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Food Composition Data from the Federated States of Micronesia

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Abstract—Food composition data on locally grown and harvested foods are important for many reasons: assessing diets for dietary improvement, nutrition research, and promotion of local foods. Vitamin A deficiency, anemia, and chronic diseases, including diabetes, heart disease, and certain cancers, have been identified as problems in the Federated States of Micronesia (FSM), and nutrient-rich foods should be promoted to alleviate these problems. The purpose of this paper is to increase understanding of local FSM foods and to determine which FSM foods have been analyzed for what nutrients. An expert informant and literature search was used to gather information on food composition studies that had been carried out. Data were found for 16 breadfruit, 17 banana, 19 giant swamp taro, and 5 pandanus cultivars; coconut products; *apuch*, *noni*, false durian, lime, and tangerine fruits; cultivars of one common taro, cassava, and sweet potato; selected dark green leafy vegetables; and seafoods. Great differences in nutrient content were found in the estimates for the various foods and food cultivars, in particular, for provitamin A carotenoids, and essential vitamins and minerals, including calcium, iron, and zinc. There are still many foods and food cultivars that have not yet been analyzed or the analyses have been incomplete. Also, there are few studies that investigate differences of nutritional content between foods grown on mountainous islands and those from atolls. Further studies are needed to fill these data gaps.

Introduction

Food composition data are needed in order to assess foods to promote for health purposes, evaluate the diet, establish locally relevant dietary guidelines, carry out research on the relationship between diet, health, and disease, and stimulate markets for new ethnic foods (Kuhnlein 1986). However, relatively few such data are available for the Federated States of Micronesia (FSM). The data on foods that have been analyzed have not been compiled into a database or single document and have not been widely disseminated. Thus, health professionals have not been provided with clear information on the nutritional data presently available. In order to increase understanding of local foods and determine data gaps, a review was made of the food composition data of the four FSM states of Pohnpei, Chuuk, Yap, and Kosrae.

Vitamin A deficiency (VAD) is a serious problem in all four FSM states (Centers for Disease Control and Prevention 2001). Anemia and chronic diseases, including diabetes, heart disease, and certain cancers, are also serious health problems (Elymore et al. 1989, Coyne et al. 1984, Coyne 2000). Foods rich in vitamin A (retinol) and provitamin A and total carotenoids and other micronutrients protect against these diseases (McLaren & Frigg 2001, Ford et al. 1999, World Cancer Research Fund 1997). Thus, one focus of the review was to identify locally grown foods rich in provitamin A carotenoids and vitamin A that could be promoted to alleviate these diseases.

There are many cultivars of the staple foods of FSM: banana, breadfruit, giant swamp taro, and pandanus (Englberger et al. 2003d). Pohnpei Island, the main island of Pohnpei State, often referred to simply as Pohnpei, is mountainous and tropical. In this paper a cultivar refers to a variety produced by cultivation. On Pohnpei, there are names for 133 breadfruit, 55 banana, and 24 giant swamp taro cultivars (Raynor 1991). On the outer atoll islands of Pohnpei State there are over 20 pandanus cultivars (Stone 1963). There are also many cultivars of breadfruit, banana, giant swamp taro, and pandanus in the three other FSM states (Merlin & Juvik 1996, Merlin et al. 1993, 1996). It is likely that many of these cultivars have a high content of provitamin A carotenoid due to the yellow coloration of the edible portions, which is an indicator of carotenoid content (Rodriguez-Amaya 1999, Englberger et al. 2003b).

Calcium, iron, and zinc are essential minerals in the diet. Calcium is important for healthy bones, iron is needed for preventing anemia, and zinc appears to be important for protecting against infection. There is often concern that diets are deficient in these micronutrients (Latham 1997).

The purpose of this paper was to review past studies, determine which FSM foods and food cultivars had been analyzed for what nutrients, and increase understanding of the available food composition data on FSM foods. A focus was on provitamin A carotenoids and vitamin A, with the levels of other essential micronutrients where available.

Methods

Published data on nutritional analyses of FSM foods were reviewed. Expert informants, three Pacific e-mail networks (Pacific Nutritionists, also called PacNut; RootcropsNet; and Pestnet) and the Food and Agriculture Organization (FAO)-based International Network of Food Data Systems (INFOODS) network were contacted. The data up to June 2003 were reviewed in order to list which foods and food cultivars had been analyzed and for which nutrients or other substances. Key informant interviews were also carried out to obtain information about some of the foods and food cultivars that are potential sources of needed nutrients.

Results and Discussion

Data on the FSM staple food cultivars and products and other plant and animal foods that have been analyzed are presented here according to the origin of the food sample by FSM state. Actual nutrient content on the different foods can be obtained from the cited papers. The names of the food cultivars are presented by the name of the cultivar that was analyzed and, if available, the names used in the other FSM states (Tables 1–6). Some data on foods from Marshallese atoll islands are presented in order to provide comparisons of nutritional content of foods from mountainous and atoll islands, which have very different soils. The foods were composite samples analyzed in duplicate or triplicate. Further details on sampling and analytical procedures are presented in the original papers.

Breadfruit

In total, 16 cultivars of FSM breadfruit (*Artocarpus spp*) have been analyzed (Table 1). These analyses were carried out in two studies. An older study analyzed and described foods from the Marshall Islands, Caroline Islands (now FSM), Gilbert Islands (now Kiribati), American Samoa, and Hawaii (Murai et al. 1958). Mature FSM breadfruit and breadfruit products were analyzed for a number of nutrients, not including carotenoid content (Murai et al. 1958). A more recent study focused on carotenoid content of different cultivars of ripe breadfruit

Table 1. Nutritional analyses of breadfruit (*Artocarpus spp*) of the Federated States of Micronesia

Name of cultivar or product; maturity, preparation; source of sample[1]	Analysis	Reference
Chuuk State		
Atchapar cultivar; mature, raw; Dublon	a	Murai et al. 1958
Meichon cultivar; mature, raw and boiled; Moen	a	Murai et al. 1958
Meichon cultivar; mature, prepared as *Kon* (steamed, pounded); Moen	a	Murai et al. 1958
Meikoch cultivar; mature, raw; Moen	a	Murai et al. 1958
Napar cultivar, mature, raw; Tol	a	Murai et al. 1958
Neisoso cultivar; mature, raw; Dublon	a	Murai et al. 1958
Sawan cultivar; mature, raw; Dublon	a	Murai et al. 1958
Apot mein mon; pit preserved, baked; Moen	a	Murai et al. 1958
Apot mei pupu; pit preserved, made with coconut cream and baked; Moen	a	Murai et al. 1958
Emesefich; steamed, pounded, prepared with coconut oil; Moen	a	Murai et al. 1958
Ror; roasted, baked *Meichon,* with coconut cream; Moen	a	Murai et al. 1958
Muatin; steamed, pounded, with coconut cream; Moen	a	Murai et al. 1958
Pohnpei State		
Meikole cultivar; ripe, raw and boiled, with and without skin; Pohnpei	b, c	Englberger et al. 2003b,e
Meiniwe[2] cultivar; ripe, boiled; Pohnpei	b, c	Englberger et al. 2003b,e
Meitoal cultivar; mature and ripe, raw and boiled; Pohnpei	b, c	Englberger et al. 2003b,e
Mei Kalik cultivar; ripe, boiled; Pohnpei	b, c	Englberger et al. 2003b,e
Mei Uhpw[2] cultivar; ripe, boiled; Pohnpei	b, c	Englberger et al. 2003b,e
Mahr; pit preserved, raw *Mei Pedahk* cultivar; Pohnpei	b	Englberger et al. 2003b
Paku Kura; baked sun-dried paste of seeded breadfruit; Kapingamarangi	a	Murai et al. 1958
Kosrae State		
Meisaip cultivar; ripe, boiled	b, c	Englberger et al. 2003b,e
Mos Ikunlal[2] cultivar; ripe, boiled	b, c	Englberger et al. 2003e
Mos Mesunwac[2] cultivar; ripe, boiled	b, c	Englberger et al. 2003b,e
Mos Parkas cultivar; ripe, boiled	b, c	Englberger et al. 2003b,e
Mos Puhtaktack cultivar; ripe, boiled	b, c	Englberger et al. 2003e
Furo; pit preserved, baked *Mos Mesunwac* cultivar	b, c	Englberger et al. 2003b,e

[a]Water, calories, protein, fat, carbohydrate, fiber, calcium, phosphorus, iron, thiamine, riboflavin, niacin, vitamin C

[b]Beta- and alpha-carotene by high performance liquid chromatography (HPLC)

[c]Water; lutein, zeaxanthin by HPLC

[1]Chuuk samples taken from main island Moen and two lagoon islands; Pohnpei samples from main island Pohnpei and one atoll; Kosrae is a single-island state

[2]Cultivars thought to be the same: *Meiniwe-Mos Mesunwac; Mei Uhpw-Mos Ikunlal*

(Englberger et al. 2003b, 2003e). Prior to the year 2000, apparently no FSM breadfruit had been analyzed for carotenoid content.

Breadfruit studies elsewhere have focused on mature (not ripe) breadfruit, as breadfruit is mostly eaten in that state. However, many Micronesians eat ripe breadfruit. Ripe breadfruit becomes very yellow, indicative of carotenoids. The analyses showed that one ripe breadfruit cultivar, a seeded breadfruit (*Artocarpus mariannensis*) from Pohnpei, has significant levels of provitamin A carotenoids. The content of beta-carotene, the most important of the provitamin A carotenoids, ranged from 140 to 868 μg/100 g (Englberger et al. 2003b, 2003e).

This can be compared to rice, which contains no beta-carotene or other provitamin A carotenoids. White rice contains no vitamin A or beta-carotene, 4 mg calcium, 0.3 mg iron, and 0.6 mg zinc/100 g (Dignan et al., 1994). Brown rice also contains no vitamin A or beta-carotene, 6 mg calcium, and 1.1 mg iron (no value is given for zinc). This is of interest because rice (white rice) has become a staple food for many Pacific Island communities.

Although seeded breadfruit is not commonly eaten on Pohnpei, informants stressed that it is a common and well-liked food on FSM atoll islands. In contrast to unseeded breadfruit, which is only eaten cooked, seeded breadfruit may be eaten raw as a fresh fruit. As far as we know, seeded breadfruit is the first breadfruit identified with high levels of carotenoid content. This same study showed that cultivars of ripe unseeded breadfruit (*Artocarpus altilis*) have low levels of provitamin A carotenoids. Of the three Marshall Islands breadfruit cultivars analyzed by Murai et al. (1958), one was a seeded breadfruit (*Mijiwan*), but it was not ripe and it was not analyzed for carotene content. The raw seeded breadfruit had high levels of vitamin C (34 mg/100 g) compared to cooked unseeded breadfruit (1–3 mg vitamin C/100 g). Murai et al. (1958) analyzed for carotenoid content in breadfruit only on two mature unseeded breadfruit cultivars from American Samoa. The sun-dried preserved breadfruit paste from Kapingamarangi analyzed was made from seeded breadfruit, but it was not analyzed for carotene content.

An early dietary study carried out on Udot, a mountainous lagoon island near Moen, the main island of Chuuk State, showed that the breadfruit quantity then consumed daily varied from small amounts of about 100 to 3250 grams of cooked pounded breadfruit per person per day (Murai 1954). In addition some people ate smaller amounts of other breadfruit preparations such as *ror, emesefich*, and *muatin.* Present-day informants indicate that these foods are still prepared and eaten, and they also described the use of crushed leaves (*otuot* and *anno)* in the preparation of *emesefich*.

Murai et al. (1958) concluded that because breadfruit is often eaten in large quantities it could supply a large proportion of the daily nutrient requirements for an adult Micronesian, as estimated at that time. They pointed out that if 1000 g breadfruit were consumed in one day, this would supply one-fifth of the protein, one-fourth of the calcium, more than half of the iron, one-half to two-thirds of thiamine (vitamin B_1), about one-half of riboflavin (vitamin B_2), three-fourths of niacin (another B vitamin), and more than half of the vitamin C estimated requirements.

The Chuuk breadfruit samples contained from 15 to 31 mg calcium/100 g and 0.3 to 0.6 mg iron/100 g. The calcium levels in breadfruit are much higher than in rice and the iron level in breadfruit is similar or slightly higher. As far as we are aware, there has been no analysis of FSM breadfruit for zinc content. Murai et al. (1958) showed that there was no striking difference in calcium content between breadfruit from the atoll islands of the Marshalls and the mountainous islands of what is now Chuuk in FSM, but that there are differences in the cultivars. On the other hand, the breadfruit from the Marshallese atolls had a relatively high iron content, ranging from 0.7 to 1.6 mg iron/100 g.

Murai et al. (1958) analyzed seeds from the Marshallese seeded breadfruit. These seeds are always eaten cooked and the taste is described as similar to that of chestnut. The authors pointed out that cooked breadfruit seeds had higher levels of calcium (48 mg/100 g) and iron (2.3 mg/100 g) compared to chestnuts (22 mg calcium/100 g and 1 mg iron/100 g). The breadfruit seeds also contained 8 g protein/100 g, higher than the level in chestnut and much higher than the levels in breadfruit flesh (1 to 2 g/100 g). The fat content in the breadfruit seeds (3–5 g/100 g) was much lower than fat content in other nuts such as peanuts and macademia nuts (47–76 g/100 g) (Dignan et al. 1994). Although the seeds of FSM seeded breadfruit have not been analyzed, the results of the analyses from the Marshalls indicate that FSM breadfruit seeds may have similar levels of these nutrients.

BANANA

In total 17 FSM banana (*Musa spp*) cultivars have been analyzed for nutritional content (Table 2). The *Karat*, a Fe'i banana of the *Australimusa* Series, also called *Musa troglodytarum,* has been analyzed in several laboratories for its carotenoid content and it has also been analyzed for 9 minerals. This banana is characterized by its erect bunch and deep yellow-orange colored edible portion. *Karat* was found to have a high carotenoid content, similar to a number of other FSM yellow- and orange-fleshed bananas (Englberger 2001, Englberger et al. 2003b, 2003e, Shovic & Whistler 2001). *Karat* has been the traditional weaning food in Pohnpei for many years (Demory 1976, Englberger 2003). The *Usr Kulasr* of Kosrae is considered the same cultivar; it was documented in 1824 as being the most common banana in Kosrae at that time (Ritter & Ritter 1982) but is now rare, like *Karat* in Pohnpei.

Prior to the studies on *Karat* and other yellow- and orange-fleshed Micronesian bananas, very few FSM bananas were analyzed. Murai et al. (1958) analyzed two banana cultivars from Chuuk, but the flesh of these were light-colored. Since the 1958 study, 15 FSM cultivars have been analyzed. Of these, 12 have significant levels of provitamin A carotenoid content. Deep yellow and orange coloration appears to be closely related to a high carotenoid content. In one study *Karat* had a significant calcium content, 68.6 mg/100 g (Englberger et

Table 2. Nutritional analyses of banana (*Musa spp.*) of the Federated States of Micronesia

Name of cultivar or product; maturity and preparation; source of sample[1]	Analysis	Reference
Chuuk State		
Marech cultivar; ripe, raw; Moen	b	Englberger et al. 2003b
Samawa cultivar; ripe, raw; Udot	a	Murai et al. 1958
Utsutop cultivar; ripe, raw and boiled; Moen	a	Murai et al. 1958
Pohnpei State		
Akadahn[2] cultivar; ripe, raw and steamed	b	Englberger et al. 2003b
Inahsio[2] cultivar; ripe, raw	d	Shovic and Whistler, 2001
Ihpali[2] cultivar; ripe, boiled	b, c	Englberger et al. 2003b,e
Karat[2] cultivar; ripe, raw and steamed	b, c, d, e	Englberger 2001; Shovic and Whistler 2001; Englberger et al. 2003b,e
Mangat cultivar; ripe, raw	c	Shovic and Whistler, 2001
Utin Kerenis cultivar; ripe, raw	b	Englberger et al. 2003b
Utin Ruk[2] cultivar; ripe, raw and boiled	b, c, d	Shovic and Whistler 2001; Englberger et al. 2003e
Utin Iap cultivar; ripe, raw and baked	b, c	Englberger et al. 2003b,e
Kosrae State		
Usr Apat Fusus[2] cultivar; ripe, boiled	b, c	Englberger et al. 2003e
Usr Apat Poel[2] cultivar; ripe, boiled	b, c	Englberger et al. 2003e
Usr Kufafa cultivar; ripe, boiled	b, c	Englberger et al. 2003e
Usr Kulasr[2] cultivar; ripe, raw and boiled	b, c	Englberger et al. 2003e
Usr Kuria cultivar; ripe, raw and steamed	b	Englberger et al. 2003b
Usr *Macao* cultivar; ripe, boiled	b, c	Englberger et al. 2003b,e
Usr Lakatan[2] cultivar; ripe, raw	b, c	Englberger et al. 2003e
Usr Taiwang cultivar; ripe, raw and boiled	b, c	Englberger et al. 2003b,e
Usr in Yeir cultivar; ripe, raw and boiled	b, c	Englberger et al. 2003b,e
Usr Wac es Sie[2] cultivar; ripe, raw and steamed	b	Englberger et al. 2003b
Usr Wac cultivar; ripe, boiled	b, c	Englberger et al. 2003e

[a]Water, calories, protein, fat, carbohydrate, fiber, ash, calcium, phosphorus, iron, thiamine, riboflavin, niacin, vitamin C

[b]Beta- and alpha-carotene by high performance liquid chromatography (HPLC)

[c]Water; lutein, zeaxanthin by HPLC

[d]Kilocalories, protein, fat, carbohydrate, fiber, calcium, phosphorus, iron, sodium, potassium, magnesium, manganese, zinc, copper, vitamin C, beta- and alpha-carotene by HPLC

[e]Beta- and alpha-cryptoxanthin by HPLC

[1]Chuuk samples taken from main island Moen and one lagoon island; Pohnpei samples all from Pohnpei Island; Kosrae is a single-island state

[2]Cultivars thought to be the same: *Akadahn-Usr Lakatan, Ihpali-Usr Wac es Sie, Inahsio-Usr Apat Poel, Utin Ruk-Usr Apat Fusus*

al. 2003b), enough to provide almost half of the estimated requirements for a non-pregnant, non-lactating woman with normal eating patterns. However, another analysis of *Karat* found that it contained a lower calcium level,12.2 mg/100 g (Shovic & Whistler 2001). This is similar to bananas elsewhere at 11 mg/100g (Dignan et al. 1994).

The *Karat* and *Taiwang* bananas analyzed by Englberger et al. (2003b) had low levels of iron and zinc similar to bananas elsewhere, 0.2 and 0.1 mg iron /100g and 0.3 and 0 mg zinc/100g. The bananas analyzed by Shovic & Whistler (2001) and Murai et al. (1958) also had low mineral levels (0.2 to 0.5 mg iron /100 g and 0.1 to 0.3 mg zinc/100g).

Some Pohnpei yellow and orange-fleshed banana cultivars, which are potentially rich in provitamin A carotenoids, have not been analyzed. This includes *Karat en Iap, Mangat en Alokapw*, and *Utimwas*. Most Chuuk banana cultivars have not yet been analyzed for their nutritional content, and there appears to be no data on analyses of any Yap banana cultivars.

TARO

In total, 19 cultivars of FSM giant swamp taro (*Cyrtosperma chamissonis*) have been analyzed (Table 3). Murai et al. (1958) analyzed two samples, *Simiden* and one called *Puna*, which is the general name for giant swamp taro in Chuuk. Murai et al. (1958) were apparently not aware that *Puna* is the general name for giant swamp taro in the lagoon islands of Chuuk. Thus this sample must be considered as an unidentified giant swamp taro cultivar. The unidentified cultivar was from the main island of Chuuk, Moen, a mountainous island. The source of *Simiden* was documented as Truk district, most probably the same area.

This study also analyzed giant swamp taro from Marshallese atoll islands. The calcium contents of the three Marshallese giant swamp taro were high (from 301 to 598 mg/100g). However, the authors pointed out that one of these taro cultivars was analyzed for oxalic acid and that it contained 1.04 g/100 g. Due to this high level of oxalic acid, which may combine with the calcium, the bioavailability of calcium in taro may be poor. The authors did not mention phytate, another food constituent known to decrease calcium bioavailability. Thus, further studies are needed to investigate whether calcium in taro is well utilized. The calcium content of the two Chuuk cultivars was lower and varied by cultivar. *Simiden* contained 156 mg/100 g and the other contained 35 mg/100g. The Chuuk cultivars contained relatively high levels of iron. *Simiden* contained 0.8 mg/100g and the other contained 1.4 mg/100 g. This was almost identical to the iron content in the three Marshallese atoll cultivars (also ranging from 0.8 to 1.4 mg iron/100g).

Bradbury & Holloway (1988) compared the differences of five giant swamp taro cultivars that were grown both on the mountainous island of Pohnpei and on the atoll island of Ngatik. None of these cultivars had a high carotenoid content, but also none had a yellow edible portion. The calcium levels of some cultivars were high, one from Ngatik containing 256 mg/100g. The mean calcium level of the same cultivars grown on the atoll island (199 mg/100 g) was higher than the

Table 3. Nutritional analyses of giant swamp taro (*Cyrtosperma chamissonis*) of the Federated States of Micronesia

Name of cultivar; preparation; source of sample[1]	Analysis	Reference
Chuuk State		
Anetchimou cultivar; raw and boiled; Chuukese variety grown on Pohnpei	b, c	Englberger et al. 2003e
Fanal cultivar; raw and boiled; Chuukese variety grown on Pohnpei	b, c, d	Englberger et al. 2003b,e
Mwashei cultivar; raw and boiled; Chuukese variety grown on Pohnpei	b, c, d	Englberger et al. 2003e
Ponon cultivar; raw and boiled; Chuukese variety grown on Pohnpei	b, c	Englberger et al. 2003e
Simiden[2] cultivar; baked; island not specified	a	Murai et al. 1958
Unidentified cultivar called *Puna*; baked; Moen	a	Murai et al. 1958
Pohnpei State		
Mwahng Medel cultivar; raw and boiled; Pohnpei	b, c	Englberger et al. 2003b,e
Nein Alex cultivar; raw; Pohnpei and Ngatik	e	Bradbury and Holloway, 1988
Nein Bob cultivar; raw; Pohnpei and Ngatik	e	Bradbury and Holloway, 1988
Nukuoro cultivar; raw; Pohnpei and Ngatik	e	Bradbury and Holloway, 1988
Pohnengles cultivar; raw; Pohnpei and Ngatik	e	Bradbury and Holloway, 1988
Simihden[2] cultivar; raw and boiled; Pohnpei and Ngatik	b, c, e	Bradbury and Holloway, 1988; Englberger et al. 2003e
Six-moon cultivar; raw and boiled; Pohnpei	b, c	Englberger et al. 2003e
Kosrae State		
Pasruk Ebon cultivar; boiled	b, c	Englberger et al. 2003b,e
Pasruk Fukeh cultivar; raw and boiled	b, c	Englberger et al. 2003b,e
Pasruk Kirngesi cultivar; boiled	b, c	Englberger et al. 2003b,e
Pasruk Siminton cultivar; boiled	b, c	Englberger et al. 2003b,e
Pasruk Tepat cultivar; boiled	b, c	Englberger et al. 2003b,e
Pasruk Wasrwasr cultivar; raw and boiled	b, c	Englberger et al. 2003b,e
Yap State		
Unspecified cultivar of *Lak*	b, c	Englberger 2001

[a]Water, calories, protein, fat, carbohydrate, fiber, ash, calcium, phosphorus, iron, thiamine, riboflavin, niacin, vitamin C

[b]Beta- and alpha-carotene by high performance liquid chromatography (HPLC)

[c]Water; lutein, zeaxanthin by HPLC

[d]Iron, zinc, calcium, magnesium, phosphorus, manganese, copper, sodium, potassium

[e]Kilojoules, protein, fat, starch, sugar, fiber, total oxalate, soluble oxalate, calcium oxalate, free calcium, malate, citrate, succinate, calcium, phosphorus, iron, sodium, potassium, magnesium, manganese, copper, zinc

[1]Chuuk samples taken from Chuuk and Pohnpei; Pohnpei samples from main island and one atoll island; Yap sample taken from main island -island state

[2]Cultivars thought to be the same: *Simiden- Simihden*

cultivars grown on Pohnpei (91 mg/100 g). On the other hand, the mean zinc level of the cultivars grown on Pohnpei (5.4 mg/100 g) was higher than the mean zinc level of those on the atoll (1.6 mg/100 g). The mean iron level of the Pohnpei cultivars (1.2 mg/100 g) was also higher than that of the atolls (0.6 mg/100 g). The mean calcium, zinc, and iron levels in FSM giant swamp taro are higher than the respective levels in white rice (Dignan et al. 1994 and the paragraph in the breadfruit section presenting micronutrient content in rice).

The recent study of giant swamp taro focused on carotenoid content of 12 cultivars from Chuuk, Pohnpei, and Kosrae. Of these, the 10 cultivars having yellow-colored edible portions had significant levels of provitamin A carotenoids, enough to provide half or the total of estimated requirements for a non-pregnant, non-lactating woman (Englberger et al. 2003b, 2003e). The two Kosrae taro with light-colored edible portions had minimal levels. These analyses indicate that the color of the raw edible corm can be used as a rough guide for selection of carotenoid-rich taro cultivars. One unspecified yellow-colored cultivar from Yap also had high carotenoid levels (Englberger 2001).

Two of the Chuuk cultivars grown on Pohnpei (*Fanal* and *Mwashei*) were analyzed for 9 minerals and they had high levels of calcium and zinc. *Fanal* contained 103 mg calcium/100 g and 7.0 mg zinc/100 g and *Mwashei* contained 137 mg calcium/100 g and 4.8 mg zinc/100 g. If eaten within normal eating patterns and if well utilized, they could provide the total estimated requirements for a non-pregnant, non-lactating woman (Englberger et al. 2003b). These two cultivars contained low levels of iron, 0.1 and 0.2 mg/100g respectively.

The corm of the Chuuk *Oni* cultivar (also called *Otsu)* of common taro (*Colocasia esculenta*) was analyzed (Table 5). It contained a low level of calcium (18.7 mg/100g), but a relatively high iron level (1.0 mg/100 g). The leaves of this taro are eaten in many Pacific countries. However, Murai et al. (1958) noted that according to their observations the natives of the Carolines (now FSM) did not eat the leaves. Murai et al. (1958) also could not find any published report elsewhere documenting the consumption of these leaves in FSM.

Pandanus

In total, nutritional analyses have been carried out on five identified and two unidentified cultivars of FSM pandanus (*Pandanus tectorius*) (Englberger et al. 2003a, Shovic & Whistler 2001) and one pandanus product (Murai et al. 1958) (Table 4). The pandanus product was pandanus flour from Kapingamarangi; it was identified as a carotenoid-rich food (1200 I.U. total carotenes). This pandanus flour also had high levels of calcium (797 mg/100g) and iron (1.7 mg/100g). No cultivars of unprocessed pandanus from FSM were analyzed in that study.

Three unprocessed pandanus cultivars from Kosrae were found to contain high carotenoid levels (Englberger et al. 2003a), and all had orange-colored edible portions. The other two cultivars had light-colored edible portions and minimal carotenoid levels. Thus, coloration of the edible portion of pandanus appears to correlate with carotenoid levels.

Table 4. Nutritional analyses of pandanus (*Pandanus tectorius*) of the Federated States of Micronesia

Name of cultivar or product; maturity and preparation; source of sample[1]	Analysis	Reference
Pohnpei State		
Unspecified cultivar; ripe, raw; Pohnpei	b, c, d	Shovic and Whistler 2001;
Pandanus flour, *Paku Harahara,* Kapingamarangi	a	Murai et al. 1958
Kosrae State		
Mweng Choipep cultivar; ripe, raw	b	Englberger et al. 2003b
Mweng Masal Lulap cultivar; ripe, raw	b	Englberger et al. 2003b
Mweng Masal Srisrik cultivar; ripe, raw	b	Englberger et al. 2003b
Mweng Masal Srisrik (new) cultivar; ripe, raw	b	Englberger et al. 2003b
Mweng Oa cultivar; ripe, raw	b	Englberger et al. 2003b

[a]Water, calories, protein, fat, carbohydrate, fiber, ash, calcium, phosphorus, iron, thiamine, riboflavin, niacin, vitamin C; carotene by older method of chromatography

[b]Beta- and alpha-carotene by high performance liquid chromatography (HPLC)

[c]Water; lutein, zeaxanthin by HPLC

[d]Kilocalories, protein, fat, carbohydrate, fiber, calcium, phosphorus, iron, sodium, potassium, magnesium, manganese, zinc, copper, vitamin C, beta- and alpha-carotene by HPLC

[1]Pohnpei samples from main island Pohnpei and one atoll island, Kapingamarangi; Kosrae is a single-island state

There are at least 20 cultivars from Kapingamarangi, including both yellow and orange-fleshed types, as well as a number from other Pohnpei atoll islands (Mokil, Pingelap, and Nukuoro) and a few from Chuuk and Yap that have not been analyzed (Englberger et al. 2003c). No fresh cultivars of FSM pandanus have been analyzed for calcium, iron, or zinc. The two raw Marshallese pandanus cultivars had low calcium levels (9.6 and 16.4 mg/100g), but relatively high iron levels (0.6 and 0.9 mg/100g).

Pandanus seeds from the Marshalls contained 10 g protein/100 g, a relatively high level. However, the authors pointed out that the seeds are very small (less than 0.5 g per seed) and are difficult to extract from the woody cases of the pandanus key. The authors concluded that the greatest nutrient contribution of pandanus was energy, provitamin A carotenoid, and vitamin C.

Other Selected Plant Foods

Table 5 presents data on the analyses of other selected plant foods. Murai et al. (1958*)* and FSM key informants described *Apuch* fruit (*Crataeva speciosa*) as a common and popular food in Chuuk. Little is known about this food (called garlic pear in English), but it is eaten in the neighboring country of Palau where it is called *tafaso* or *tafach* (Watson et al. 2002). The fruit, weighing 150 grams per piece on average, has a pungent odor, which is repugnant to the uninitiated, but well-liked by local people, as noted both by Murai et al. (1958) and present-

Table 5. Nutritional analyses of other selected plant foods of the Federated States of Micronesia

English, local, scientific name; maturity and preparation; source of sample[1]	Analysis	Reference
Chuuk State		
Apuch fruit (*Crataeva speciosa);* raw	a	Murai et al. 1958
Coconut liquid from drinking nuts, *nu (Cocos nucifera);* immature, raw	a	Murai et al. 1958
Coconut flesh from drinking nuts, *apun* (*Cocos nucifera);* immature, raw	a	Murai et al. 1958
Coconut liquid from mature nuts (*Cocos nucifera);* mature, raw	a	Murai et al. 1958
Coconut flesh from mature nuts, *taka* (*Cocos nucifera);* mature, raw	a	Murai et al. 1958
Coconut embryo, *chofar* (*Cocos nucifera);* mature, raw	a	Murai et al. 1958
Common taro cultivar, *oni/otsu (Colocasia esculenta);* roasted	a	Murai et al. 1958
Lime fruit (*Citrus aurantifolia);* ripe; raw	e	Murai et al. 1958
Sweet potato (unidentified cultivar), *kamuti* (*Ipomoea batatas*); boiled	a	Murai et al. 1958
Pohnpei State		
Bird's nest fern, *tehnlik (Asplenium nidus);* boiled	b, c	Englberger et al. 2003b,e
Chaya leaves, *chaya* (*Cnidoscolus chayamansa*); raw	d	Shovic and Whistler 2001
False durian fruit, *duhrien* (*Pangium edule*); ripe, raw and boiled	b, c	Englberger et al. 2003b,e
Noni fruit, *weipwul* (*Morinda citrifolia*), ripe, raw	d	Shovic and Whistler 1958
Pele leaves, *pele* (*Hibiscus manihot*); raw	d	Shovic and Whistler 1958
Kosrae State		
Cassava root, *tapioka* (*Manihot esculenta*); boiled	b	Englberger et al. 2003b
Tangerine, *mo srisrik* (*Citrus reticulata*); ripe, boiled	b, c	Englberger et al. 2003e

[a]Water, calories, protein, fat, carbohydrate, fiber, ash, calcium, phosphorus, iron, thiamine, riboflavin, niacin, vitamin C

[b]Beta- and alpha-carotene by high performance liquid chromatography (HPLC)

[c]Water; lutein, zeaxanthin by HPLC

[d]Kilocalories, protein, fat, carbohydrate, fiber, calcium, phosphorus, iron, sodium, potassium, magnesium, manganese, zinc, copper, vitamin C, beta- and alpha-carotene by HPLC

[e]Vitamin C

[1]Chuuk samples from main island Moen; Pohnpei samples from main island; Kosrae is a single-island state

day informants. The fruit is a potential source of carotenoids as the flesh turns orange when ripe. However, Murai et al. (1958) did not analyze the fruit for carotenoid content. *Apuch* is eaten ripe and raw, as well as ripe and cooked on some islands. Murai et al. (1958) found that *apuch* has a high level of vitamin C (45 mg/100 g), comparing favorably with oranges (30 to 52 mg/100 g) (Dignan et al. 1994). Thus, *apuch* may be an important source of vitamin C in Chuuk where it is commonly eaten. *Apuch* has low calcium (11.3 mg/100 g) and medium iron levels (0.6 mg/100 g).

Another FSM fruit is *Morinda citrifolia*, called *weipwul* in Pohnpei and *noni* in other parts of the Pacific. It has been used traditionally as a medicine. According to present-day informants, it is also eaten occasionally as a fruit, although less so than in the past. It contains a very high level of vitamin C (155 mg/100 g), medium level of calcium (41.7 mg/100 g), and low levels of iron (0.4 mg/100 g), zinc (0.4 mg/100 g), and beta-carotene (<20 µg /100 g) (Shovic & Whistler 2001).

False durian fruit is considered a wild fruit and is not well-liked. It is rarely eaten, although informants explained that it was eaten more in the past. It was analyzed only for carotenoid content; it contained minimal levels (60 to 189 µg beta-carotene/100 g) (Englberger et al. 2003b, 2003e).

A lime sample from Chuuk was analyzed for just one nutrient, vitamin C; it contained 24 mg/100 g, a meaningful amount, although this is a lower level than that found in *apuch* and *weipwul* (*noni*).

A tangerine sample from Kosrae was analyzed for carotenoid content. It contained low carotenoid levels, 40 µg beta-carotene/100 g (Englberger et al. 2003e).

Murai et al. (1958) pointed out that there are many different food products from coconut. Mature coconut meat contains important amounts of fat and immature coconut liquid provides a source of clean drinking water. The mature coconut from Chuuk provided relatively high levels of iron (2.4 mg/100 g), possibly from the layer of brown skin adhering to the white part that was not removed from the coconut meat for the analysis (Murai et al. 1958). The authors mentioned that the coconut cream as well as the mature coconut meat contains important amounts of vitamin C, calcium, phosphorus, protein, and niacin. The authors also indicated that coconut embryo, which is a popular food, could provide a significant proportion of the daily estimated adult nutrient requirements, including one-third of vitamin C, one-fourth to one-third of iron, one-fifth to one-fourth of niacin, and one-tenth of the protein, calories, calcium, and riboflavin, if four or five were eaten in a day.

According to FSM informants, coconut sap, which is also called coconut toddy, has been an important food in FSM in the past, but it is used less now. This liquid is collected in the coconut tree from the coconut blossom. When fresh, it has no alcohol content. The fresh sweet unfermented liquid has been consumed as a drink by FSM people of all ages. The sap is also boiled to make a concentrated product used for sweetening other foods. Although no FSM coconut toddy was analyzed, slightly fermented toddy samples from the Marshall Islands and Kiribati were analyzed, as well as the concentrated syrup. Both contained important levels of vitamin C, from 15 to 25 mg/100 g for the toddy and 21 to 51 mg/100 g for the concentrated syrup (Murai et al. 1958).

Present-day informants described another food obtained from coconut: the husk obtained from certain FSM coconut cultivars. In Kosrae, for example, this is the *Nuweewee* coconut. Its husk is eaten raw and is described as very tasty. Murai et al. (1958) did not obtain any samples of that food, although they pointed out that prior researchers had documented the consumption of raw coconut husk.

Three types of dark green leafy vegetables available in FSM are sometimes eaten (Englberger 2003). They were analyzed for a range of nutrients (Table 5). *Chaya* and *pele* contained high levels of provitamin A carotenoid (11,200 and 5530 µg beta-carotene/100 g, respectively), calcium (150 and 220 mg/100 g), and iron (both with 0.8 mg/100 g). The zinc levels were relatively low at 0.4 and 0.5 mg/100 g respectively (Shovic & Whistler 2001). The bird's nest fern, which is eaten in Yap, is rather pale green in color. It was analyzed only for carotenoid content. It had low and medium levels (<5 and 410 µg beta-carotene/100 g) (Englberger et al. 2003b, 2003e).

Two samples of FSM cassava were analyzed for carotenoid content, one with yellow and one with white colored edible portions. The yellow sample contained 104 µg beta-carotene/100 g and the white one contained <5 µg beta-carotene/100 g (Englberger et al. 2003b, 2003e).

One sample of an unidentified sweet potato cultivar was analyzed and the authors noted that the nutrient content was similar to sweet potato analyzed elsewhere (Murai et al., 1958). The color of the flesh of this sweet potato was cream-colored (not deep yellow). Although no analysis was made for provitamin A carotenoid content, it was expected that carotenoid content would be low. No analysis was made for FSM arrowroot, *Tacca leontopetaloides*, another light-colored root crop eaten in Micronesia. However, Marshallese arrowroot flour (*mokmok*) was analyzed for various nutrients (Murai et al. 1958). This food resembles cornstarch and the authors noted that its most important contribution would be a source of readily digested carbohydrate.

Selected Animal Foods

In the past, fish, shellfish, and seafood were the major sources of protein for FSM people and also provided other micronutrients. Murai et al. (1958) analyzed a number of seafoods from Chuuk for a range of nutrients. The seafood analyzed contained important levels of protein: fish (24.2 to 27.9 g/100g; shellfish (10.5 to 25.3 g/100 g); octopus (22.1 and 24.0 g/100 g); and sea cucumber (7.7 to 14.6 g/100 g). The clams had a high level of vitamin A (reported as 800 to 1000 I.U.), whereas the fish and other seafood had none. The fish species analyzed had a high calcium content (83 to 824 mg/100 g). All the clams contained high calcium levels (94 to 188 mg/100 g). In this study, the seafoods were not analyzed for iron or zinc.

Table 6. Nutritional analyses of selected animal foods of the Federated States of Micronesia

English name, local name, scientific name[1]; preparation; source of sample[2]	Analysis	Reference
Chuuk State	a	Murai et al. 1958
Clam, *sim; Hippopus hippopus*; raw	a	Murai et al. 1958
Clam, *to; Tridacna sp;* raw and baked	a	Murai et al. 1958
Shellfish, *nikoburo; Lambis sp;* raw	a	Murai et al. 1958
Shellfish, bivalve, *onon; Lucina edentula;* raw	a	Murai et al. 1958
Octopus, *nippach; Octopus sp*; raw	a	Murai et al. 1958
Sea cucumber, *penichon*; *Holothurian*; raw	a	Murai et al. 1958
Parrotfish, *ar; Scarus;* raw	a	Murai et al. 1958
Sardines, small; *senif*; probably *Harengula*; raw	a	Murai et al. 1958
Sea bass, *kinfou*; *Epinephelus macrospilos*; raw	a	Murai et al. 1958
Sergeant major, damsel, squirrel or soldier fish of several species and families; *musum*; raw	a	Murai et al. 1958
Surgeon fish, *bula; Naso lituratus*; raw	a	Murai et al. 1958
Unidentified fish, *kuo; Siganus punctatus*?; raw	a	Murai et al. 1958
Unidentified fish, *meich; Siganus rostratus*?; raw	a	Murai et al. 1958
Pohnpei State		
Parrotfish liver, *eh en mahu*, *Scarus nuchipunctatus;* cooked	b, c	Englberger 2003
Skipjack tuna liver, *eh en kasuo*, *Katsuwonus pelamis;* cooked	b, c	Englberger 2003
Yellowfin tuna liver, *eh en karangahp*, *Thunnus albacares;* cooked	b, c	Englberger 2003
Skipjack fish egg, *kutohr en kasuo*, *Katsuwonus pelamis;* cooked	b	Englberger 2003
Skipjack fish heart, *mohngiong en kasuo*, *Katsuwonus pelamis;* cooked	b	Englberger 2003

[a]Water, protein, fat, carbohydrate, ash, calcium, phosphorus, vitamin A, riboflavin

[b]Retinol (vitamin A)

[c]Mercury

[1]Names provided as those in original references

[2]Chuuk samples taken from Chuuk area; Pohnpei samples taken from Pohnpei main island area

Pohnpei fish liver from yellowfin tuna, skipjack tuna, and parrot fish; fish egg and heart from skipjack tuna, tinned imported mackerel (4 brands) and tinned imported sardine (1 brand) were analyzed, focusing on vitamin A (retinol) content (Englberger 2003). The fish liver samples were also analyzed for mercury, which is a naturally-occuring toxic substance. All three fish liver samples had very high levels of retinol and the fish egg contained retinol levels similar to the levels in chicken egg, which is considered a vitamin A-rich food (Dignan et al. 1994). All three fish liver samples were within the safe levels of mercury. The tinned mackerel and sardine had low levels of retinol, in contrast to findings elsewhere (Dignan et al. 1994).

Conclusions

This review shows that there is already a wealth of data available on FSM foods that could provide a basis for promoting these foods for their health benefits. For example, there are twelve banana, ten giant swamp taro, one breadfruit, and three pandanus cultivars that have a high level of provitamin A carotenoids. These foods all have a yellow-colored edible portion, which may be used as a rough guide for carotenoid content. Some giant swamp taro cultivars have also been shown to have high levels of calcium and zinc. However, there are differences between the cultivars grown on mountainous and atoll islands, and these differences need further study.

The review also shows that there are considerable data gaps. Few of the Chuukese banana cultivars and none of the Yap bananas have been analyzed for carotenoid or other nutrients. No identified cultivar of Yapese giant swamp taro, the major staple food for Yap, has been analyzed. Two Chuuk carotenoid-rich giant swamp taro cultivars were found to contain high levels of zinc. However, it is not known whether all giant swamp taro cultivars are rich in zinc, whether this is a characteristic for just some cultivars, or whether this depends largely on the particular soils. Also, it is still not clear whether the Chuuk giant swamp taro cultivars grown on the atoll islands have a high carotenoid content, as the four Chuuk cultivars analyzed were samples from plants grown on Pohnpei, a mountainous island.

The Pohnpei seeded breadfruit was found to have a high level of provitamin A carotenoids, but it is on the atoll islands where seeded breadfruit is a major food. None of the several types of seeded breadfruit from the atolls have been analyzed.

Although Kosrae pandanus cultivars have been found to contain high levels of provitamin A carotenoids, pandanus is most important on the Pohnpei and some Chuuk atoll islands. No pandanus cultivars from those areas have been analyzed. The *apuch* fruit is orange-fleshed, a characteristic indicative of carotenoid content, but it has not been analyzed for provitamin A carotenoids. Many of the local FSM seafoods have not been analyzed, including the crab ovary, which is a favorite food in Kosrae and may have a high vitamin A content.

In closing, the data available on nutrient content of FSM foods provides a valuable database that can be used in many ways to benefit these communities. However, there are still many FSM foods and food cultivars that have not been investigated. These data are important, not only because of the differences in the nutrient content (i.e. carotenoids and minerals), but also because of basic differences in the diet in each context. The information from one context may not be applicable in another. Further research is needed to eliminate data gaps and to provide food composition data for use in both program and research work.

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