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

By Lois Englberger
A Lorens, J Alfred, T Iuta, B Aalbersberg, J Schierle, P Hoffman, J Humphries, A Huang

30th NNDC, September 2006
<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSM</td>
<td>107,000</td>
</tr>
<tr>
<td>Chuuk, Pohnpei, Yap, Kosrae</td>
<td>107,000</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td>67,731</td>
</tr>
<tr>
<td>Kiribati</td>
<td>84,494</td>
</tr>
</tbody>
</table>
**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
<table>
<thead>
<tr>
<th>Food</th>
<th>ug β-carotene/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>0</td>
</tr>
</tbody>
</table>
**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
- 133 FSM breadfruit
- >100 Marshalls pandanus
- >48 FSM giant swamp taro
- >40 FSM 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: β-, α-carotene, β-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
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
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 β-carotene/100 g)

orange or yellow color 
good indicator

high levels cooked/raw samples

*Karat delivered unfrozen to lab: 
2230 µg β-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 flavanoids
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

These and the carotenoid findings published in:
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
## Giant Swamp Taro

**Beta-carotene and Mineral Levels/100g**

<table>
<thead>
<tr>
<th>Flesh color</th>
<th>β-carotene (µg)</th>
<th>Zinc (mg)</th>
<th>Iron (mg)</th>
<th>Calcium (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mwahng en Wel</strong></td>
<td>yellow</td>
<td>5580</td>
<td>36.0</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>Mwashei</strong></td>
<td>yellow</td>
<td>2040</td>
<td>4.8</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Ebon</strong></td>
<td>cream</td>
<td>85</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td><strong>Adult female RDA</strong></td>
<td>500 RE</td>
<td>9.8-3.0</td>
<td>23-8</td>
<td>1000</td>
</tr>
</tbody>
</table>

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 β-carotene/100 g

Englberger et al. 2006  J Food Comp Anal 19:484-494
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 flavonoids in *Karat*).
- To disseminate and publish the results.
Acknowledgements:
- Farmers, growers, local markets
- FSM, ROK, RMI Governments and local government agencies and NGOs including Agriculture; Health/Education; College of Micronesia-FSM; Peace Corps; IFCP; RMI Ministry of Health, Kiribati Ministry of Health and Medical Services, RMI Ministry of R&D, Kiribati Ministry of Environment, Lands, Agricultural Development, RMI CMI, AMAK
- CDC/UNICEF, FAO, Sight and Life
- Secretariat of the Pacific Community (SPC)
- SPC Pacific German Regional Forestry Project
- Center for Indigenous Peoples’ Nutrition and Environment
- Australian, New Zealand, and German Governments
- University of Queensland - University of Adelaide
- University of Hawaii - University of Sydney
- University of the South Pacific - Emory University, Howard University
- DSM Nutritional Products - Atlanta Center of Nutrient Analysis

Photos: Lois Englberger, Amy Levendusky and Luciano Mathias
Thank you!