Original Article

Phytochemical intakes of the Fijian population

Jimaima Lako PhD[1], Naiyana Wattanapenpaiboon PhD[1], Mark Wahlqvist MD[1] and Craige Trenerry PhD[2]

[1]*Asia Pacific Health and Nutrition Centre, Monash Asia Institute, Building 11A, Monash University, Victoria, 3800, Australia.*
[2]*PIRVic DPI-Werribee, 621 Sneydes Road, Werribee, Victoria, 3030, Australia.*

The dietary intakes of major phytochemicals in Fijian population were estimated from the consumption of 90 plant foods reported in five major surveys conducted in Fiji from 1952 to 2001. These surveys included the Naduri Longitudinal study, for which food intake data were collected on four occasions in 1952, 1953, 1963 and 1994), the 1982 and 1993 National Nutritional Surveys, the 1996 Suva-Nausori Corridor cross-sectional study, the 1999 Verata cross-sectional study, and the 2001 Fiji Food Choice study. It was found that the Fijian population generally had low intakes of total phenols (275 mg/day), and total flavonoids (17.5 mg/day), but high intake of total carotenoids (20 mg/day), in comparisons with the intakes of other populations reported in literature. It has been speculated that the change of eating patterns resulting in the low intakes of phytochemicals may have partly contributed to the increase in the nutritionally chronic disease morbidity and mortality among the Fijians. It is further recommended that the traditional Fijian food patterns with high fruits and vegetables should be revived, and the consumption of sweet potato leaves and drumstick leaves, both of which were rich in phytochemicals, should be promoted.
.

Key Words: phytochemicals, flavonoids, carotenoids, anthocyanins, polyphenols, food intake, Fijians, Fiji

Introduction

Numerous studies have demonstrated the impact of certain phytochemicals from fruits and vegetables on serum antioxidant capacity,[1-3] oxidative stress markers[2,4] and DNA damage.[5,6] Flavonoids are thought to exert antioxidant abilities through protection and enhancement of endogenous antioxidant defense activities,[7] while carotenoids may protect biological systems against the damage caused by singlet molecular oxygen ($^1O_2$).[8] Apart from their antioxidant activities, phytochemicals also possess other properties such as anti-mutagenicity, anti-biocidality, anti-fertility, anti-inflammatory, anti-immunomodulatory and anti-transduction.[9] It has been reported that flavonoids have a two-fold anti-carcinogenic activity, their cytostatic properties which reduce tumour growth and their biochemical protection of cells against damage from carcinogenic substances.[10] Some of these phytochemicals have already been been proved to have some protective effects against nutritionally-related chronic diseases, such as coronary heart disease,[11] ischemic stroke,[12,13] high blood pressure,[14,15] and cancer.[16,17] This study was conducted to estimate the dietary intakes of phytochemicals in Fijian communities in Fiji, based on the food consumption data from five major nutritional surveys in Fiji over the period of 49 years from 1952 to 2001.

Methodology

Food consumption data

The sources of food consumption data were five major nutritional surveys conducted in different communities at different times; the Naduri Longitudinal Survey of 1952 to 1994, [18-21], the 1982 and 1993 Fiji National Nutrition Surveys,[22,23] the 1996 Suva-Nausori Corridor cross-sectional study,[24,25], the 1999 Verata cross-sectional study[26] and the 2001 Fiji Food Choice Study.[27] The information on survey participants and dietary assessment methods is summarised in Table 1. Total of 90 plant foods were reported to be consumed by the participants of one or more of the five surveys listed in Table 1. Of these, 72 foods were identified and analysed for the content of total polyphenols (TPP), total anthocyanins (TAT), individual and total flavonols (quercetin, kaempferol, myricetin, fisetin, morin and isorhamnetin), individual and total carotenoids (lycopene, α-carotene and β-carotene) at the Chemistry Department of the University of the South Pacific and the Chemistry Laboratory of the Ministry of Agriculture at the

Correspondence address: Dr N Tikky Wattanapenpaiboon, Asia Pacific Health and Nutrition Centre, Monash Asia Institute, Building 11A, Monash University, Victoria, 3800, Australia
Tel: +61 3 9905 8147; Fax: + 61 3 9905 8146
Email: tikky.w@adm.monash.edu.au
Accepted 24 January 2006

Ministry of Agriculture at the Koronivia Research Station by Lako and colleagues (2006).[28] Another eight food items were collectively reported by survey partcipants as "green leaves," "other fruits," "other vegetables" or "other fruits and vegetables." The phytochemical content and anti-oxidant capacity of these foods were calculated by averaging the values of three to five similar foods in the same category: green leaves (taro leaves, edible hibiscus and Chinese cabbage), other fruits (apple, orange, mango and soursop), other vegetables (eggplants, onions, cucumber and French bean), other fruits and vegetables (other vegetables and other fruits). The phytochemical composition data of another 10 food items (kumquat, corn, cantaloupe melon, okra, passionfruit, potato, celery, lemon juice, lime juice and green peas) were obtained from the published literature.[29-32]

Data analysis

All the food consumption and phytochemical composition data were recorded in Microsoft Excel® spreadsheets. Each food item was assigned a food code, which was then used as the matching variable when the two data sets were merged. The descriptive statistics of these data were calculated using the Statisical Analysis System (SAS) program, version 8.2.

Results

The daily intakes of phytochemicals including total polyphenols (TPP), total anthocyanins (TAT), individual and total flavonols, and individual and total carotenoids of survey participants, are listed in Table 2. It is worth mentioning that these surveys, which were conducted at different times, used different dietary assessment methods. As a result, there were variations in both data collection and reporting. This therefore limits the comparison of phytochemical intakes for these five communities, and between different time points in the same community. As a consequent, it would not be appropriate to establish the trends of changes in phytochemical intakes over a 49-year period.

The Naduri longitudinal study

The data on food intake from the surveys conducted at Naduri village in 1952, 1953, 1963 and 1994 were obtained from archival research.[18-21] It appears that the reports listed only the major foods consumed. However, it is evident that phytochemical intakes have increased over the years. The data also show that the estimated dietary intakes of anthocyanins and lycopene in 1952 were zero. It is likely that the agricultural farm projects which wee conducted post-1952 had the impact on plant food availabilty by introducing cash crops, and on the population's food patterns by encouraging the consumption of tomatoes, papaya, eggplants and sweet potato, all of which are good sources of lycopene and anthocyanins.

It appears that the data reported from the Naduri Longitudinal Surveys were limited and vague. Only foods that were regarded as major and important at the time of the studies were reported. From a personal communication in 2006 with Ms Verona Lucas, who was one of the investigators of one of the Naduri surveys, it was learned that the food items were considered important at that time if they contributed high energy. Therefore low energy food sources were either recorded collectively or not recorded at all. This is highly likely to be the case for the case of fruits, vegetables, tea leaves and spices. While the 1994 surveys reported the consumption of spices such as onions, garlic, ginger, spring onions and tea leaves, the 1952, 1953 and 1963 surveys did not. This would have led to the under-esimation of dietary phytochemical intakes. As previously reported by Lako and colleagues, tea leaves are good sources of TPP, quercetin, myricetin, kaempferol, morin, α- and β-carotene.[28] Hence they were expected to contribute to the dietary phytochemical intakes. Similarly, other good sources of phytochemicals are herbs and spices that are used regularly in cooking, which include ginger, onions and spring onions.

Furthermore, the report of fruit and vegetable consumption was not at a very high level of detail. The 1952 data included no individual fruits and vegetables. They were reported in collective terms such as "green vegetables" for all the leaves, "other vegetables" for vegetables other than green vegetables, and "fruits" for all the fruits consumed. In 1953 and 1963, the same collective terms were used again. The four fruits reported in 1953 and 1963 include pawpaw, pineapple, watermelon and mango, while tomatoes and eggplant were the only vegetables. It is obvious that under-reporting of food consumption may have occurred in 1952, 1953 and 1963. This leads to the under-estimation of phytochemical intakes of the community concerned. The 1994 data listed all individual food items that were consumed.

It could be assumed that the limitations of data and insufficient information may have contributed to the discrepencies in the estimation of phytochemical intakes of the Naduri community. A trend on the phytochemical and antioxidant intakes over a 42-year period longitudinal study in Naduri therefore could not be established.

The 1982 and 1993 National Nutrition Surveys

The National Nutrition Surveys in 1993 confirmed the expected vast differences beween the urban and rural communities (Table 2). The key finding was a dramatically decreased intake of TPP, total flavonols and total carotenoids in the urban area. It should be pointed out that the food intake data from these surveys were obtained through archival research.[22,23] Since the current study focuses more on the welfare of indigenous Fijians, information was extracted and further modified prior to use. The major limitation of these surveys was that only the top 20 most consumed food items were reported, and only 20 foods were used to estimate the intakes of phytochemicals, as shown in Table 2.

The 1996 Cross-Sectional Study: along the Suva-Nausori corridor

The food intake data for the Suva-Nausori Corridor community in 1996 was obtained from the secondary data,[25] in which approximately 200 apparently healthy indigenous women volunteers, aged 30 to 39 years, were interviewed. However, due to certain difficulties in data analysis, the food intake data of only 87 subjects were used in the estimation of phytochemical intakes for this community. It appears that the Suva-Nausori community's

Table 1. Information on subjects and food intake assessment methods of five major surveys in Fiji

Survey	Year of the survey	Survey subjects	Assessment of food consumption
Naduri Longitudinal Survey[18-21]	1952	142 subjects, 18 households	• Weighing all household edible raw food consumption over a one-week period of all meals. • Information on preparation meals from store foods and native foods were recorded.
	1953	142 subjects, 18 households	Same as the 1952 survey above
	1963	146 subjects, 19 households	• Weighing all household edible raw food consumption over a three-week period of all meals. • Information on preparation meals from store foods and native foods were recorded.
	1982	172 subjects, 29 households	• Weighing all household edible raw food consumption over a one-week period of all meals. • Information on preparation meals from store foods and native foods were recorded.
	1994	220 subjects, 39 households	• Weighing all household edible raw food consumption over a one-week period of all meals. • Information on preparation meals from store foods and native foods were recorded.
Fiji National Nutrition Surveys[22-23]	1982	4,964 people, including 3,625 Fijians	• Information on the frequency of daily food intake (1x24 hour recall method).
	1993	4,606 people, including 2,216 Fijians	• Information on the frequency of daily food intake (1x24 hour recall method).
Suva-Nausori Corridor cross-sectional study[24-25]	1996	200 apparently healthy indigenous women volunteers, aged 30 to 39 years	• Information on food consumption (3x24 hours recall method).
Verata cross-sectional study[26]	1999	20 apparently healthy female volunteers aged 18 to 27 years	• Seven-day food record method, twice with an interval of 17 days.
Fiji Food Choice Survey[27]	2001	140 randomly selected households	• Seven-day food record method • Information on food preferences, consumption patterns and changes in food consumption behaviour (a mixture of structured and semi-structured interviews followed by focus group discussions).

phytochemical intakes (Table 2) were low compared to the 42-year mean intakes of the Naduri community. The under-estimation may have also occurred in the Suva-Nausori community because the consumption of tea leaves, herbs and spices was not taken into account when the estimation of phytochemical intakes was made. It should be noted that the consumption of tea leaves was excluded from the estimation of phytochemical intakes, due to the inconsistency in the information collected in this survey. The average intake of tea leaves in this community was three cups a day.[25] Since tea leaves are a good source of TPP, quercetin, myricetin, kaempferol, morin, α- and β-carotene, tea consumption would have increased the intakes of phytochemicals. Similarly, other good sources of phytochemicals are herbs and spices that are used regularly in cooking, which include ginger, onions and spring onions, which had not been included in the secondary data.

The 1999 Verata Cross-Sectional study

Table 2 shows the mean daily intakes of TPP, TAT, flavonols and carotenoids of 20 apparently healthy female Fijian volunteers, aged 18 to 27, recruited from the Verata Village, Central Division, in 1999. The food intake data of this study was kindly provided by Dr Elaine Rush who was the principal researcher in the study that assessed food consumption and body composition.[26]

The 2001 Fiji Food Choice survey

The phytochemical groups intakes of Fijians in 2001 appeared to be 50% lower than those in 1993 (Table 2). The daily intakes of individual flavonols and carotenoids were also lower than the 1993 intakes. The food intake

Table 2. Average dietary intakes of phytochemicals of Fijian population in the period of 1952-2001

Survey	Year of the survey	Phytochemical intake (mg/d)												
		Total polyphenols	Total anthocyanins	Total flavonols	Total carotenoids	Myricetin	Fisetin	Morin	Quercetin	Kaempferol	Isorhamnetin	Lycopene	α-carotend	β-carotene
Naduri	1952	171.9	0	6.1	9.0	0.4	1.2	0.2	3.1	1.1	0.2	0	1.3	7.7
Naduri	1953	459.6	0.03	33.5	28.5	3.6	7.2	2.8	13.6	5.3	1.0	0.8	3.3	24.4
Naduri	1963	429.4	0.1	31.4	20.6	3.2	2.8	2.6	16.3	5.3	1.2	2.6	4.1	14.0
National Nutrition Survey	1982	323.7	0.02	14.7	31.4	1.7	0.6	0.9	8.2	1.9	1.4	0.1	1.0	30.3
National Nutrition Survey	1993	267.4	0.05	23.8	25.1	2.0	1.0	1.0	14.4	3.4	1.5	0.7	2.4	22.0
- *Urban*	*1993*	*217.3*	*0.04*	*21.7*	*23.5*	*2.1*	*0.9*	*0.9*	*13.1*	*3.3*	*1.1*	*0.5*	*2.7*	*20.2*
- *Rural*	*1993*	*322.4*	*0.05*	*30.1*	*38.5*	*3.7*	*1.2*	*1.3*	*18.4*	*3.5*	*1.7*	*0.9*	*3.4*	*34.3*
Naduri *	1994	1293	0.4	262.1	176.4	24.1	3.3	12.1	182.8	23.3	12.3	7.4	22.7	14.6
Suva-Nausori Corridor	1996	178.3	0.04	10.6	18.4	1.7	0.7	1.3	5.2	1.4	0.4	0.2	1.7	16.6
Verata Survey	1999	195.8	0.05	8.5	18.6	1.5	0.4	1.1	3.8	1.0	0.7	0.2	1.0	17.4
Fiji Food Choice Survey	2001	136.7	0.02	12.3	9.8	0.8	0.4	0.7	8.3	1.5	0.7	0.1	1.1	8.6
Average over a 49-y period		270	0.04	17.6	20.2	1.8	1.8	1.3	9.1	2.6	0.89	0.58	2.0	17.4

* Treated as an outlier, thus excluded from the calculation of the average intakes. For the Naduri Longitudinal Surveys, one to three weeks of weighing raw food method was used in the assessment of all foods consumed. For the National Nutrition Surveys in 1982 and 1993, a 1x24 hr food recall method was used in the assessment of the frequency of foods consumed. For the study of Suva-Nausori Corridor community in 1996, a 3x24 hr food recall method was used in the assessment of food consumed. For the study of Verata village in 1999, A seven-day food record method was used in the assessment of foods consumed. For the Fiji Food Choice Survey in 2001, a seven-day food record was randomly selected from a 14-day food method used in the assessment of foods consumed. The quantities of foods were estimated from the average intake of 1996 Suva-Nausori Corridor Survey, 1999 Verata and the 2001 Fiji Food Choice Survey. The data was estimated from the first 20 foods reported in the 1982 and 1993 National Surveys. Consumption of tea was not included in the estimation due to the incompatibility of units recorded in the raw data from the analytical data.

data from the Fiji Food Choice Survey was provided by Dr Philip Hone of Deakin University, Melbourne. This was a collaboration between the Fiji Food and Nutrition Centre and the Australian Centre for International Agricultural Research. The average phytochemical intakes among the Fijians over a period of 49 years were also shown in Table 2. It is important to note that because of the differences in the reporting of food items, especially tea leaves, ginger, onions and spring onions, the 1994 Naduri data has been treated as an outlier, and removed from the estimation of the national average intakes.

Total polyphenol intake

The average intake of total phenol intake among the Fijians over a period of 49 years was 270 mg/d (expressed as gallic acid equivalent). Among the five surveys, the Naduri population appears to have a relatively higher intake of phenols. The Naduri phenols intake was as low as 172 mg/d in 1952. As discussed earlier, this was due to limitations in reporting techniques. There are great variations in the intake of total phenols among different populations, as shown in Table 3. Even in the US, the various studies which have estimated total phenols differ in their findings. A study conducted by Chun and colleagues reported that American phenolic intake was 450 mg/d; of which 320mg was obtained from fruits and 129mg from vegetables.[33] These findings were based on the annual per capita food consumption data of 2001

Table 3. Comparison of phytochemicals intakes in Fijian population with those of other populations

Phytochemical	Country	Reference	Average daily intake (mg/d)
Total polyphenols	Fiji	The current study	270
	USA	- Chun *et al.*, 2005[33]	450
		- Kuhnau, 1976[35]	1000
		- Vinson *et al.*, 1998 & 2001[31,34]	473
Total anthocyanins	Fiji	The current study	0.04
	USA	Clifford, 2000[36]	215 (summer); 180 (winter)
Total flavonoids	Fiji	The current study	17.6
	USA	- Chun *et al.*, 2005[33]	103 (catechin equivalent)
		- Hertog *et al.*, 1995[37]	12.9
		- Rimm *et al.*, 1996[38]	20.1
	Denmark	Leth *et al.*, 2000[41]	23 (sum of flavonols, flavones and flavanones)
	The Netherlands	- Hollman & Katan, 1999	23 (sum of flavonols and flavones)
		- Hertog *et al.*, 1995[37]	Zutphen - 33.1
	Greece	Hertog *et al.*, 1995[37]	Corfu - 15.6; Crete - 15.7
	Italy	Hertog *et al.*, 1995[37]	Rome railroad workers - 23.1 Crevalcore - 23.3 Montegiorgio - 33.9
	Finland	Hertog *et al.*, 1995[37]	2.6
	Croatia	Hertog *et al.*, 1995[37]	Dallmatia - 40.2 Slavonia - 58.2
	Serbia	Hertog *et al.*, 1995[37]	Belgrade - 13.3 Velika Krsna – 9 Zrenjanin – 13
	Japan	Hertog *et al.*, 1995[37]	Tanushimaru - 60.8 Ushibuka - 68.2
Total carotenoids (sum of lycopene, α- and β-carotene)	Fiji	The current study	20
	USA	- Forman *et al.*, 1993[45]	7.4 (7-day food record); 8.6 (HHHQ)
		- Enger *et al.*, 1995[46]	10 (FFQ)
		- Enger *et al.*, 1996[47]	11 (FFQ)
		- Michaud *et al.*, 1998[48]	17.2 (FFQ)
		- Schunemann *et al.*, 2002[49]	6.4 (HHHFFQ)
		- Tucker *et al.*, 1999[50]	12 (FFQ)
		- Yong *et al.*, 1994[51]	6.3 (7-day food record); 7.5 (FFQ)
	Denmark	Leth *et al.*, 2000[41]	4.8 (7-day food record)
	Finland	Ylonen *et al.*, 2003[43]	2.8 (3-day food record)
	The Netherlands	Botterweck *et al.*, 2000[42]	4.7 (FFQ)
	China	Jian *et al.*, 2005[40]	7.9 (FFQ)

HHHQ: Health Habit and History Questionnaire; FFQ: Food frequency questionnaire

which was prepared by the Economic Research Services (ERS) and the United States Department of Agriculture (USDA). Vinson and colleagues conducted similar studies in the US, using the per capita consumption of phenols from fruit and vegetables.[31,34] These studies show that the total phenol intake was 473 mg/d of which 255 mg came from fruits and 218 mg from vegetables. These figures were calculated from the 1994 and 1997 consumption data of the ERS and the USDA, respectively. [31,34]

Another study of Kuhnau showed a much higher phenol intake of 1 g/d.[35] These discrepancies in the phenol intake of the US population reported by Kuhnau and the other investigators may be due to the differences in the dietary assessment methods, analytical techniques and the sources of information. It is highly likely that overestimation of intakes by Kuhnau was the result of using outdated analytical techniques, rather than the HPLC separation techniques used by other investigators.[35]

Total anthocyanin intake

The total anthocyanin intakes of Fijians is very low (0.04 mg/d) compared to the US intake, which also showed that summer intake (215 mg/d) was higher than winter intake (180 mg/d).[35,36] In Fiji, it appears that there is little consumption of anthocyanin-rich foods. This may be due to poor availability of violet-reddish-purplish coloured foods. Observations reveal that of the 72 plant foods analysed in the current study, total anthocyanins were detected in only eight foods (11%). Anthocyanins were detected in sour cherry, red tannia, red yams and red eggplants, but only red eggplants were readily available in the marketplace. According to the 1993 Fiji National Food and Nutrition Survey,[23] only a small percentage of Fijians ate eggplants daily: with 8.8% eating it rarely, 8.3% eating up to one a day and 0.5% eating at least one a day, when assessed by a one-day 24-hour recall method.

Total flavonoid intake

Table 3 shows wide differences in the estimates of flavonoid intakes in the US. One study showed that the total flavonoids intake was 103 mg/d of catechin equivalent (CE), of which 85.6 mg was obtained from fruits and 17.8 mg from vegetables.[33] This data indicates that the American intake is six times higher than the Fijian population's 49-year mean intake (17.6 mg/d). However, the other two American studies show comparability with the Fijian intake. Hertog and colleagues reported a low intake of 12.9 mg/d of total flavonoids among US Railroad workers,[37] while Rimm and colleagues found a figure of 20.1 mg/d.[38]

The discrepancies in American flavonoid intakes reported by these investigators may be due to various reasons. These include differences in analytical methods, the differences in dietary assessment methods for food consumption and the differences in the sources of information gathered. For example, Chun and colleagues used colourimetric methods,[33] while Hertog and colleagues used HPLC quantification which appeared to give much lower values.[37] Additionally, the use of different methods in assessing food consumption, such as the annual per capita food consumption data,[33] the population based one-day dietary record method,[37] and the use of food tables[38] may not be comparable. Table 3 shows that the total flavonoid intake in Japan is the highest (68.2 mg/d) while West Finland is the lowest (2.6 mg/d).[37] It appears that the high intake of flavonoids in Japan may explain longevity in the population. The total flavonoid intake in Fiji is roughly within the Greek level of intake, ranging from 15 to 17 mg/d. Food items contain more than 5 mg flavonoids per 100 g would be considered flavonoid-rich.[37] Analy-tical determinations of phytochemical composition pre-viously reported reveal that of 72 Fijian plant foods, 25 (about 35%) were rich in flavonoids.[28] These foods included the five varieties of sweet potato leaves, drumstick leaves, edible hibiscus, amaranth, kangkong, edible fern and watercress. The major flavonoid rich foods consumed by Fijians are edible hibiscus, Chinese cabbage, ripe banana, onion and tea leaves.

A detailed study on the flavonoid composition of different diets in 14 countries shows that the average intake of flavonoid consumption was 27.6 mg/d (one-day diet record). The same study showed that the Dutch intake was 34.1 mg/d and 41.9 mg/d by the use of a three-day diet record and food frequency questionnaire respectively.[39] The study estimated the flavonoids intakes from five major flavonols and flavones including quercetin, kaempferol, luteolin, and epigenin. The sample size of this study was small (N =17), however, it still provides a rough guide to the major types of dietary patterns in 14 countries. More to the point, this study is the only one ever conducted on the flavonoids compositions of different national diets. Table 4 demonstrates that different diets have different flavonoid levels.

Table 4. Flavonoid contents of various diets in 16 countries

Country	Diet type	Flavonoid intake* (mg/d)
USA	Macrobiotic	15.7
China	Chinese	5.1
Czechoslovakia	East European	24.2
Ethiopia	African	52.9
Finland	Scandinavian	77.0
India	Asian	15.6
Indonesia	Asian	28.3
Italy	Mediterranean	15.3
Lithuania	East European	13.2
Malaysia	Asian	12.7
Mexico	South American	3.6
Netherlands	Lacto-ovo	50.3
	vegetarian	26.3
	Vegetarian	47.7
	Western	
Surinam	Surinam	35.4
Turkey	Middle Eastern	19.8
Japan	Japanese	64.5[#]
Fiji (current study)	Fijian	17.6

Sources: Hertog *et al.*, 1995; de Vries *et al.*, 1997. *Dietary assessment: the use of a 1-day dietary records by 17 volunteers from 14 different countries (international subjects), 3-day records and a food frequency by 8 Dutch adults. [#]Average of the intake of two Japanese provinces; Tashunimaru & Ushinibuka (Hertog *et al.*, 1995).

The South American diet of Mexico has the lowest (3.1 mg/d) flavonoid content while the Scandinavian (17.6 mg/d) diet of Finland has the highest (77.0 mg/d). It appears that the flavonoid level of Scandinavian diet is comparable to the Japanese average intake (65 mg/d).[37] The Fijian diet is comparable to the Asian diet of India (15.6 mg/d), the Mediterranean diet of Italy (15.3 mg/d) and the Middle Eastern diet of Turkey (19.8 mg/d). It is quite surprising that the Mediterranean diet is low in flavonoids content.[39] Hertog and colleagues showed that the Mediterranean diet was 23 mg/d (mean of *N*=2).[37] As widely documented, the Mediterranean diet is rich in fruits and vegetables, which should make it a rich source of phytochemicals and antioxidants. It is possible that the low flavonoid intake reported by de Vries and colleagues[39] is counterbalanced by a high carotenoid content.

Carotenoid intake

Table 3 shows that Fijian population had a relatively higher carotenoid intake, compared to the US, China, Denmark, the Netherlands and the Finnish region of Botnia.[40-43] The various American studies all showed different levels of total carotenoid intake, which may be due to the existence of different diets among multi-ethnic communities, or in the methods of collecting data. Nevertheless, the total carotenoid intake is used in this context as a comparison.

Individual phytochemical intakes

Like the phytochemical main groups, the 49-year mean intakes of individual phytochemicals were decreasing. Obvious changes can be seen with the intakes of β-carotene and quercetin. While the intake of quercetin was low, it contributes 52% of the total flavonols in the diets of the Fijian people, and this suggests that quercetin is the dominant flavonol in Fijian diet. The Fijian intake of quercetin is approximately the same as those in Velika Krsna, Serbia and East Finland. All three of these intakes are low compared to the high intake by the people of Slavonia, Croatia, and Ushibuka, Japan (Table 5). As shown in Table 6, the Fijian intake of lycopene was relatively low compared to the intakes by the Italians, Chinese and Dutch. Likewise, all the American studies also showed high levels of lycopene intake. However, α- and β-carotene intake were higher among the Fijians, compared to the other national communities.

Discussion

In Fiji, like the rest of the world, there has been a dietary shift away from fruits and vegetables and towards animal proteins and refined carbohydrates. Many Fijians now consume a much reduced intake of fibre, vitamins, phytochemicals and antioxidants, and a higher intake of sugar and saturated fats. This type of diet impacts health status and poses higher risks in the development of nutritionally-related chronic diseases. Numerous studies have

Table 5. Comparison of dietary intakes of individual flavonols in Fijian population with those of other international populations

Flavonoid	Country	Reference	Average dietary intake (mg/d)
Myricetin	Fiji	The current study	1.8
	USA	Rimm *et al.*, 1996[38]	0.9
	The Netherlands	Hertog *et al.*, 1993[52]	1.4
Quercetin	Fiji	The current study	9.1
	USA	Hertog *et al.*, 1995[37]	US Railroad workers – 11
		Rimm *et al.*, 1996[38]	15.4
	Finland	Hertog *et al.*, 1995[37]	9.6 (East) 2.6 (West)
	The Netherlands	Hertog *et al.*, 1993[52]	16
		Hertog *et al.*, 1995[37]	Zutphen - 13.1
	Greece	Hertog *et al.*, 1995[37]	Corfu - 14.1 Crete - 15
	Italy	Hertog *et al.*, 1995[37]	Rome Railroad - 17.2 Crevalcore - 18.3 Montegiorgio – 26.8
	Croatia	Hertog *et al.*, 1995[37]	Dalmatia – 21 Slavonia - 38.2
	Serbia	Hertog *et al.*, 1995[37]	Velika Krsna – 9 Zrenjani -13.1 Belgrade -7.7
	Wales	Hertog *et al.*, 1997[53]	14.2
	Japan	Hertog *et al.*, 1995[37]	Tanushimaru - 27.2 Ushibuka - 34.6
Kaempferol	Fiji	The current study	2.6
	USA	Rimm *et al.*, 1996[38]	3.6
	The Netherlands	Hertog *et al.*, 1993[52]	3.9

Table 6. Comparison of individual carotenoid intakes in Fijian population with those of other international communities

Country	Carotenoid intake (mg/d)		
	Lycopene	α-carotene	β-carotene
Fiji			
The current study	0.6	2.0	17
USA			
Enger *et al.,* 1995	4.3	0.94	4.8
Tucker *et al.*,1999	7.3	0.76	3.9
Michaud *et al.*,1998	11.2	0.97	5.1
Schunemann *et al.*,2002	2.8	0.42	3.2
Enger *et al.,* 1996	4.4	1.1	5.6
Yong *et al.,* 1994			
- 7-day food record	3.1	0.57	2.7
- Food frequecy questionnaire	3.4	0.75	3.3
Forman *et al.,* 1993			
- 7-day food record	3.7	0.65	3.2
- Health Habit & History Questionnaire	3.9	0.84	3.9
Finland			
Ylonen *et al.,* 2003	0.72	0.09	1.94
The Netherlands			
Rimm *et al.,* 1996	1.09	0.66	2.92
Italy			
Bosetti *et al.,* 2004	7.48	0.70	4.52
China			
Jian *et al.,* 2005	3.08	0.75	4.08

shown the protective effects of fruits and vegetables rich in phytochemical and antioxidant against nutritionally-related chronic diseases including cardiovascular diseases, certain cancers, stroke and diabetes.[55-59] The importance of phytochemical intake is highlighted by studies that show an inverse association in the intakes of some phytochemicals, tea consumption and mortality with coronary heart disease and stroke.[52,53,60-62]

The food consumption data were gathered from selected survey sources discussed earlier. Because this material is secondary data, with its own aims and objectives, it may not be as accurate or as useful in addressing the issues of this study.[63,64] Therefore data were modified and validated to suit the current study. The data presented in this paper reveals that the 49-year national mean intakes of phyto-chemicals (including TPP, TAT and flavonols) among the Fijians were low, while carotenoid intakes were high. Due to the limitations of the secondary data, a trend analysis cannot be definitively established, however, in general, it can be stated that intakes of selected phytochemicals have decreased from 1982 to 2001.

The main limitation of the Naduri longitudinal data of 1952, 1953 and 1963 was the vagueness in the recording and reporting of foods consumed. Only foods that were regarded as important sources of energy were reported. Food sources with insignificant energy contents were either collectively recorded or not recorded. There was also no record made of foods such as onions, garlic, ginger, spring onions and tea leaves. The major limitation of the 1982 and the 1993 national surveys was its listing of only the twenty most commonly consumed foods.

In the current study, no test was carried out to demonstrate the therapeutic nature of traditional Fijian foods. However, it has been clearly established that the traditional Hawaiin diet, which is very similar to the Fijian diet, has therapeutic properties. Shintani studied the traditional Hawaiian diet of fresh fish, taro, sweet potatoes, yams, breadfruit, seaweed, bananas, taro leaves, sweet potato leaves and occasionally chicken, and several other native green vegetables, many of which the current study has also investigated.[65] It was demonstrated that there were many beneficial effects when this diet was eaten exclusively for 21 days. There was a great reduction in serum glucose, decreased cholesterol, normalised blood pressure and increased weight loss in obese people.[65,66]

Research related to relationships between the composition of traditional foods and good health led to the comparison of the contemporary Fijian diet with traditional diets.[24,25,67] The comparison shows that the traditional Fijian diet resembles the hunter-gatherer diet. They both show high intakes of fruits and vegetables, high fibre, low protein and moderate fat. On the other hand, the contemporary Fijian diet shows a dramatic transition with a low intake of fruits, vegetables,[68] fibre and high intake of sugar and glycemic load.

It is important to note that the 1952 diet survey in Naduri only represents the highland type of diet. Therefore, it could be argued that the Naduri diet does not represent the true average Fijian diet. Nevertheless, it was selected for the study because it was the only longitudinal nutritional data available. A true traditional Fijian diet existed before colonisation. Personal communication with Lucas, Gatty and Parkinson revealed that the traditional Fijian diet for highland people was mostly vegetable-based with fewer spices. This diet has now been modified to suit the preferences of today.

Further environmental and behavioural changes that relate to dietary shift are affected by changes in the food system. Traditional food systems were composed of sea mammals, land animals, fish, birds, shellfish, and plants, with the majority of dietary energy coming from sea mammals.[69] Due to globalisation of the human diet, traditional food systems have deteriorated. This in turn leads to the disappearance and loss of traditional food knowledge, including related food activities, preparation, taste and preference. There is a strong possibility that traditional food systems, once they have fallen into disuse, will never revive, and that traditional food knowledge, once lost, will be lost forever. Any approach in the enhancement of diets needs to be culturally appropriate to be effective. Food-based approaches in promoting traditional, locally grown phytochemical and antioxidant rich foods (such as sweet potato leaves) will help combat transitional nutrition and health problems, and in a sustainable way. It is suggested that diets high in antioxidants, through their flavonoid and carotenoid contents, be included in the Fijian diet.

In conclusion, this study has demonstrated that the phytochemical intake of the Fijian population is relatively low, which may be due to the low consumption of fruits and vegetables. Low phytochemical intakes are associated with low protective health status. It is clear that, from a dietary point of view, the contemporary Fijian population has an unneccessarily low protective health status. Nutrition transition may be inevitable, however efforts should be made to improve the phytochemical content of the Fijian diet. Like the people of many other countries, Fijians

should be encouraged to consume at least five to ten servings of fruits and vegetables daily.

References

1. Berg RV, Vliet TV, Broekman WMR, Cnubben NHP, Vaes WHJ, Roza L, Haenen GMM, Bast A, Berg HV. A vegetable/fruit concentrate with high antioxidant capacity has no effect on biomarkers of antioxidant status in male smokers. J Nutr 2001; 131: 1714-1722.
2. Cao G, Prior RL. Postprandial increases in serum antioxidant capacity in older women. J Clin Pathol 2000; 89: 877-883.
3. Cao G, Russell RM, Lischner N, Prior RL. Serum antioxidant capacity is increased by consumption of strawberries, spinach, red wine or vitamin C in elderly women. J Nutr 1998; 128: 2383-2390.
4. Nelson JL, Berstein PS, Schmidt MC, Tress MSV, Askew EW. Dietary modification and moderate antioxidant supplementation differentially affect serum carotenoids, antioxidant levels and markers of oxidative stress in older humans. J Nutr 2003; 133: 3117-3123.
5. Bianchini F, Elmstahl S, Martnez-Garcia C, Kappel A-Lv, Douki T, Cadet J, Ohshima H, Riboli E, Kaaks R. Oxidative DNA damage in human lymphocytes: Correlations with plasma levels of alpha-tocopherol and carotenoids. Carcinogenesis 2000; 21: 321-324.
6. Riso P, Pinder A, Santangelo A, Porrini M. Does tomato consumption effectively increase the resistance of lymphocyte DNA to oxidative damage? Am J Clin Nutr 1999; 69: 712-718.
7. Ross JA, Kasum CM. Dietary flavonoids: Bioavailability, metabolic effects and safety.Ann Rev Nutr 2002;22:19-34.
8. Paiva SAR, Russell RM. Beta-carotene and other carotenoids as antioxidants. J Am Coll Nutr 1999; 18: 426-433.
9. Bors W, Heller W, Michel C, Stettmaier K. Flavonoids and polyphenols: Chemistry and biology. In: E Cadenas, L Packer, eds. Handbook of Antioxidants. New York: Marcel Dekker, 1996; 409-465.
10. Kadam SS. Vegetables in human nutrition. In: DK Salunkhe, ed. Handbook of Vegetable Science and Technology: Production, Composition, Storage and Processing. New York: Marcel Dekker, 1998: 695-703.
11. Joshipura KJ, Hu FB, Manson JE, Stampfer MJ, Rimm EB, Speizer FE, Colditz G, Ascherio A, Rosner B, Spiegelman D, Willett WC. The effect of fruit and vegetable intake on risk for coronary heart disease. Ann Intern Med 2001; 134: 1106-1114.
12. Joshipura KJ, Ascherio A, Manson JE, Stampfer MJ, Rimm EB, Speizer FE, Hennekens CH, Spiegelman D, Willett WC. Fruits and vegetable intake in relation to risk of ischemic stroke. JAMA 1999; 282: 1233-1239.
13. Sauvaget C, Nagano J, Allen N, Kodama K. Vegetable and fruit intake and stroke mortality in the Hiroshima/ Nagasaki life span study. Stroke 2003; 34: 2355-2360.
14. John JH, Ziebland S, Yudkin P, Roe LS, Neil HAW. Effects of fruit and vegetable consumption on plasma antioxidant concentrations and blood pressure: A randomised controlled trial. Lancet 2002; 359: 1969-1974.
15. Lawrence AJ, Thomas MJ, Eva O, Williams VM, Laura SP, Frank SM, George A, Thomas VM, Jeffrey CA, Marlene WM, Pao-Hwa P, Njeri K. A clinical trial of the effects of dietary patterns on blood pressure. N Engl J Med 1997; 336: 1117-1124.
16. Colditz GA, Branch LG, Lipnick RJ, Willett WC, Rosner B, Posner BM, Hennekens CH. Increased green and yellow vegetable intake and lowered cancer deaths in elderly population. Am J Clin Nutr 1985; 41: 32-36.
17. Verhagen H, Poulsen HE, Loft S, Poppel G, Willems MJ, Bladeren PJ. Reduction of oxidative DNA-damage in humans by brussels sprouts. Carcinogenesis 1995; 16: 969-970.
18. Fiji National Fooda and Nutrition Centre. Report of the 5th Decennial Naduri Nutrition & Health Survey: June 24-July 2,1994. Suva: National Food&Nutrition Centre, 1996.
19. Johnson J, Bolabola C. Report on Nutrition Survey Naduri village. Suva: Fiji National Food &Nutrition Centre, 1982.
20. Langley D. Dietary surveys and growth record in a Fijian village, Naduri: June 1952-November 1953: South Pacific Health Services, 1953.
21. Wilkins RM. Dietary survey in a Fijian village, Naduri, Nadroga, 1963: Souh Pacific Health Services, 1963.
22. Johnson JS, Lambert JN. The National Food and Nutrition Survey of Fiji. Suva: Fiji National Food and Nutrition Centre, 1982.
23. Saito S. 1993 National Nutrition Survey Main Report. Suva: National Food and Nutrition Centre, 1995.
24. Lako J. The dietary pattern and dietary antioxidants among the Indigenous Fijians. In: Nutritional Biochemistry Laboratory. Tokyo: Japan Women's University, 1998: 119.
25. Lako J, Nguyen V. Dietary patterns and risk factors of diabetes mellitus among urban indigenous women in Fiji. Asia Pac J Clin Nutri 2001; 10: 188-193.
26. Rush E, Hedges R, Albersberg B, Qionibaravi D, Laulu M. Staple food intake in a rural village in Verata, Fiji. Pac Health Dialog 2001; 8: 44-46.
27. Fiji Nantional Fooda and Nutrition Centre. Fiji Food Choice. Suva: National Food and Nutrition Centre, 2001.
28. Lako J, Trenerry C, Wahlqvist ML, Wattanapenpaiboon N, Subramanium S, Premier R. Phytochemical flavonols, carotenoids and the antioxidant properties of a wide selection of Fijian fruit, vegetables and other readily available foods. Food Chem 2006 (in press).
29. US Department of Agriculture. References for USDA-NCC Carotenoid Database for US Foods: Nutrient Data Laboratory, Food Composition Laboratory, Beltsville Human Nutrition Research Centre, Agriculture Research Service, US Department of Agriculture, 1998.
30. US Department of Agriculture. USDA Database for the Flavonoid Content of Selected Foods: Nutrient Data Laboratory, Food Composition Laboratory, Beltsville Human Nutrition Research Centre, Agriculture Research Service, US Department of Agriculture, 2003.
31. Vinson JA, Su X, Zubik L, Bose P. Phenol antioxidation quantity and quality in foods: Fruit. J Agric Food Chem 2001; 49: 5315-5321.
32. Franke AA, Custer LJ, Arakaki C, Murphy SP. Vitamin C and flavonoid levels of fruits and vegetables consumed in Hawaii. J Food Comp Anal 2004; 17: 1-35.
33. Chun OK, Kim D, Smith N, Schroeder D, Han JT, Lee CY. Daily consumption of phenolics and total antioxidant capacity from fruit and vegetables in the American diet. J Sci Food Agric 2005; 85: 1715-1724.
34. Vinson JA, Hao Y, Su X, Zubik L. Phenol antioxidant quantity and quality in foods: Vegetables. J Agric Food Chem 1998; 46: 3630-3634.
35. Kuhnau J. The flavonoids: a class of semi-essential food components; their role in human nutrition. World Rev Nutr Diet 1976; 24: 117-191.
36. Clifford MN. Anthocyanins-nature, occurrence and dietary burden. J Sci Food Agric 2000; 80: 1063-1072.

37. Hertog MGL, Kromhout D, Aravanis C, Blackburn H, Buzina R, Fidanza F, Giampaoli S, Jansen A, Menotti A, Nedeljkovic S, Pekkarinen M, Simic BS, Toshima H, Feskens EJM, Hollman PCH, Katan MB. Flavonoid intake and long-term risk of coronary heart disease and cancer in Seven Country Study.Arch Intern Med 1995;155:381-386.
38. Rimm EB, Katan MB, Ascherio A, Stampfer MJ, Willett W. Relationship between intake of flavonoids and risk for coronary heart disease in male health professionals. Ann Intern Med 1996; 125: 384-389.
39. de Vries J, Janssen K, Hollman PCH, Staveren W, Katan M. Consumption of quercetin and kaempferol in free-living subjects eating a variety of diets. Cancer Lett 1997; 114: 141-144.
40. Jian L, Du C, Lee AH, Binns CW. Do dietary lycopene and other carotenoids protect against prostate cancer? Int J Cancer 2005; 113: 1010-1014.
41. Leth T, Jakobsen J, Andersen NL. The intake of carotenoids in Denmark. Eur J Lipid Sci Technol 2000; 102: 128-132.
42. Botterweck AAM, Brandt PAv, Goldbohm RA. Vitamins, carotenoids, dietary fiber, and the risk of gastric carcinoma. Cancer 2000; 88: 737-748.
43. Ylonen K, Alftham G, Groop L, Saloranta C, Aro A, Virtanen SM. Dietary intakes and plasma concentrations of carotenoids and tocopherols in relation to glucose metabolism in subjects at high risk of type 2 diabetes: The Botnia dietary study. Am J Clin Nutr 2003;77: 1434-1441.
44. Hollman PCH, Katan MB. Dietary flavonoids: Intake, health effects and bioavailability. Food Chem Toxicol 1999; 37: 937-942.
45. Forman MR, Lanza E, Yong L-C, Holden JM, Graubard BI, Beecher GR, Melitz M, Brown ED, Smith JC. The correlation between two dietary assessments of carotenoid intake and plasma carotenoid concentrations: Application of a carotenoid food-composition database. Am J Clin Nutr 1993; 58: 519-524.
46. Enger SM, Longnecker MP, Shikany JM, Swenseid ME, Chen M-J, Harper JM, Haile RW. Questionnaire assessment of intake of specific carotenoids. Cancer Epidemiol Biomarkers Prev 1995; 4: 201-205.
47. Enger SM, Longnecker MP, Chen M-J, Harper JM, Frankl HD, Haile RW. Dietary intake of specific carotenoids and vitamins A, C, and E, and prevalence of colorectal adenomas. Cancer Epidemiol Biomarkers Prev 1996; 5:147-153.
48. Michaud DS, Giovannucci E, Ascherio A, Rimm EB, Forman MR, Sampson L, Willett WC. Associations of plasma carotenoid concentrations and dietary intake of specific carotenoids in samples of two prospective cohort studies using a new carotenoid database. Cancer Epidemiol Biomarkers Prev 1998; 7: 283-290.
49. Schunemann HJ, McCann S, Grant BJB, Trevisan M, Muti P, Freudenheim JL. Lung function in relation to intake of carotenoids and other antioxidant vitamins in a population-based study. Am J Epidemiol 2002; 155: 463-471.
50. Tucker KL, Chen H, Vogel S, Wilson PWF, Schaefer EJ, Lammi-Keefe CJ. Carotenoid intakes, assessed by dietary questionnaire, are associated with plasma carotenoid concentrations in elderly population.J Nutr1999;129:438-445.
51. Yong L-C, Forman MR, Beecher GR, Graubard BI, Campbell WS, Reichman ME, Taylor PR, Lanza E, Holden JM, Judd JT. Relationship between dietary intake and plasma concentrations of carotenoids in premenopausal women: application of the USDA-NCI carotenoid food-composition database. Am J Clin Nutr 1994; 60: 223-230.
52. Hertog MGL, Hollman PCH, Katan MB, Kromhout D. Intake of potentially antiocarcinogenic flavonoids and their determinants in adults in the The Netherlands. Nutr Cancer 1993; 20: 21-29.
53. Hertog MGL, Sweetnam PM, Fehily AM, Elwood PC, Kromhout D. Antioxidant flavonols and ischemic heart disease in a Welsh population of men: The Caerphilly study. Am J Clin Nutr 1997; 65: 1489-1494.
54. Bosetti C, Talamini R, Montella M, Negri E, Conti E, Franceschi S, Vecchia CL. Retinol, carotenoids and the risk of prostate cancer: A case-control study from Italy. Int J Cancer 2004; 112: 689-692.
55. Steinmetz KA, Potter JD. Vegetables, fruit, and cancer prevention: A review. J Am Diet Assoc 1996; 96: 1027-1039.
56. Ness AR, Powles JW. Fruit and vegetables, and cardiovascular disease:A review. Int J Epidemiol 1997; 26: 1-13.
57. Michael KB, Giovannucci E, Joshipura KJ, Rosner B, Stampfer MJ, Fuchs CS, Colditz GA, Speizer FE, Willett WC. Prospective study of fruit and vegetable consumption and incidence of colon and rectal cancers. J Natl Cancer Inst 2000; 92: 1740-1752.
58. Liu S, Lee I-M, Ajani U, Cole SR, Buring JE, Manson JE. Intake of vegetables rich in carotenoids and risk of coronary heart disease in men: The physicians' health study. Int J Epidemiol 2001; 30: 130-135.
59. Genkiger JM, Platz EA, Hoffman SC, Comstock GW, Helzisouer KJ. Fruit, vegetable, and antioxidant intake and all-cause, cancer, and cardiovascular disease mortality in a community-dwelling population in Washington country, Maryland. Am J Epidemiol 2004; 160: 1223-1233.
60. Knekt P, Ritva J, Reunanen A, Jouni M. Flavonoid intake and coronary mortality in Finland: A cohort study. BMJ 1996; 312: 478-481.
61. Knekt P, Kumpulainen J, Jarvinen R, Rissanen H, Heliovaara M, Reunanen A, Hakulinen T, Aromaa A. Flavonoid intake and risk of chronic diseases. Am J Clin Nutr 2002; 76: 560-568.
62. Keli SO, Hertog MGL, Feskens EJM, Kromhout D. Dietary flavonoids, antioxidant vitamins, and incidence of stroke. Arch Intern Med 1996; 156: 637-642.
63. Malhotra N. Sampling: Design and procedures. In: Marketing research: An applied orientation. 4th Ed. New Jersey: Prentice Hall, 2004; 312-368.
64. Malhotra N. Exploratory research design: Secondary data. In: Marketing research: An applied orientation. 4th Ed.. New Jersey: Prentice Hall, 2004; 100-133.
65. Shintani TT, Hughes CK, Beckham S, O'connor HK. Obesity and cardiovascular risk intervention through the ad libitum feeding of traditional Hawaiian diet. Am J Clin Nutr 1991; 53: 1647S-1651S.
66. Hughes CK. Traditional Hawaiian diet programmes: A culturally competent chronic disease intervention. Pac Health Dialog 1999; 5: 328-331.
67. O'Keefe HH, Cordain L. Cardiovascular disease resulting from a diet and lifestyle at odds with our paleolithic genome: How to become a 21st century hunter-gatherer. Mayo Clin Proc 2004; 79: 101-108.
68. Fiji Ministry of Health. WHO Stepwise Approach to NCD Risk Factor Surveillance in Fiji. Suva: WHO, 2003.
69. Kuhnlein HV, Receveur O. Dietary change and traditional food systems of indigenous peoples. Ann Rev Nutr 1996; 16: 417-442.

Original Article

Phytochemical intakes of the Fijian population

Jimaima Lako PhD[1], Naiyana Wattanapenpaiboon PhD[1], Mark Wahlqvist MD[1] and Craige Trenerry PhD[2]

[1]*Asia Pacific Health and Nutrition Centre, Monash Asia Institute, Building 11A, Monash University, Victoria, 3800, Australia.*
[2]*PIRVic DPI-Werribee, 621 Sneydes Road, Werribee, Victoria, 3030, Australia.*

对斐济群岛人群关于他们植源性化学成分和抗氧化成分的摄入情况的调查

从 1952 年到 2001 年进行的 5 次针对斐济群岛人饮食情况进行了调查，我们根据这些调查所报道的 90 种斐济群岛人常食用的可食性植物，对他们饮食中摄入的植物性成分进行了统计调查。这 5 次调查包括：Naduri 纵向调查（该调查对 1952，1953，1963，1994 这四个时期对食物摄入情况进行调查），1982 年和 1993 年全国营养调查，1996 年 Suva-Nausori Corridor 横向调查，1999 年 Verata 横向调查和 2001 年的斐济群岛人食品消费调查。与文献所报道的其他地区人所摄入的植源性化学成分相比，我们发现斐济群岛人摄入的总酚(275 mg/天)和总黄酮(17.5 mg/天)的量相对较低，但摄入的总类胡萝卜素量较高(20 mg/天)。我们推测造成斐济群岛人对植源性化学成分摄入低的原因是饮食习惯的改变，而饮食结构的改变会部分地增加由于营养失调而导致的慢性疾病的发病率和死亡率。进而我们建议斐济群岛人应多沿袭他们传统饮食模式，多吃水果蔬菜和多食用富含植源性化学成分的红薯叶和鼓槌叶。

关键词：植源性化学成分、黄酮类、类胡萝卜素、花青素、多酚、食品摄入、斐济人、斐济群岛人。