

# Insights on food and nutrition in the Federated States of Micronesia: a review of the literature

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Submitted 7 January 2002: Accepted 13 June 2002

## Abstract

**Background:** Nutrition-related disorders, including vitamin A deficiency (VAD) and chronic diseases, are serious problems in the Federated States of Micronesia (FSM). Many suggest that these disorders are new problems related to dietary and lifestyle changes. In the past four decades, imported foods, such as white rice, flour, sugar, refined foods and fatty meats, have increasingly replaced local foods in the diet.

**Aim:** A literature review was conducted to understand underlying issues related to dietary change and obtain insights for nutrition research and interventions.

**Method:** Published and unpublished papers from different disciplines were reviewed and collated for information on food and nutrition in FSM. Topics covered were historical background, local foods, infant and child feeding, dietary assessment, and nutritional status. Particular focus was on information and data relating to VAD, the primary topic that led to the review of the literature.

**Conclusions:** FSM, a tropical country of abundant agricultural resources, has suffered a great loss in production and consumption of local foods. Inconsistent external and internal government policies and food aid programmes have contributed to the problem. Further research on the nutrient content of local foods and factors affecting production, acquisition and consumption is needed, as well as a broad, well-planned, intersectoral intervention aimed at dietary improvement for all age groups in the population.

## Keywords

Vitamin A deficiency  
Chronic disease  
Local foods  
Infant nutrition  
Child feeding  
Dietary patterns  
Nutritional status  
Review  
Micronesia

Health and nutrition literature concerning the Federated States of Micronesia (FSM) is limited; however, literature from other disciplines such as anthropology, agriculture, geography, history and environmental science contribute important information for the present situation of food and nutrition. This multidisciplinary review was undertaken to provide background for understanding the food and nutrition situation in FSM, with particular focus on the current status of vitamin A deficiency (VAD) in FSM.

FSM is made up of four states and 607 islands (atoll and volcanic) spread over the western Pacific Ocean<sup>1</sup>. The population is around 107 000 (Chuuk, 53 600; Pohnpei, 34 500; Yap, 11 200; Kosrae, 7700)<sup>2</sup>, and includes people with many cultural identities. Agricultural resources are adequate in general (atoll islands having poorer soils and less rainfall than volcanic islands). Rainfall (~250–500 cm annually)<sup>3</sup> and temperatures (annual average 27°C)<sup>1</sup> are high. Agriculture, the predominant occupation for most people, is mainly on a subsistence level.

The traditional diet was based on meals of cooked starchy staples, fish and seafood<sup>4–14</sup>, with fruits and sugar cane eaten as snacks<sup>6,10</sup>, and vegetables (other than starchy staples) not commonly eaten. This diet has been

considered by commentators to be very healthy<sup>15–21</sup>. In the past there were problems with infectious diseases<sup>22,23</sup> and intestinal parasites<sup>20,24</sup>, but diabetes and hypertension were unusual<sup>25,26</sup>, and there was little evidence of malnutrition<sup>22,23</sup>.

The diet has changed significantly since World War II. Imported white rice, flour, sweet and refined foods, and fatty meats have increasingly replaced local foods.† During this same period, nutrition-related disorders, including VAD and chronic diseases, have become serious problems and appear to be the consequence of dietary and lifestyle changes<sup>27,28</sup>.

The underlying cause of VAD is a lack of vitamin A (VA) or provitamin A carotenoids<sup>29</sup>. White rice, flour and sugar contain neither of these nutrients, whereas local foods contain small amounts, but important in local diets<sup>30</sup>. Epidemiological evidence suggests that carotenoid-rich foods also have a protective role against chronic disease, including certain types of cancer, cardiovascular disease, diabetes and age-related macular degeneration<sup>31–33</sup>. Thus,

†Local foods in this paper refer to foods that are grown, harvested, hunted or gathered from the land or sea.

to understand better this apparently diet-related epidemiological transition, this paper looks at past and contemporary diets, in particular those local foods that may impact on VA and nutritional status.

## Methods

The paper reviews all identified published and unpublished documents containing information related to food and nutrition in FSM up to October 2001. Government and locally available documents that are not normally available were reviewed, as were primary electronic sources. The analysis was organised around five key headings: historical background, local foods, infant and young child feeding, dietary assessment and nutritional status.

## Historical background

Prior to the first recorded European discovery in 1529 of the islands now known as FSM, there are no written records<sup>5,34</sup>. Although there are few early records related to diet or nutritional status, reports from early visitors to the islands suggest that the people ate a variety of foods and appeared healthy<sup>5,19,34</sup>.

In the mid-1850s, newcomers brought new foods and cooking methods<sup>35</sup> and, unfortunately, introduced new diseases<sup>18,36</sup>. This resulted in a great loss of lives. From 1885 to 1945, three foreign powers colonised the islands: Spain, Germany<sup>5,34</sup> and Japan<sup>5,8,37,38</sup>. During the Japanese tenure, rice was introduced as a staple food. After the Japanese surrendered at the end of World War II, the islands became a part of the Trust Territories of the Pacific Islands (TTPDI) under United States' administration. Several health surveys<sup>20,39,40</sup> were carried out, and a healthcare system based on modern biomedicine was established<sup>41,42</sup>. However, US interest was mainly strategic and little economic improvement was seen<sup>5,43</sup>. In 1961, the United Nations criticised the USA for neglecting the islands<sup>43</sup>, at which time development activities were greatly increased. Unfortunately, the programmes established were often inappropriate for small island communities.

One set of controversial programmes that greatly influenced FSM food habits was the United States Department of Agriculture (USDA) supplementary feeding programmes<sup>16,44–57</sup>. The programmes started in the 1960s, increased in the 1970s<sup>46,51</sup> and continued to the early 1990s. USDA surplus commodities, including rice and tinned foods, provided food for school lunches, needy families, the elderly and disaster relief<sup>46,49</sup>. In 1985, the school lunch programme (US\$ 5 million per annum) provided meals to 29 000 people (30% of the entire population), 180 days per year<sup>47</sup>. Long-time FSM residents report that the big dietary shift to rice consumption was in the 1970s, following the initiation of the programmes in

the 1960s, indicating that the programmes and dietary shift were related.

There were sharp criticisms related to these programmes causing increased dependency, new food tastes<sup>47–51</sup>, and, according to some reports, malnutrition related to households selling produce to school lunch programmes and using the money to buy imported foods<sup>46,47</sup>. USDA foods such as canned vegetables were not always liked<sup>58</sup>. Requests for inclusion of acceptable local items in the programme, such as drinking coconuts, were often not accepted due to US regulations requiring foods such as milk<sup>49</sup>. Furthermore, the lack of baseline surveys made it difficult to evaluate effects<sup>45,46,49</sup>. A nutritional evaluation in 1987 stated that the food services programme in Micronesia appeared to be an extension of the programme in the USA, and that there were no clear objectives<sup>53</sup>. In conclusion to this all, food habits were being shaped<sup>48,50</sup>. By the 1970s rice had become a major staple in the islands, along with sugar and other refined and tinned foods.

Another US food-related programme (established 1985) was the Expanded Food and Nutrition Education Program (EFNEP)<sup>59</sup>. Although it had some positive achievements, messages were often US-oriented and culturally inappropriate<sup>49</sup>, promoting US-type foods and food guides, and undermining efforts for promoting local foods<sup>60</sup>.

In 1986, Pohnpei, Kosrae, Chuuk and Yap joined to become a nation, signing a compact with the USA<sup>61</sup> that provided significant funding and had a strong influence on the economy, food production and consumption, and health programmes. Agriculture policies were however inconsistent, espousing written plans for promoting subsistence local food production but with most development efforts focused on export crops<sup>62,63</sup>.

Local foods were promoted as part of a Family Food Production and Nutrition programme, supported by the United Nations Children's Fund (UNICEF), and carried out in an intersectoral project involving the schools, health offices, agriculture departments and non-governmental groups in all four states<sup>58</sup>. This programme ran from 1984 to 1999, and increased awareness of the importance of local foods. Yet the effect of this programme was small, in comparison with the other forces affecting the nation<sup>61</sup>.

## Local foods

FSM has an extraordinary diversity of plants<sup>64</sup>, with a number of cultivars for each of the major food crops<sup>62,65</sup>. Apart from coconut, the major food crops are breadfruit, banana, giant swamp taro<sup>5–8,10–14,18,48</sup> and pandanus<sup>5,6,11–14</sup>. Because of the importance of these food crops to the overall diet and their potential contribution to vitamin A intake, the review focuses on these. Some cultivars have a yellow edible portion, suggesting carotenoid content<sup>66</sup>, and yet few have been analysed. In 1998 and 1999, yellow banana and giant swamp taro

**Table 1** Documented diversity (number of cultivars) of breadfruit, banana, giant swamp taro and pandanus in the Federated States of Micronesia

Researcher(s) (year)	State	Breadfruit ( <i>Artocarpus</i> spp.)		Banana ( <i>Musa</i> spp.)		Giant swamp taro ( <i>Cyrtosperma chamissonis</i> )		Pandanus ( <i>Pandanus tectorius</i> )	
		Number given	Names listed	Number given	Names listed	Number given	Names listed	Number given	Names listed
Lesson (1839)†	Kosrae	–	–	4	Yes	–	–	–	–
Von Kittlitz (1858) <sup>70</sup>	Kosrae	–	–	4	Yes	–	–	–	–
Sarfert (1919) <sup>71</sup>	Kosrae	18	Yes	21	Yes	8	Yes	11	Yes
Bascom(1946) <sup>72</sup>	Pohnpei	78	*	41	Yes	29	No	5	Yes
Stone (1963) <sup>73</sup>	Pohnpei‡	–	–	–	–	–	–	55	No
Wilson (1968) <sup>38</sup>	Kosrae	18	Yes	23	Yes	14	Yes	–	–
Lieber (1968) <sup>74</sup>	Pohnpei§	–	–	–	–	–	–	15	No
Peoples (1970)¶ <sup>75</sup>	Kosrae	6	Yes	–	–	–	–	–	–
Goodenough and Sugita (1990) <sup>76</sup>	Chuuk	52	Yes	–	–	–	–	–	–
Raynor (1991) <sup>62</sup>	Kosrae	131	Yes	55	Yes	24	Yes	–	No
Ragone (1997) <sup>77</sup>	Kosrae	13	No	–	–	–	–	–	–
Ragone (1997) <sup>77</sup>	Pohnpei	42	No	–	–	–	–	–	–
Merlin <i>et al.</i> (1992) <sup>11</sup>	Pohnpei	130+	No	–	–	–	–	–	–
Merlin <i>et al.</i> (1993) <sup>12</sup>	Kosrae	25	Yes**	15	Yes	9	Yes	9	Yes
Merlin and Juvik (1996) <sup>13</sup>	Chuuk	***	Yes	31	Yes	24	Yes	6	No***
Merlin <i>et al.</i> (1996) <sup>14</sup>	Yap	33	Yes	24	Yes	***	No	–	–
Nero <i>et al.</i> (2000) <sup>78</sup>	Kosrae	20	Yes	17	Yes	11	Yes	–	–
Debounce(1996) <sup>63</sup>	Kosrae	**	**	**	**	**	**	**	**
Sacks (1996)†† <sup>79</sup>	Pohnpei	–	–	14	No	12	No	–	–
Kosrae Department of Agriculture (2001) <sup>80</sup>	Kosrae	16	Yes	19	Yes	–	–	–	–

\* Of the total number of cultivars, 32 were listed by name.  
 \*\* Researcher lists numbers and names from other researchers.  
 \*\*\* Incomplete.  
 † Translated and edited by Ritter and Ritter<sup>35</sup>.  
 ‡ Researcher refers to four Pohnpei outer islands, total number given here for all four.  
 § Researcher refers to Pohnpei outer island of Kapingamarangi.  
 ¶ Researcher lists only cultivars of economic importance.  
 †† Researcher refers to Pohnpei outer island of Pingelap.

cultivars were found to contain significant amounts of provitamin A carotenoids<sup>67,68</sup>, suggesting that other yellow cultivars may also be carotenoid-rich. Pandanus was known to be VA-rich<sup>10,30,69</sup>. Table 1 summarises the number of cultivars of these staple foods and whether cultivar names were listed<sup>11–14,35,38,62,63,70–80</sup>.

### **Breadfruit (*Artocarpus spp.*)**

Breadfruit is the traditional staple food most commonly eaten<sup>5,6,10–14,77,81–83</sup>. In the past, breadfruit was baked or roasted in an earth oven<sup>71</sup>. Ripe seeded breadfruit can be eaten raw as a fruit. In recent times, breadfruit has also been boiled or fried<sup>5,63</sup>. Breadfruit is seasonal, with different cultivars bearing in succession. Preserved breadfruit<sup>83</sup> has provided food in times of need as well as between breadfruit seasons, and the fermented food, which is still well-liked by older people, provided variety in taste. The unseeded (*Artocarpus altilis*) and seeded (*Artocarpus mariannensis*) cultivars<sup>77</sup> are important respectively for the volcanic and atoll islands<sup>84</sup>. Analyses of unseeded breadfruit indicate a low content of carotenoid<sup>69,85</sup>, but that it is a good source of energy and dietary fibre, and a reasonable source of vitamin C. Seeds provide protein and thiamin<sup>4,30,86</sup>.

### **Banana (*Musa spp.*)**

Banana has long been an important staple food<sup>5–7,11–14,18,63</sup>. Certain cultivars were mentioned in early reports in the 1800s<sup>12,87</sup>. Bananas are eaten raw as a fruit, and as a cooked part of the meal in a variety of recipes, either cooked alone or mixed with other starchy staples and coconut cream<sup>18,63</sup>. They are considered by some as a 'poor man's food'<sup>5,88</sup>. Bananas, and particularly *karat* banana, have also been important weaning foods<sup>89</sup>. Yet in recent years, this banana (now known to be VA-rich<sup>67,68</sup>) has become rare, along with a number of other local cultivars. Bananas are a good source of energy, vitamin C, potassium and fibre<sup>4,30</sup>.

### **Giant swamp taro (*Cyrtosperma chamissonis*)**

Giant swamp taro is commonly eaten throughout FSM and is the most important traditional food for Yap<sup>5,8,81,82,90</sup> and the atoll islands<sup>90,91</sup>. It can be boiled or ground and baked with coconut cream or mashed banana in a number of recipes. Some cultivars were analysed for nutrient content and found to be low in provitamin A carotenoids<sup>30,92</sup>, but the yellow-fleshed cultivars were not analysed. Giant swamp taro grows in more saline soils, can remain in the soil for 10 years and still be edible, is not seasonal and endures hurricanes<sup>5,10,93</sup>, thus providing food security. It is a good source of energy, fibre and calcium<sup>4,30,86,94</sup>.

### **Pandanus (*Pandanus tectorius*)**

Pandanus, many cultivars of which are known to be rich in vitamin A<sup>30,69,86,95,96</sup>, is another plant that can be grown in saline soils and is a major food on atoll islands<sup>93</sup>. The soft

part of the pandanus key is chewed and sucked; on some islands, pandanus has been boiled for eating or dried for storage and made into flour for later cooking<sup>95</sup>. There have been as many as 19 cultivars on the atoll island Kapingamarangi<sup>73,74,97</sup>, 14 on Pingelap, 15 on Mokil<sup>73,97</sup> and 11 on Kosrae<sup>71</sup>, although little recognition was given to pandanus in recent agriculture work in Kosrae<sup>80</sup>. Pandanus is also a good source of vitamin C, thiamin, riboflavin and niacin<sup>30,69,86</sup>.

### **Other foods**

Dark green leaves, a VA-rich food commonly eaten in other parts of the world, are regarded by many in FSM as pig food, similar to ripe papaya<sup>58,98</sup>. Green leafy vegetables including chilli pepper leaves, kangkong (*Ipomoea aquatica*), Chinese cabbage and two greens introduced in the 1990s<sup>58</sup>, *pele* (*Hibiscus manihot*) and *chaya* (*Cnidoscolus chayamansa*), have been promoted, although with limited success<sup>58,98,99</sup>.

Contrary to common Western perceptions, the traditional Pacific diet did not include an abundance of different fruits. Papaya and mango, which are VA-rich if ripe<sup>30,66,69,86</sup>, were introduced to Micronesia by Europeans in the 19th century<sup>5,6,11–14,100</sup>. Yet in FSM papaya and mango are commonly eaten green.

There are considerable differences in the names for foods according to state and island group. Although there is yet no compiled listing of all local names of FSM foods, there are some lists of food plants prepared by state<sup>5,6,11–14,36,62,63,76,82</sup> and also a listing of food plants for the Pacific specifying some foods from FSM<sup>101</sup>.

Local animal foods include fish and other seafood<sup>50</sup>, which have been the major protein foods in the past. Raw fish liver, which is high in pre-formed VA<sup>29</sup>, is considered a delicacy<sup>20</sup>, and some fish are eaten whole with the liver intact.

In summary, there is a great diversity of local foods, some which have potential for impact on VA status. Yet, the trends indicate that cultivar diversity, and knowledge, use and availability of local foods, are decreasing at an alarming rate<sup>11–14,62,63,102</sup>.

### **Infant and young child feeding**

Infant and young child feeding is also an important part of the total food and nutrition situation. In the 1950s initiation of breast-feeding in FSM appeared to be almost universal, and it was common that mothers breast-fed children until the second year of life or later<sup>40,103</sup>. The situation had changed by the 1970s, with bottle feeding as a major factor in poor infant nutrition<sup>44,104,105</sup>.

An active breast-feeding campaign was started in the mid-1970s, and there appeared to be some increase in breast-feeding. However, although initiation of breast-feeding was high in the late 1980s (95% of FSM infants were breast-fed in the first three months), duration was

inadequate, with only 49% breast-fed at 12–17 months and most not breast-fed at 18–23 months<sup>50</sup>. The Baby Friendly Hospital Initiative, supported by UNICEF and the World Health Organization (WHO), was introduced in the 1990s, providing greater support to breast-feeding<sup>106</sup>. Yet there is still a great lack of exclusive breast-feeding in the first six months of life, and duration of breast-feeding is still inadequate<sup>107</sup>.

In the past, mothers did not give their breast (and colostrum) immediately to the newborn<sup>18,37,108</sup>, thinking that it was inadequate<sup>108</sup>. Young coconut water was given until the milk came in<sup>20</sup>; coconut oil lubricant was often given as the first feeding<sup>109</sup>. Breast-feeding was 'on demand', mothers sleeping with their babies so that nursing could continue through the night<sup>18</sup>. When mothers became pregnant or wanted early weaning, chilli pepper or breadfruit tree sap might be applied onto the breasts<sup>37</sup>. People believed that one could not breast-feed in pregnancy, as the milk became bad and could harm the child. Weaning was sometimes abrupt and was accomplished by sending the child to stay with relatives until the mother's milk dried up<sup>18</sup>. Sex taboos during lactation, extending until the child was around one year, were meant to ensure the health of the child and mother<sup>37,106,109,110</sup>, but may have led to an early termination of breast-feeding to allow resumption of sexual relations. In recent years the duration of this taboo has shortened<sup>110</sup>.

Solid foods have been given at an early age. In the 1980s, 48% of infants were given these by four months of age<sup>50</sup>. Local staple foods, often mashed banana or breadfruit, were common first foods, along with fruit, fruit juice and imported staples, including rice<sup>104</sup>. One problem identified in child feeding was that caretakers did not believe in the positive qualities of food related to health, and often did not encourage children to eat<sup>89</sup>. Pohnpei mothers believed that fish and meat should not be given until babies are 1 year old<sup>89</sup>, thinking either that they cause diarrhoea in babies or that these foods should be withheld to avoid the children getting used to them and becoming unhappy if they were unavailable<sup>110</sup>.

There have been numerous dietary taboos associated with pregnancy and the postpartum period<sup>110</sup>, including some foods such as fish, seafood and meat, which were thought to cause vomiting in pregnancy and difficult deliveries<sup>50</sup>. Similar foods were to be avoided during lactation for various reasons; for example eating octopus by a breast-feeding mother was thought to cause skin rash in the baby<sup>110</sup>. Foods encouraged during lactation were those made with coconut milk, as it was believed that these foods helped to make more breast milk. Mothers were also advised to drink water and other drinks as these were also believed to help make more breast milk<sup>110</sup>, and mothers were supported emotionally and not left alone<sup>109,110</sup>.

Belief in the supernatural is a strong part of the Micronesian belief system<sup>39,89,111–114</sup>. Traditionally,

people in FSM believed that spirits caused people to become sick if the people were in conflict<sup>5,114</sup> and especially affected a child's well-being. People consider some illness treatable by Western medicine and other illnesses as those caused by spirits to be best treated by local medicine<sup>89,104</sup>. With strong beliefs in the supernatural, the relationship between food and health is not always well appreciated.

In summary, there have been many changes in infant and young child feeding practices in recent years. Campaigns promoting breast-feeding helped to curb the trend towards bottle feeding, although still there are problems with lack of exclusive breast-feeding, insufficient breast-feeding duration, and some other child feeding practices.

### Dietary assessment

Only a few population-based dietary studies coupled with nutritional status assessments have been carried out in FSM. These include the 1987/88 FSM National Nutrition Survey<sup>50</sup>, and in the year 2000 the Yap and Kosrae Micronutrients Survey<sup>115,116</sup>. However, smaller studies have been conducted that also help us understand the local diet<sup>40,44,50,63,78,89,103,115,117–120</sup> (Table 2).

Four studies collected information on quantities of food eaten<sup>40,44,89,117</sup>. A review of the dietary assessments clearly showed an increasing reliance on rice, flour, sugar and imported meats. A low intake of VA-rich food was found, although previously it was not known that certain local staple foods contained high or moderate amounts of provitamin A carotenoids, which might have led to an underestimation of VA intake.

Dietary studies and papers since 1973 expressed concern over the increasing use of rice, sugar and flour, and poor food selection<sup>44,45,49,50,58,89,121</sup>. Rice was often the sole food for young children<sup>89</sup>. Health workers suggested that past feeding programmes based on rice, and expatriate buying patterns, helped lead to erroneous beliefs that rice and imported foods were superior to local foods<sup>48,121</sup>. That may no longer be the case. People appear to know now that local food is healthier, due to promotion programmes. Yet, rice, wheat flour and sugar foods are commonly eaten<sup>122</sup> because of convenience, affordability, availability, taste and prestige<sup>50,63</sup>.

In 1986, food and beverage imports accounted for more than 40% of the total value of imports. The same study reported that 'most of the items imported cannot be considered essential or without local substitutes in nutritional terms. Some may actually be nutritionally harmful'<sup>47</sup>.

Common foods consumed in Pohnpei, Chuuk and Yap in the 1970s are presented in Table 3. Since then, rice has become the main starch food for many people<sup>63,106</sup>.

A recent assessment of the diet in Kosrae showed that local fish (reef and pelagic), imported chicken and turkey

**Table 2** Summary of dietary assessments in the Federated States of Micronesia 1951–2000

Researcher(s) (year)	Details of study	Main findings of report
Murai (1954) <sup>40</sup>	<i>Type of study:</i> 7-day quantified record of hh food intake, describing local foods with local names, recipes, meals and food consumption patterns. <i>Sampling:</i> all hh on island, <i>n</i> = 290; all ages, both sexes. <i>Time:</i> 3.5 months, June–October 1951. <i>Place:</i> Chuuk lagoon island Udot.	Strong reliance on local food. Low intake calculated for vitamins A & C, riboflavin, fat and other nutrients, compared with US NRC allowances. Small fish often eaten whole (including liver). Food intake varies by season.
Malcolm (1995) <sup>103</sup>	<i>Type of study:</i> infant feeding, description of local foods, meal patterns, food practices, imported foods. <i>Sampling:</i> purposive, infants 0–2.5 years of age. Chuuk, <i>n</i> = 376; Pohnpei, <i>n</i> = 166; Yap, <i>n</i> = 100. <i>Time:</i> 3 months, July–September 1953. <i>Place:</i> Pohnpei, Chuuk, Yap.	Breast-feeding common. Solid foods given at about 6 months, but not given regularly and little variety. Child on family food at 1 year. Usual adult meal: starchy food either local, or imported, fish, coconut, sometimes green vegetables. Fruit never eaten at mealtime. Main imported foods: rice, flour, sugar.
Kincaid (1973) <sup>44</sup>	<i>Type of study:</i> 24-hour recall of hh food intake, food habits. <i>Sampling:</i> modified random sampling of hh – Pohnpei, <i>n</i> = 56; Chuuk, <i>n</i> = 51; Yap, <i>n</i> = 22. <i>Time:</i> 1973. <i>Place:</i> main islands of Pohnpei, Chuuk, Yap, and four outer islands of Chuuk including Nama, Namoluk.	Generally adequate intake of calories, protein, iron. Problems: less local foods, poor school lunches, much bottle feeding and 'empty calorie' imported food, poor knowledge of relationship between food intake and growth, poor weaning food, lack of supervision of diet after child learns to walk.
Gilbert and Moses (1975) <sup>117</sup>	<i>Type of study:</i> 24-hour recall on 192 child aged 0–5 years, infant feeding practices, hh water, food storage equipment. <i>Sampling:</i> stratified random sampling for hh. <i>Time:</i> summer 1974. <i>Place:</i> main island of Chuuk, Moen.	Adequate protein intake for all ages, low fruit, dglv. Low calcium, iron, vitamins A & C after 1 year of age. Six children in 12–17 months group eating only white rice. Shorter breast-feeding duration for younger children. Main energy sources: rice/imported, fish often eaten.
Demory (1976) <sup>89</sup>	<i>Type of study:</i> PhD ethnographic study of infant feeding, meal patterns, childcare, 24-hour recall for hh + child. <i>Sampling:</i> purposive, 30 hh, 33 child, 7 months to 2 years of age. <i>Time:</i> June 1974–May 1975. <i>Place:</i> Uh, Pohnpei island, 11 miles from urban centre.	Toddler diet: low in calories, protein, vitamins A & C, iron, calcium; little variety; passive feeding, child needs to fend for itself, borderline malnutrition common for child taken off breast. Karat banana and papaya considered infant foods.
Hargreaves and Reichert (1983) <sup>118</sup>	<i>Type of study:</i> dietary study carried out as part of a nutrition education programme. <i>Sampling:</i> all hh on island, <i>n</i> = 57 hh. <i>Time:</i> 7–14 November 1983. <i>Place:</i> Pohnpei outer island of Pingelap.	Very high consumption of rice. 33% consuming only rice. 7% consumed rice + taro. 37.5% rice + some source protein, usually fish. 6.5% a variety of rice, fish, taro and/or breadfruit. 16% a variety of foods, plus some fruit or vegetable.

Elymore <i>et al.</i> (1989) <sup>50</sup>	<p><i>Type of study:</i> 24-hour recall – women 15–49 years, child 0–4 years – for imported or FSM foods: staple, fat, or protein and greens, time of eating, profession, urban/rural and area.  <i>Sampling:</i> randomised national survey including main and outer islands – mothers, <math>n = 3781</math>; children, <math>n = 1781</math>.  <i>Time:</i> May 1987–May 1988 (data collection).  <i>Place:</i> Chuuk, Pohnpei, Kosrae, Yap.</p>	<p>More local foods eaten in outer island/rural areas, but even in remote areas imported food common.  Morning meals were least balanced, but also overall meals were not well balanced.  Fruit intake low; and dglv, vegetables rarely eaten.  Consumption of sugar and sweet foods moderately high, particularly in Kosrae.</p>
Debounce (1996) <sup>63</sup>	<p><i>Type of study:</i> PhD geographic study on traditional horticulture, food ways, food preparation, meals.  <i>Sampling:</i> purposive, centred in one village area.  <i>Time:</i> 10 months period ~1995.  <i>Place:</i> Malem village area of Kosrae.</p>	<p>88% of hh heads said that their families eat as much imported as local foods. 83% of villagers gave rice as most common food. Fish given as most common, meat, then turkey tails, chicken, canned meats. Fizzy drinks and coffee with much sugar very common.</p>
Englberger and Elymore (1999) <sup>119</sup>	<p><i>Type of study:</i> school survey on VAD, hh production/consumption of <i>karat</i> banana, papaya and dglv.  <i>Sampling:</i> purposive, elementary grades 5, 6, 8, <math>n = 347</math>.  <i>Time:</i> 3–14 May 1999.  <i>Place:</i> four schools throughout Pohnpei – Madolenihm, Nett, Sokehs and Ohmine.</p>	<p>45% said VAD is a problem in Pohnpei; 34% gave XN as a symptom of VAD, 64% said their hh grew <i>karat</i>, 93% papaya, 81% dglv, 77% reported having eaten <i>karat</i> ever, 93% ate papaya at least 1 x last week, 78% ate dglv at least 1 x last week, mostly <i>pele</i>.</p>
Englberger <i>et al.</i> (2001) <sup>115</sup>	<p><i>Type of study:</i> 7-day HKI FFQ for child 24–59 months (mothers/caretakers as proxies) comparing imported and local staples, fish, eggs, dglv, papaya eaten at least 3 days.  <i>Sampling:</i> randomised survey – Kosrae, <math>n = 282</math>; Yap, <math>n = 235</math>.  <i>Time:</i> 2 weeks Yap, 1 week Kosrae, year 2000.  <i>Place:</i> main islands Kosrae and Yap.</p>	<p>Low consumption of vitamin A-rich foods.  Less frequent consumption of fish, eggs, papaya, dglv and local staple foods* in Kosrae.  38% children eating local staples in Kosrae at least 3 days/week or more, compared with 83% in Yap.  Milk drunk was greatly diluted with water and sugar.</p>
Snowdon (2000) <sup>120</sup>	<p><i>Type of study:</i> 7-day food frequency on hh foods, hh food production, infant feeding, meal patterns, knowledge on vitamin A and iron, family size.  <i>Sampling:</i> purposive, 5–10 hh in five lagoon, five outer islands and five communities on main island, total <math>n = 27</math> hh.  <i>Time:</i> June–December 1999.  <i>Place:</i> throughout islands of Chuuk.</p>	<p>All families growing some foods, mainly banana, breadfruit, coconut. Outer island families growing greater variety. No differences in breast-feeding in outer and lagoon islands. Meals based heavily on a staple, rice or breadfruit, mainly with fish, low in fruits, vegetables. Ripe papaya eaten 1–3 x/week. Little knowledge on vitamin A and iron.</p>
Nero <i>et al.</i> (2000) <sup>78</sup>	<p><i>Type of study:</i> 1-day recall taken in four waves over 1 year by five regions of island: food eaten by hh, meal patterns, cooking method, food exchange, work related to food.  <i>Sampling:</i> randomised, 30 hh from Lelu, 10 each Malem, Utwa, Tafunsak, Watung; adults 15 years and over.  <i>Time:</i> four waves of 4 weeks each, 1992–3.  <i>Place:</i> Kosrae, all main areas of the island.</p>	<p>Food varied by area, season, day of week, meal. Greater intake local foods on weekends and towards evenings. Rice the basic unit of meal. Breadfruit (if available) substituted for local bread. Banana, taro common. Chicken, turkey tail major dietary components. Fish if available substituted for canned/imported foods. Fruits and vegetables, low intake.</p>

Abbreviations: child – children; dglv – dark green leafy vegetable; FFQ – food-frequency questionnaire; hh – household; HKI – Helen Keller International; US NRC – United States National Research Council; XN – night blindness.

\* Here, local staple foods refer to cooked breadfruit, taro, banana, yam, sweet potato and cassava.

**Table 3** Foods mentioned frequently by families in a dietary survey in Pohnpei, Chuuk and Yap, 1973\*

Area	n†	Principal carbohydrate-rich foods	Principal protein-rich foods	Fruits and vegetables
Pohnpei				
Kolonia town	11	Rice, breadfruit, biscuits, bread, mayonnaise, sugar	Canned fish, canned meat, chicken	Mango, banana, watermelon, cucumber
Other municipalities	45	Rice, breadfruit, doughnuts, sugar	Fresh fish	Mango, coconut, banana, cucumber
Chuuk				
Moen	24	Breadfruit, rice, taro	Fish canned/fresh, canned meat, octopus	Mango, banana, watermelon, coconut, cucumber
Lagoon islands	29	Breadfruit, rice, sugar	Fresh fish, clams, crabs	Pineapple, watermelon, coconut
Outer islands	8	Breadfruit	Fresh fish, crab, octopus	Papaya, coconut
Yap				
Yap (main island)	22	Taro, breadfruit, rice	Fresh fish, crab, clams, octopus, corned beef	Banana, coconut, pumpkin

\* Data taken from Kincaid, South Pacific Commission (1973)<sup>44</sup>. Families interviewed were randomly selected. Note that the author does not specify if foods are listed in decreasing order of frequency of consumption.  
 † Number of families interviewed.

tail are the major protein foods, and that consumption of canned fish increases when local fish are less available<sup>78</sup>. Turkey tail\* (a fatty frozen product imported from the USA) is commonly eaten throughout FSM<sup>50,63,78,120</sup>. Turkey tail is another example of the replacement of healthy local foods with inferior food likely to cause health problems, which brings up the issue of food dumping by industrialised countries.

In summary, this section describes the great shift in the diet, with healthy local foods increasingly replaced by foods such as white rice, flour and sugar that contain no provitamin A carotenoids, and by other imported foods that are likely to cause health problems.

### Nutritional status

This section focuses on vitamin A deficiency, anaemia, weights and heights of children, obesity, diabetes, hypertension in adults, and parasite infection.

#### Vitamin A deficiency

VAD in FSM was first documented in 1988 in a hospital-based study in Chuuk<sup>123</sup>. Of 60 randomly selected 36–83-month-old children, 12% were found with night blindness and 5% with Bitot's spots, far exceeding WHO cut-offs for a public health problem, 1% and 0.5%, respectively<sup>124</sup>. VAD was suggested to be a new problem, based on the lack of a local term for night blindness and old people in the community not knowing the problem. A 1991 state-wide survey including 455 randomly selected children showed similar results<sup>125</sup>, and a 1994 study relating VAD with otitis media<sup>126</sup> confirmed the problem. In 1992 a study of children aged 18–24 months and 3–6 years found that 55–76% of children surveyed had VAD as defined by levels of serum retinol < 20 µg/dl, the prevalence varying depending on age group and with higher prevalence rates in older children<sup>127</sup>. VAD in Chuuk has been documented as among the most prevalent in the world<sup>124,128</sup>. In 1993, a VA supplementation and dietary improvement programme began<sup>129,130</sup>.

In Pohnpei, a 1994 Child Health Survey looked at 24–47-month-old children. In that randomised population-based survey ( $n = 362$ ) 51% of the children had VAD, defined by serum retinol < 20 µg/dl<sup>131</sup>. Night blindness was reported for 0.3% of the children, under the cut-off level for a public health problem. A VA supplementation and dietary improvement programme began in Pohnpei in 1997, with promotion of VA-rich foods, including the *karat* banana (from 1999)<sup>132</sup>.

Due to concern about the remaining two FSM states, a population-based survey measuring serum retinol was carried out in January–February 2000 in Kosrae and the main island of Yap. Of the children aged 24–59 months

\*Turkey tails are literally the tails of the turkeys.

surveyed, 63.3% in Kosrae and 33.8% in Yap had VAD, defined by serum retinol  $<20 \mu\text{g}/\text{dl}^{116}$ ; caretakers were asked if their children had experienced night blindness, and no such case was found although there were no visual evaluations. Some Kosrae mothers reported night blindness in the last pregnancy, although questioning was difficult due to the lack of terminology and understanding of night blindness. Serum retinol measurements were taken on mothers and caretakers. Of the women surveyed, 58% in Kosrae and 11.7% in Yap had VAD, defined by a serum retinol  $<30 \mu\text{g}/\text{dl}^{133}$ , which is a matter of concern particularly in light of the new evidence linking night blindness in pregnancy with increased mortality<sup>134</sup>.

### **Anaemia**

In the FSM National Nutrition Survey, high rates of mild to moderate anaemia were found in the women studied (15–49 years) in all states, with a greater problem in Kosrae where 37.6% of non-pregnant, non-lactating women had a haemoglobin measurement  $<12 \text{g}/\text{dl}^{50}$ . The 1994 Pohnpei Child Health Study found 33% of children were anaemic, with anaemia defined as haemoglobin  $<11.5 \text{g}/\text{dl}$ . However, anaemia rates in children examined in Yap and Kosrae were 12.6% and 9.8%, respectively, with anaemia defined as haemoglobin  $<11.0 \text{g}/\text{dl}$  measured by the portable HemoCue™ instrument<sup>116</sup>. These rates are relatively low given that rates of anaemia are often more than 50% in many communities in developing countries<sup>135</sup>, and anaemia tends to be high in populations with high rates of VAD<sup>29</sup>.

### **Weights and heights of children**

The 1987/88 FSM National Nutrition Survey found that, overall, among children 0–4 years old, there were 9.9% stunted and 13.3% underweight ( $<80\%$  of WHO/National Center for Health Statistics standards). In the Yap and Kosrae study in 2000, 17.1% and 16.2% of children were stunted, respectively. Wasting in both populations was less than 5%. Stunting and wasting were defined as  $<2$  standard deviations below WHO/Centers for Disease Control and Prevention standards for height-for-age and weight-for-height, respectively. These reports can be compared with the WHO proposed classification of worldwide prevalence of low stunting and wasting among children  $<5$  years of age, which are  $<20\%$  and  $<10\%$ , respectively<sup>136</sup>.

### **Obesity, diabetes and hypertension in adults**

Obesity, diabetes and hypertension are now serious problems in FSM. In the 1987/88 FSM National Nutrition Survey<sup>50</sup>, the weights and heights of 3588 women (15–49 years) were measured, finding a mean body mass index (BMI) of  $28 \text{kg m}^{-2}$ . Approximately one-third of all women were moderately overweight in every age group, with overweight defined as  $\text{BMI} \geq 25$  and  $<30 \text{kg m}^{-2}$ . Prevalence of obesity (defined as  $\text{BMI} \geq 30 \text{kg m}^{-2}$ ) was

particularly high in Kosrae (77%) in those aged 40–49 years. The Non-Communicable Disease (NCD) study carried out in 1992–94 examined over 4500 adults in all FSM states, and preliminary analyses found high prevalences of obesity, hypertension, diabetes and dyslipidaemia. A further analysis focusing on Kosrae data<sup>137</sup> indicated that of 1259 females and 908 males examined, 24% were obese (defined as  $\text{BMI} \geq 35 \text{kg m}^{-2}$ ), with average BMI of  $31 \text{kg m}^{-2}$ . This BMI, exceeding the WHO Grade 2 overweight cut-off<sup>136</sup>, and the other obesity levels is of concern. Hypertension (systolic blood pressure  $\geq 140 \text{mmHg}$  or diastolic blood pressure  $\geq 90 \text{mmHg}$ ) was found among 17% of those surveyed and 12% qualified as diabetic (fasting blood sugar  $\geq 126 \text{mg}/\text{dl}$  or 2-hour oral glucose tolerance test  $\geq 200 \text{mg}/\text{dl}$ ). The highest risk for obesity was in middle age. There seemed to have been little problem with hypertension in former times, with blood pressures low in Pohnpeians in the late 1940s<sup>25</sup>. A 1970 study found increasing diastolic and systolic pressures with increasing modernity<sup>26</sup>.

### **Parasite infection**

Parasite infection has a great effect on nutritional status and health and has been a serious problem in FSM<sup>20,27,39,89</sup>. In Kapingamarangi in 1953, 36.4% of those 275 people examined had at least one parasite<sup>20</sup>. In 1975 one-third of all hospitalised children had intestinal parasites<sup>27</sup>. With sanitation improvements, parasite infection has been reduced in recent years, although there are few data available. Along with VA supplementation in Chuuk and Pohnpei, all children from 1 to 12 years are now treated for parasite infection twice annually<sup>130</sup>.

In summary, although parasite and infectious disease have decreased in FSM in recent years, the emergence of vitamin A deficiency, obesity, hypertension and diabetes are serious concerns.

### **Conclusions**

This review brings together, for the first time, a diverse body of data on food and nutrition for FSM. This shows that nutritional status prior to European contact was apparently good, and there was a diversity of local staple foods. The data available indicate that these foods contain at least minimal amounts of carotenoids, and some have high levels<sup>67</sup>, important for protection against VAD and apparently against certain types of cancer, cardiovascular disease, diabetes and age-related macular degeneration. The replacement of local foods with foods such as white rice, flour and sugar, which contain no VA<sup>30</sup>, and increased use of breast-milk substitutes, is a matter of concern particularly in relation to child health.

The great changes in diets and infant feeding practices in the 1970s, which preceded the apparent emergence of VAD in the 1980s, appear to be a main causal component in the present-day nutrition problems. The coherence and

consistency of the collection of studies provide a basis for arguing that the dietary and lifestyle changes are in fact largely responsible for the present-day VAD and chronic diseases problem. Inconsistent external and internal government policies and food aid programmes contributed to the dietary changes.

The review indicates that there is a need for further research into the nutritional content of local foods and underlying factors affecting their consumption, as well as information on dietary intake. Such information is essential in understanding better how and when local foods could be realistically and reasonably promoted to contribute to improved nutritional status. Finally, this review indicates that local foods have been important in the past in maintaining the health of FSM people. Serious consideration should be given to the establishment of a broad, well-planned, intersectoral intervention aimed at increasing the production and consumption of local foods and dietary improvement for all population age groups.

### Acknowledgements

Acknowledgement is given to Fran Hezel and Jane Paterson for reviewing the original manuscript, and to Task Force Sight and Life, Centers for Disease Control and Prevention and Thrasher Research Fund for funding support.

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