods for health (global health project with CINE)

Methodology

-Ethnography to select foods and factors of production/consumption/acceptability:

key informant interviews focus group discussions
photography literature review

-**Sampling, sample preparation/transport**

-**Analysis** (using HPLC and standard methods) **for:**

Carotenoids: ß-, α-carotene, ß-cryptoxanthin lutein, zeaxanthin, lycopene

Vitamins: riboflavin, niacin, α-tocopherol, + other including folate (*Karat* banana) using microbiological method

Minerals: iron, zinc, calcium, magnesium, + other

Federated States of Micronesia

Inter-agency approach: Island Food Community of Pohnpei, Agriculture, Health, College of Micronesia-FSM

Focusing on: banana, giant swamp taro, breadfruit, pandanus and other foods (apuch fruit, fish liver)

Samples collected from: all four states (Pohnpei, Kosrae, Chuuk, and Yap), from 2001 to 2006

Karat

Republic of the Marshall Islands

Inter-agency approach:
Ministry of Resources and Development, College of the Marshall Islands,
WUTMI women's group,
Ministry of Health

Focusing on: pandanus, some other atoll foods

Samples collected from:
Majuro Atoll in 2003-2004

Pandanus

Republic of Kiribati

Inter-agency approach: Ministry of Environment, Lands, and Agricultural Development; Health and Medical Services, AMAK women's group

Focusing on: pandanus and some other atoll foods

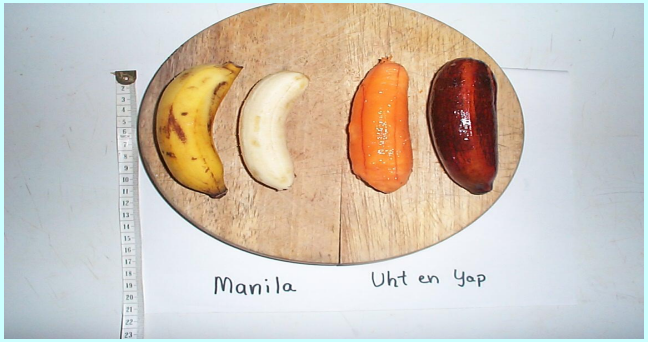
Samples collected from: Tarawa Atoll, 2003 to 2004

Pandanus Paste

Banana: Carotenoid Analysis

18 of 26 cultivars
high* carotenoid levels
(38 – 8508 µg ß-carotene/100 g)

orange or yellow color
good indicator



high levels cooked/raw samples

***Karat* delivered unfrozen to lab:**
2230 µg ß-carotene/100 g
(4x level in previous samples). **This is > 100 x level in Cavendish.**

***Meeting half or all of estimated RDA within normal consumption patterns**

Karat - riboflavin and unidentified flavenoids
0.47 to 14.30 mg/100 g

1 Karat banana (200g) meets almost entire RNI

Niacin and α-tocopherol in *Karat* are also at significant levels

<u>These and the carotenoid findings published in:</u>
Englberger et al. 2003 J Food Comp Anal 16: 3-19
Englberger et al. 2003 J Food Comp Anal 16: 219-236
Englberger et al. 2006 (in press) Int J Food Science Nutr
Englberger et al. 2006 (in press) Food Nutr Bulletin

Giant Swamp Taro

Beta-carotene and Mineral Levels/100g

	Flesh color	ß-carotene	Zinc	Iron	Calcium
		µg	mg	mg	mg
Mwahng en Wel	yellow	5580	36.0	3.2	1440
Mwashei	yellow	2040	4.8	0.2	137
Ebon	cream	85	na	na	na
Adult female RDA		500 RE	9.8-3.0	23-8	1000

Low phytate:zinc molar ratios - May be consumed at high levels 1000g/d

Englberger et al. 2003 J Food Comp Anal 16: 3-19
Englberger et al. 2003 J Food Comp Anal 16: 219-236
Englberger et al. 2004 IZINCG Symposium

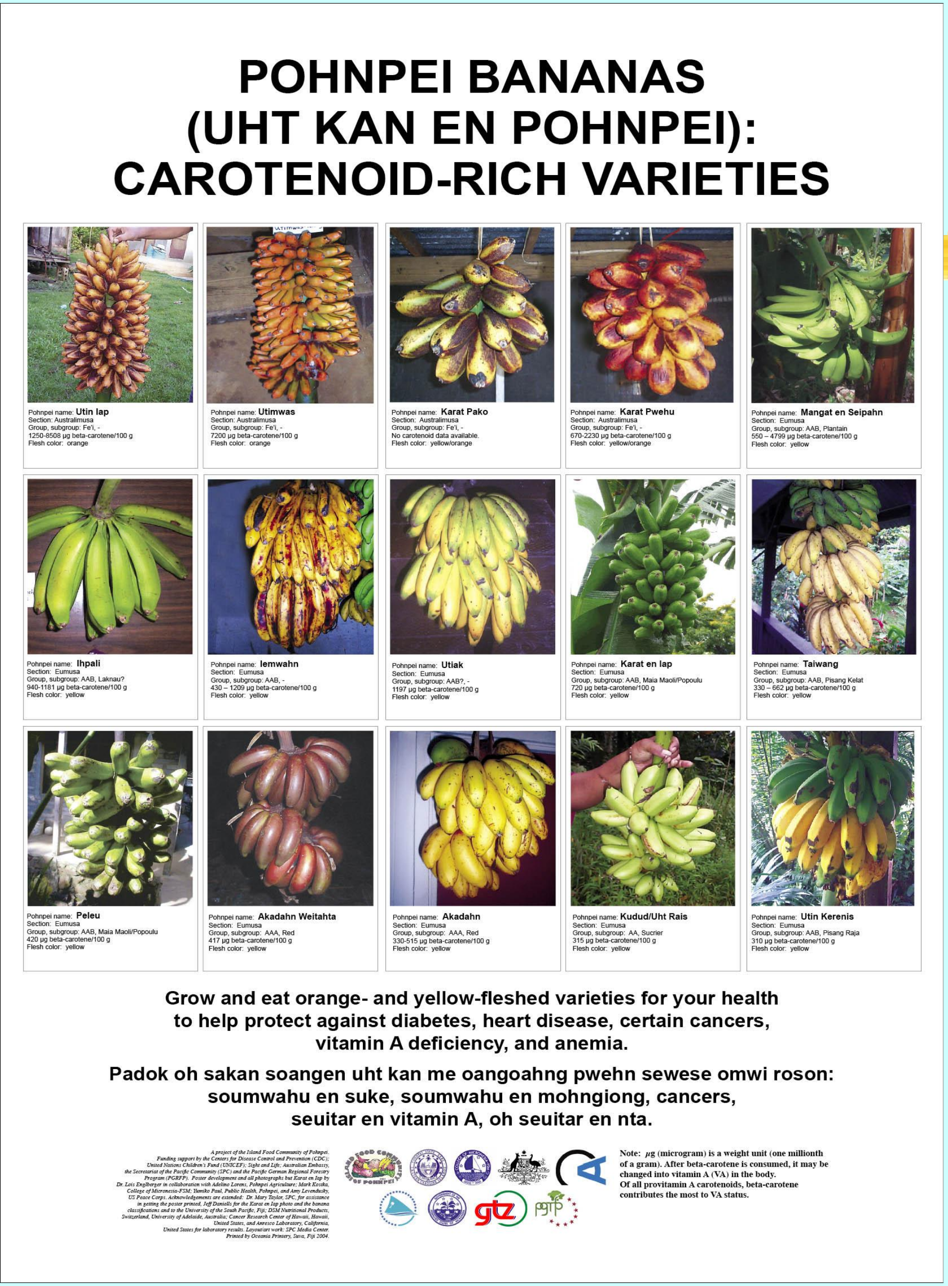
Pandanus Carotenoid Levels

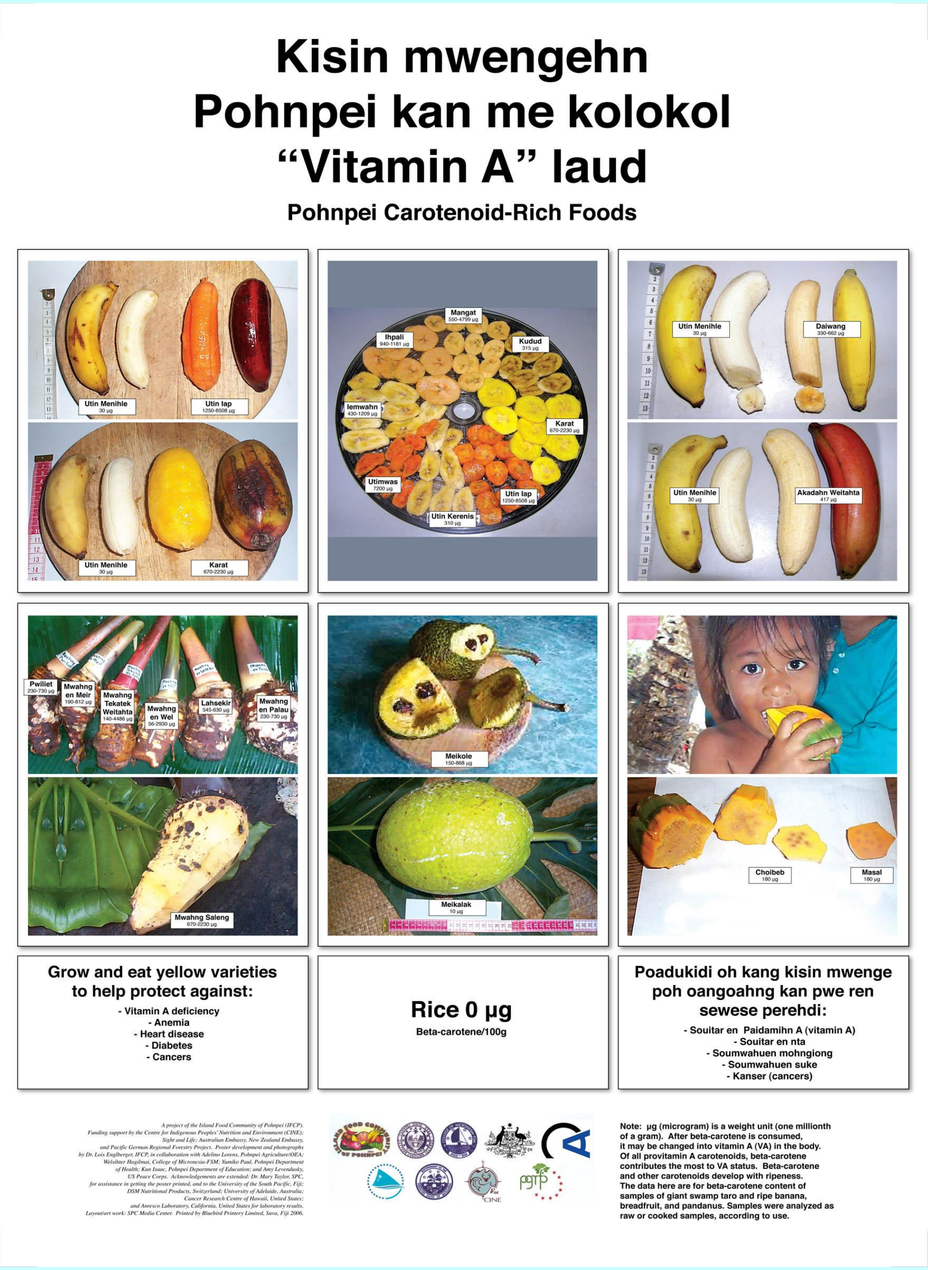
- Fed. States of Micronesia
- Marshall Islands
- Kiribati

28 of 35 cultivars analyzed had rich levels

Ranges: 19 to 19,086 µg ß-carotene/100 g)

Englberger et al. 2003 J Food Comp Anal 16:237-247
Englberger et al. 2006 Public Health Nutrition 9:631-643
Englberger et al. 2006 J Food Comp Anal 19:484-494





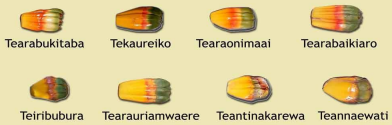
http://www.islandfood.org

TE TOU, KANAM NI KAKAKIBOTU AO NI KAMARURUNG NGKOE TE I-KIRIBATI

Uniki ao kang rinanin tou aika a babobo bwa e bati te Vitamin A iai ao a na buoki totokoan aoraki aikai: te Mataki n te bong, te Akeanrara, te Tioka, Aorakin te Buro ao te Mka ke Maneka ake aki mamaoa.

Grow and eat deep-colored pandanus to help protect against vitamin A deficiency, night blindness, diabetes, heart disease, anemia (weak blood), and certain cancers.

KEY COLOR, SHAPE AND SIZE



Te Tuae - Pandanus Paste
390-444 µg beta-carotene/100 grams

Local name: Tekaureiko
Also known as: Teraeraeti, Tearabuatoro, Tearaantebwe
Big bunch, medium-sized key
Flesh color: orange
410 µg beta-carotene/100 grams

Local name: Tearaonimaai
Big bunch, big key
Flesh color: orange
287 µg beta-carotene/100 grams

Local name: Teiribubura
Big bunch, big key
Flesh color: orange
129 µg beta-carotene/100 grams

Local name: Tearabukitaba
Medium-sized bunch and key
Flesh color: red-orange
896 µg beta-carotene/100 grams

Local name: Tearabaikiaro
Big bunch, big key
Flesh color: yellow
233 µg beta-carotene/100 grams

Local name: Teantinakarewe
One type: big bunch, big key
Another type: small bunch, small key
Flesh color: yellow
94-150 µg beta-carotene/100 grams

Local name: Tearauriamwaere
Big bunch, big key
Flesh color: orange
103 µg beta-carotene/100 grams

Local name: Teannaewati
Big bunch, medium-sized key
Flesh color: yellow
62 µg beta-carotene/100 grams

Te Kabubu - Pandanus Powder
88-90 µg beta-carotene/100 grams

Young pandanus tree,
Agriculture Central Nursery,
Bikenibeu, South Tarawa.

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NOTE:
µg is a weight unit (one millionth of a gram). The pandanus varieties that are rich in beta-carotene (the dark orange ones) are higher in Vitamin A.

Te tou are e mwaiti riki ana beta-carotene (tokatoka riki babobon karana/matana) bon ngaia ae e korakora riki iai te vitamin A.

Kiribati Pandanus Poster

Conclusions

- A systematic investigation using an ethnographic approach for identifying nutrient-rich foods and for understanding food practices and beliefs is critical.

-Many varieties of traditional Micronesian foods contain high content of carotenoids (including provitamin A carotenoids), vitamins, and minerals.

-Thus, they offer potential for alleviating VAD and micronutrient deficiencies in Micronesia, and there is growing evidence of their role in chronic disease.

-Yellow coloration may be used as an indicator for carotenoid-rich banana cultivars (+ other foods).

-Certain cultivars are rare whereas other cultivars + foods (fish liver) that are available but not well utilized.

-There is a wealth of micronutrient-rich foods & cultivars in Micronesia, most not yet assessed.

- Micronesian community very interested in having their own foods analyzed.

-This approach may be relevant for other Pacific Island countries with similar foods.


Challenges

- To identify cultivar (in some cases), to screen so many **cultivars**, and to obtain samples of rare cultivars.

- To obtain samples of cultivars from remote islands.

- To transport samples to the laboratory.

- To obtain quarantine papers and import permits.

- To identify certain substances in analytes (as the unidentified flavenoids in *Karat*).

- To disseminate and publish the results.

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- University of Sydney
- University of the South Pacific
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- DSM Nutritional Products
- Atlanta Center of Nutrient Analysis

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Thank you!

Photo by Amy Levendusky