Original Article

Significance of wild vegetables in micronutrient intakes of women in Vietnam: an analysis of food variety

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The association between food variety and nutrient intake/health status among rural women was tested in two agro-ecological settings in Vietnam. Special emphasis was placed on the significance of wild vegetables '*Rau Dai*' in micronutrient supply and on the usefulness of food variety analysis in determining their current role. Data from 7-day food frequency interviews and a nutrition/health survey with 93 and 103 rural women in the Mekong Delta and the Central Highlands, respectively, were used in the analysis. Energy and nutrient intakes in the groups with the highest food variety score (FVS) (high = ≥ 21) in the two regions were compared to those with the lowest food variety score (low = ≤15). The high FVS groups in both regions also had a more diversified diet in terms of food categories. With the exception of low iron and riboflavin intakes in all groups, the high FVS groups had relatively adequate diets. A large variety of vegetables was used and only approximately half of the vegetable species were cultivated. In both regions the high FVS groups used a significantly greater variety of vegetables than the low FVS groups. Wild vegetables contributed significantly to the overall micronutrient intakes, mostly carotene, vitamin C and calcium intakes, but only the contribution to carotene intake was significantly higher in the high FVS group. Overall, we conclude that a food variety analysis is a useful tool in capturing the dietary role of wild vegetables.

Key words: dietary diversity, dietary intake of women, food-based dietary guidelines, food variety analysis, sociocultural variations, Vietnam, wild vegetables.

Introduction

The International Conference in Nutrition in 1992 identified the development of Food Based Dietary Guidelines as one important strategy in the promotion of nutritional improvement and healthy lifestyles. The arguments were raised that people generally think of diets in terms of foods rather than nutrients and that such guidelines should preferably be built on traditional diet and food practices.[1]

Among the core features that countries have emphasised in recent guidelines are the recommendations to consume a wide variety of foods and to eat plenty of fruits and vegetables.[2,3] However, while a diversified diet often is associated with a healthier diet, it is a very diffuse term to use. Several researchers have noted that there is little guidance for measurement of dietary diversity and suggested that a count of the different foods or food categories consumed may be a useful indicator.[4–6] Some have analysed the association between the number of foods or food groups and nutrient adequacy,[7–9] others the links between food variety and improved health and nutrition status.[4,10,11] Yet others have looked at dietary diversity in relation to causes of mortality,[12] or at the protective function of diversified intakes of fruits and vegetables in some forms of cancer.[13,14] The nutritional benefit of fruits and vegetables is mostly argued on the basis of the contribution to intakes of known minerals and vitamins. However, research also continues to identify additional substances with biological activities of importance to health, for example a large number of carotenoids in these food items.[4,15]

Hatloy *et al.* has noted that most of the analytical studies of food variety have been carried out in western or affluent countries.[6] This study is one of the few that have related food variety to nutrient intake and health outcome in a low-income country and made reference to the use of wild foods.

Rural people in many countries continue to include wild foods in their diets, but the role of this food category is still difficult to capture in conventional dietary assessment.[16] Many characteristics of wild foods contribute to this difficulty; a vast variety of species is used; they are often site specific, they vary with ethnicity, they are known only by their local vernacular names; users are often illiterate and there is sometimes a social stigma attached. In addition, data on composition are often missing or outdated. In such situations it can be of interest to test whether a Food Variety Analysis, defined as an analysis of the diversity of foods or food categories included in the diet, can be a useful tool.

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Vietnam offers an interesting example for such analysis. A large number of wild plants have traditionally been used as vegetables '*Rau Dai*' but there is little information as to their dietary role today.[17,18] The aim of this paper is to analyse the association between food variety, specifically on the role of wild vegetables, nutrient intake and health status among adult women in Vietnam. The analysis is based on data from field studies in four villages in two agro-ecological settings in Vietnam, the Mekong Delta and the Central Highlands.[19]

The study is one of several collaborative activities between the Swedish University of Agricultural Sciences and universities in Vietnam. Ethical permission was obtained through the research ethics committee, Faculty of Medicine, Uppsala University and local approval through the Universities of Can Tho and Hue.

Study area

The field surveys for this study were carried out in two villages in the Mekong Delta in 1997 and two Central Highlands villages in 1998. Both surveys took place in the rainy season.

Characteristic for the Mekong Delta area is the very intensive agriculture, which is based primarily on rice production, either irrigated or rain-fed. It is one of the most fertile regions in Vietnam but there are also lower areas of depressed back-swamps where agricultural production is constrained by permanent or seasonal salinity of the soils, annual risks of flooding, damaged dykes and destroyed crops. In the dry season, the water in the canals, which is used for both household and farm use, is heavily polluted and there is lack of fresh water.[20,21] The Delta is densely populated and the population is mostly of Vietnamese origin *(Kinh).* The study sites were located in Can Tho and Soc Trang provinces and both study sites were most easily accessible by small boat.

In contrast to the Mekong Delta, the Central Highlands region is sparsely populated. Over half the area is under forest cover and although deforestation in this region is of major concern, some of the nation's best and most extensive forests are found here. Typical for the highlands are the narrow, populated valleys surrounded by stretches of steep hills and rugged densely forested mountains. The Thua Thien–Hue province, where the research was carried out, is one of the three poorest provinces in the Central Region. Two forest villages in two districts were selected, one close to the border of Laos and the other neighbouring the Bac Ma nature reserve. The infrastructure in the study villages is poor. The economy relies mainly on agriculture and forestry products, typically upland rice, cassava, maize, cinnamon, coffee and rubber. Regular flooding during the rainy season of September to November is common also in this region.

A large number of ethnic minority groups in Vietnam live in the mountain areas. In addition, lowland *Kinh* people have moved to the highland regions under various resettlement schemes. In the highlands of Thua Thien–Hue province, two groups dominate, the Ca–Tu and the Ta–Oi, of which the Pa–Ko is a subgroup.[22] Both these groups have traditionally practised slash and burn agriculture on forest clearings but, after the war, have been transferred to settled agriculture in highland valleys.

Sampling and participants

A simple random sampling was used for the formal survey. In the Mekong Delta villages, hamlets were segmented into canal areas and, using random numbers to start, clusters of households were selected. In the Central Highlands, village authorities assisted with lists of households in all hamlets and a random sample was drawn where a proportional number of minority and *Kinh* households were selected.

Within the households, women in the age range 19–60 were included in the dietary interviews and the nutrition status/health study. In total, 217 women took part; that is, 107 in the Mekong Delta and 110 in the Central Highlands villages. From the Mekong Delta interviews, a subsample consisting of the 93 women (87%) who consented to the blood tests has been used in this analysis. From the Central Highlands population, 103 (94%), who fully completed interviews and health controls, have been included in the food variety analysis. Some characteristics of the study population are presented in Table 1**.**

Methods

Dietary intake assessment

Information from an initial qualitative survey was used in the design of the dietary assessment survey.[23] An adapted food frequency methodology with a recall period of seven consecutive days (7dFFQ) was used, as this approach has been suggested as a time-efficient method to assess short-term food intake.[24–26] Face to face interviews were conducted in the homes of the respondents.

The 7dFFQ included commonly used foods divided into 12 food categories and the foods listed under each category were specifically selected to cover foods commonly available in the area, especially local vegetables, fruits and indigenous fish species. Special care was taken to probe for information on additional foods eaten during the week. Several techniques were used to determine usual portion sizes. These included the use of photos of foods and dishes produced by the National Institute of Nutrition (NIN); providing selected households with scales and asking them to weigh and record all foods used during three of the seven days, and purchasing, weighing and preparing local foods. The team members also recorded weights of foods directly, whenever possible.

Individual dietary intake data were computed from the 7dFFQ using Ebis for Windows 95/98/NT (Univ. Hohenheim, Germany). The mean daily intakes of energy and

Table 1a. Key characteristics of study participants

Characteristics	Mekong Delta (*n* = 93)	Central Highlands (*n* = 103)
Age (mean years ± SD)	40 ± 10	38 ± 10.8
Weight (kg)	48.1 ± 6.7	43.3 ± 5.1***
Height (m)	1.52 ± 0.05	1.48 ± 0.06***
BMI (mean ± SD)[1]	20.3 ± 4.6	17.6 ± 6.4***
BMI (% < 18.5)	15.1	19.4
BMI (% > 25.0)	8.6	1.9
Number of children, mean (SD)	4 ± 2.7	4 ± 2.1
Food variety score, mean (SD)	20 ± 6.6	18 ± 5.9
Diet diversity score, mean (SD)	8 ± 1.4	9 ± 1.7*

Statistical significance (Student's *t*-test): *$P<0.01$, ***$P<0.001$. [1]Body mass index (BMI) values excluding pregnant women (*n* = 13).

Table 1b. Ethnic variation within the Central Highlands population

Parameter	Ethnic group		
	Kinh (n = 44)	Pa–Ko (n = 29)	Ca–Tu (n = 30)
Age (mean years ± SD)	41.0 ± 10.3	33.0 ± 10.0**	37.0 ± 11.0
Weight (kg)	44.8 ± 4.2	44.3 ± 5.5	40.1 ± 4.7**
Height (m)	1.51 ± 0.04	1.46 ± 0.07**	1.44 ± 0.06*
BMI (mean ± SD)[1]	19.2 ± 3.6*	15.4 ± 9.0*	17.2 ± 6.0
BMI <18.5	10 women	2	7 women
BMI >25.0	1	1	1
Pregnant, no. women	0	7	3
Breast-feeding, no. women	0	14	3
Number of children (mean ± SD)	4.0 ± 2.5	4.0 ± 2.0	4.0 ± 2.1
Food variety score (mean ± SD)	19.0 ± 5.0	17.0 ± 6.6	16.0 ± 6.3*
Diet diversity score (mean ± SD)	10.0 ± 1.0	8.0 ± 1.8***	8.0 ± 1.8***

Statistical significance (Student's t-test): *$0.05>P>0.01$, **$0.01>P>0.001$, ***$P<0.001$.[1] Body mass index (BMI) values excluding pregnant women (n = 10).

11 major nutrients were evaluated at a group level against the recommended dietary allowances for women in Vietnam aged 18–60 years.[27] Details of the methodology and results have been published elsewhere.[19]

Food variety and dietary diversity scoring

The food variety score (FVS) was calculated on the basis of the 7dFFQ. We adapted the approach used by Hatloy *et al.*, Hodgson *et al.* and Hsu-Hage and Wahlquist.[4,28,29] We defined FVS as the total number of different food items consumed during the 7dFFQ period. All the food items included in Table 2 were included in the FVS.

The dietary diversity score (DDS) was calculated as proposed by Hatloy *et al.* through a simple count of the different food groups reported during the week of investigation.[28] The food categories were those used by the NIN in previous national dietary surveys;[30] for example, rice, other staples, green leafy vegetables, other vegetables, meat/poultry, fish/shellfish, eggs, legumes/nuts/seeds, fruits, oils/fats, sauces/condiments and beverages/biscuits/sweets. In addition, we grouped the vegetables into cultivated and wild species for further analysis. A summary of the food categories and frequencies in the reporting from the 7dFFQ is found in Table 2.

Anthropometric and biochemical data

The health and nutrition status survey included anthropometric parameters (height and bodyweight), as well as a health examination that included general condition, and enquiries regarding problems of respiratory, gastrointestinal or genital infections. Heights and weights of all respondents were recorded using digital solar scales (Tanita, USA) and the minimetre measuring tapes (Raven, Essex, UK). Qualified doctors assisted the researchers with individual health examinations. The team carried with them medication for common conditions and distributed these free of charge when medication was required. Where necessary, patients were referred to the local clinic for further treatment. In the Mekong Delta survey, venous blood samples were taken for testing of selected biochemical parameters. On a voluntary basis, women were asked for non-fasting blood samples and 87% consented to this. Blood samples were analysed for haemoglobin (Hb), serum ferritin, serum retinol, retinol binding protein and C-reactive protein (CRP). The health survey in the Highlands did not include blood samples.

Biochemical analysis

Haemoglobin values were analysed on the spot, using HemoCue units (HemoCue AB, Angelholm, Sweden). Women with low Hb values were provided with ferrous sulphate tablets for a 2-week period and referred to the local clinics for further check-up and continued free treatment. The CRP levels were also assessed ocularly in the village using NycoMed CRP cards (NycoMed Pharma, Birmingham, UK). Blood samples were transported in a cool-box each evening to Can Tho Hospital and stored in a refrigerator. Serum ferritin levels were determined immediately at the Can Tho Hospital using a standard bioassay procedure (Human ferritine enzyme immunoassay test kit; Diagnostic Automation, CA, USA). Frozen samples were transported to the Benh Vien Cho Ray Hospital in Saigon where retinol-binding protein was determined using enzyme-linked immunosorbent assays (Randox laboratories) and to the NIN, Hanoi for analysis of serum retinol using high performance liquid chromotography (HPLC).[31]

Statistical analysis

Statistical Packages for Social Sciences (SPSS version 9) for Windows was used for the analysis of associations between food variety/dietary diversity, nutrient intake and anthropometric/biochemical data. The association between food variety and nutrient intake, and between food variety and biochemical parameters was tested by creating three subgroups of the study population on the basis of the FVS, DDS and number of wild vegetables. In each region the group in the highest variety tertile was compared to that of the lowest variety tertile. Student's t-tests and ANOVA were used to test differences in nutrient intakes between groups with the lowest and highest tertile of food variety, dietary diversity and adequacy of nutrient intakes. Multiple regression was used to test associations between the number of wild vegetables, nutrient adequacy and nutrition status/health data.

Results

The women in the two study areas had many characteristics in common. They were mostly farming women who had lived in the community for over 10 years, they were married and the mean age and number of children were similar (Table 1). With the heavy workload of farming women, many complained of backaches, painful shoulders and joints. In the

Table 2. Food groups and food items eaten at least once during the 7-day period

Food groups	Mekong Delta villages (*n* = 93) Freq. of use of food group: % women	Mean no. food items	Food items used by >10% of women	Central Highland villages (*n* = 103) Freq. of use of food group: % women	Mean no. food items	Food items used by >10% of women
Cereals	100	1.5	100 rice >20 rice noodles >10 sticky rice, maize	93	1.3	>90 rice >10 rice noodles >10 sticky rice
Starchy roots	82	1.1	>60 sweet potatoes >20 yams >10 taro	90	1.4	>80 cassava >40 sweet potatoes >10 yams
Green leafy vegetables	88	3.2	>60 *Ipomoea aquatica* >40 *Centella asiatica, Sauropus androgynus* >30 *Limnocharis flara*, sweet potato leaves >20 *Commelina communis*, *Passiflora foetida* >10 *Amaranthus* sp., *Eryngium foetidum*	94	3.8	>90 sweet potato leaf >50 *Centella asiatica* >30 *Nasturdium officinale* >20 *Houttuynia cordata*, *Basella rubra*, *Schismatoglottis calyptr*, *Portulaca oleracea*, *Ipomoea aquatica*, *Polygonum odorum* >10 *Colocasia* sp., squash leaf
Other vegetables	100	2.2	>80 chili peppers >40 *Eleocharis dulcis* >30 *Nymphea lotus*, *Nelumbo nucifera*, >20 bitter cucumbers, cucumbers	87	1.7	>80 chili peppers >20 bamboo shoots *Homalomena occulta*, pumpkin, squash, >10 banana flower, long beans, tomatoes
Fish/seafood	98	2.5	>70 *Anabus testudinus* >50 *Trichogaster trichogaster* >40 snakehead fish >30 *Kryptopterus kryptopterus* >10 *Leiocassis siamensis*	87	1.4	>70 Tetradon >20 carp >10 tilapia
Meat	74	1.3	>60 pork >40 duck >10 chicken	66	1.0	>50 pork >30 chicken >10 beef
Eggs	16	0.2	>10 duck eggs	28	0.3	>20 chicken eggs >10 duck eggs
Nuts/legumes	17	0.2	>10 peanuts	54	0.8	>30 peanuts >20 tofu, fresh, salted, fermented
Fruits/juice	89	2.6	>60 bananas >40 papaya, longan, rambutan >30 guava, coconut juice, >10 lime juice	95	2.3	>80 bananas >60 guavas >40 papaya >10 oranges
Oils/fats	76	0.8	>70 pork fat	68	0.9	>50 oil >40 pork fat
Sauces	100	1.2	>90 fish sauce >10 soy sauce	94	1.0	>50 fish sauce >10 soy sauce
Beverages/Biscuits/Sweets	97	2.7	>80 rain water >10 sugar cane, Che, Banh (many different kinds) coffee, green tea	94	1.8	>30 rain water >40 green tea, coffee >20 biscuits, candy, Banh

<10% also reported the following food items:
Cereals/tubers: wheat bread, potatoes, *cu nau, mon vang.*
Green leafy vegetables: *Alternanthera repens*, *Asystasia gangelica*, *Blyxa aubertii*, *Bacopa monnieri*, *Costus speciosus*, *Diplazium esculentum*, *Gymnopetalum cochincinense*, *Gynura crepidioides*, *Oenanthe javanica*, Piper la lot, *Plantago major*, *Schefflera tonkinensis*, cassava leaves, bitter cucumber leaves, leaf cabbage, lettuce , pumpkin leaves and rattan tops.
Other vegetables: banana stem, beet, carrot, *cu cai trang,* green figs, green banana, green onions, lemon grass, *mo qua*, pumpkin flower, straw mushrooms, *susu*, water hyacinth shoots, water hyacinth flower.
Fish/sea foods: mackerel, goby, carp, *Leiocassis siamensis*, *ca ngu, ca bien, ca soui, ca con, ca giec*, *Puntius biochantus*, *ca rong rong*, *Clarias batrachus*, *Notopterus notopterus*, clams, eel, soft shell crab, shrimps, snails, fermented fish (*mam*).
Meat/poultry/offal: buffalo, forest pig, frog, mice, pigs blood, snake, toad.
Eggs/milk: condensed milk.
Nuts/legumes/seeds: green beans, red beans, sesame.
Fruits/juice: dragon fruit, jack fruit, pineapple, forest fruits, *sims,* sour sop, tangerines.
Beverages/biscuits etc: forest tea leaves.

rainy season, when the surveys took place, acute respiratory infections were common. Access to clean water was a common problem and genital infections were widespread.

The women differed with respect to ethnic background. The study population in the Mekong Delta were all ethnic Vietnamese *(Kinh)* while in the Central Highlands villages, 43% were *Kinh,* 29% Ca–Tu and 28% Pa–Ko. Sociocultural differences between the ethnic groups are reflected in several parameters including weight, height and anthropometric status (Table 1a,b). The Mekong Delta population was taller and heavier, had a higher mean BMI and a higher proportion of overweight women (nearly 9% with BMI >25). Within the Central Highlands group, Pa–Ko and Ca–Tu women were significantly shorter and had lower mean BMI, 15.4 and 17.2, respectively, than *Kinh* women (BMI 19.2). Overall, the Central Highlands population had a higher proportion of chronically undernourished women, with 18% falling below a BMI <18.5, the cut-off point used by WHO.

In the Mekong Delta, where the health survey included blood samples, 36% had Hb values < 120 g/L of which 11% were < 110 g/L (Table 3). The mean serum retinol value was 42 mg/100 mL, which compares well to the mean values of 40 mg/100 mL reported in Vietnam, but is lower than the international norm (60 mg/100 mL). Mean serum ferritin levels were 137 ng/mL and 15% had values less than 30 ng/mL, indicating iron depletion. The retinol-binding protein value was 21 mg/L and 18% were below the normal range of 17–44 mg/L used by the International Vitamin A Consultative Group (IVACG). The CRP levels indicated that approximately 9% of the women had acute infections.

Food variety and diet diversity

Over 120 different food items were registered in the 7dFFQ. The FVS for individual women ranged from six to 39. There was no significant difference between the regions in the mean FVS, which was 20 for the Mekong Delta and 18 for the Central Highlands (Table 1). The number of food groups (DDS) ranged from a low of five to 11, with a mean DDS of 8 in the Mekong Delta, and 9 in the Central Highlands, a difference that was significant at the 0.01 level. Within the Central Highlands population, women from the two minority groups had significantly lower mean DDS than the ethnic Vietnamese (*P*-value < 0.001).

The food items and the food categories reported by the women (Table 2) showed that the majority of women had a rice/tuber or root-based diet supplemented with fish, vegetables, fruits and fish-sauce or soy sauce. More than two-thirds had eaten some meat, mostly pork or poultry, during the week of investigation. In the Mekong Delta, all women had consumed either fish, meat or eggs during the period, but in the Central Highlands 12% had not included animal products other than lard in their diet. In both regions more than two-thirds used fats/oil in the food preparation, but in small quantities. Some food items were very specific for each region, notably the many species of wild vegetables in both regions and the use of cassava in the highlands, especially among the minority groups. The variety of fish and other aquatic species was especially wide in the Mekong Delta population and the mean number of species eaten was also significantly higher.

Table 3. Selected biochemical parameters

Parameters	Mekong Delta population (n = 93)
Haemoglobin* (g/L)	122 ± 12.8
Serum retinol (μg/100mL)	42.0 ± 12.8
CRP†	8.7 ± 5.2
RBP‡ (mg/L)	20.8 ± 5.2
Serum ferritin (ng/mL)	137 ± 135

* Haemoglobin 11% had values <110; †C-reactive protein (CRP) 9% had values ≥ 10; ‡RBP, retinol-binding protein.

The greatest diversity was recorded in the food category of vegetables. Altogether, 62 species of vegetables were reported in the 7dFFQ, but only approximately half of these were cultivated. Only 5% of the women did not consume any wild vegetables at all compared with 17% who did not report the use of cultivated vegetables. Most of the wild species were leafy vegetables, while the cultivated vegetables were a more diverse group including vegetable fruits, bulbs, tubers/roots, flowers, shoots and seeds. The mean overall consumption of vegetable species was five, and of these the mean number of wild species was three. There was no significant difference between the regions in the number of vegetables consumed, but relatively few vegetable species were widely used in both regions.

Food variety and nutrient intake

Nutrient intakes in the groups with the highest food variety score (high FVS = ≥ 21) in the two regions are compared to those with the lowest food variety score (low FVS = ≤15) in Table 4. In the Mekong Delta, women in the high FVS group had significantly higher mean energy intakes, as well as higher mean intakes of all analysed nutrients than the low FVS group (*P*-value < 0.01 for energy, protein, calcium and zinc, *P*-value < 0.001 for all others). In the Central Highlands, the difference between the high and low FVS group was also significant for energy and thiamine ($P < 0.05$), protein, fats and niacin ($P < 0.001$), but non-significant for other nutrients.

The high FVS groups in both regions consumed a significantly higher variety of foods of most food categories. Observations at the food group level (DDS) showed that only 5% of the women had a DDS of ≤ five food groups. Those who had a DDS of ≥ eight had significantly higher mean adequacy ratios for energy, protein, niacin, vitamin C and zinc.

Food variety and nutrient density

Interesting differences were observed between the low FVS and high FVS groups in nutrient density; that is, the nutrient concentration relative to energy. The high FVS groups had relatively lower intakes of carbohydrates (– 8 and – 14%, in the Mekong Delta and the Central Highlands, respectively) and significantly higher intakes of fats; that is, + 5 and + 6 energy per cent (E%), in the two regions, respectively. The high FVS group in the Central Highlands also had a relatively higher protein E%, 11 compared to 8 protein E% in the low FVS group. Differences in nutrient density in the diets of the low FVS and high FVS groups are illustrated in Fig. 1. Of interest here is that the high FVS group in the Mekong Delta generally had a higher nutrient density in their diet, while the high FVS group in the Central Highlands had relatively lower concentrations of vitamin C, riboflavin and iron than the low FVS group.

Table 4a. Food variety and nutrient intake: a comparison between the groups with lowest and highest food variety

Nutrients	Mekong Delta Lowest tertile FVS* (n = 30) Mean ± SD	Mekong Delta Highest tertile FVS* (n = 34) Mean ± SD	Central Highlands Lowest tertile FVS* (n = 41) Mean ± SD	Central Highlands Highest tertile FVS* (n = 29) Mean ± SD
Total energy (MJ/day)	8.5 ± 2.4	10.1 ± 4.8[b]	8.2 ± 2.4	9.3 ± 2.1[a]
CHO (g)	395 ± 118	433 ± 137	409	410
Protein (g)	66 ± 20	81 ± 23[b]	37 ± 15	60 ± 17[c]
Protein (E%)	13	13	8	11
Fat (g)	15 ± 7	32 ± 16[c]	15 ± 14	32 ± 15[c]
Fat (E%)	7	12	7	13
Calcium (mg)	592 ± 217	857 ± 498[b]	515 ± 219	577 ± 320
Iron (mg)	13.2 ± 4.3	17.4 ± 5.0[b]	15 ± 5.9	16 ± 3.7
Zinc (mg)	8.5 ± 3.0	10.6 ± 3.9[a]	11.1 ± 5.2	12.7 ± 5.3
Vitamin A (µg)**	189 ± 202	557 ± 427[c]	320 ± 265	360 ± 213
Thiamine (mg)	0.9 ± 0.3	1.4 ± 0.4[c]	1.1 ± 0.4	1.2 ± 0.3[a]
Riboflavin (mg)	0.5 ± 0.2	0.9 ± 0.3[c]	0.9 ± 0.5	0.9 ± 0.3
Niacin (mg)	12.5 ± 3.7	17.0 ± 4.9[c]	12.4 ± 4.3	15.6 ± 3.8[b]
Folate (mg)	210 ± 91	354 ± 179[c]	570 ± 388	452 ± 242
Vitamin C (mg)	60 ± 45	159 ± 93[c]	376 ± 278	282 ± 148

* Lowest food variety tertile = FVS ≤ 15, highest food variety tertile = FVS ≥ 21–39. ** Calculated retinol +1/26 carotene for wild vegetables and 1/12 carotene for other.
Statistical significance (Student's t-test): [a] 0.05 > P > 0.01, [b] 0.01 > P > 0.001, [c] P < 0.001. CHO, cholesterol; FVS, food variety score.

Table 4b. Ethnic variation in food variety score and nutrient intake in the Central Highlands population

Nutrients	Ethnic group: Kinh (n = 44) Mean ± SD	Pa–Ko (n = 29) Mean ± SD	Ca–Tu (n = 30) Mean ± SD
Total energy (MJ/day)	8.7 ± 2.3	9.5 ± 2.2	7.4 ± 1.9***
CHO (g)	384 ± 120	456 ± 123**	359 ± 92*
Protein (g)	53 ± 15	44 ± 16*	38 ± 19***
Protein (E%)	10.3	7.8	8.6
Fat (g)	30 ± 14	20 ± 29	14 ± 14***
Fat (E%)	13.1	8.0	7.1
Calcium (mg)	431 ± 158	718 ± 365	562 ± 331
Iron (mg)	12.5 ± 3.9	19.0 ± 4.9***	15.1 ± 4.4**
Zinc (mg)	11.9 ± 5.5	15.3 ± 6.4	8.3 ± 2.8***
Vitamin A RE (µg)[1]	312 ± 202	417 ± 255	438 ± 351
Thiamine (mg)	0.98 ± 0.27***	1.4 ± 0.33***	1.1 ± 0.37***
Riboflavin (mg)	0.75 ± 0.35	1.24 ± 0.39***	0.75 ± 0.36***
Niacin (mg)	13.2 ± 3.4***	16.8 ± 3.9	11.25 ± 3.3***
Folate (mg)	407 ± 236	811 ± 325***	347 ± 187***
Vitamin C (mg)	201 ± 128	511 ± 196***	302 ± 149***

[1] Calculated retinol +1/26 carotene for wild vegetables and 1/12 carotene for other. Statistical significance (Student's t-test): *0.05 > P > 0.01, **0.01 > P > 0.001, ***P < 0.000. CHO, carbohydrate.

Sociocultural variation in food variety and nutrient intake

Within the Central Highland population there were significant differences between the ethnic groups in the mean energy and nutrient intakes (Table 4b). With the exception of protein and fats, Pa–Ko women had significantly higher intakes of all nutrients analysed. Ca–Tu women had the lowest energy intake, lowest intakes of protein, fats and B vitamins, while *Kinh* women had the lowest intakes of calcium, iron, vitamin A and vitamin C. Although the subgroups were small, a comparison was made between low FVS and high FVS groups within each ethnic subgroup (Table 4c). This indicated especially low protein E% among low FVS groups of Ca–Tu and Pa–Ko women (6.9 and 6.4 protein E%, respectively), as well as low fat E% (4.0 and 4.2 fat E%, respectively). With respect to minerals and vitamins, Pa–Ko women, however, even in the low FVS group had relatively high intakes. Pa–Ko women in both the low FVS and high FVS groups used similar quantities of wild vegetables, but the high FVS group used twice as many varieties.

Significance of wild vegetables

The nutrient contribution of wild vegetables to total micronutrient intakes in the two regions is illustrated in Fig. 2. The contribution was generally higher in the Mekong Delta population, but also in the Central Highlands wild vegetables were of substantial importance and heterogeneity. Some specific differences in the use of wild vegetables were observed among the three ethnic subgroups in the Central Highlands (Table 5), showing that wild vegetables were significantly more important to the Pa–Ko women than to the other two

Table 4c. Comparison between low FVS and high FVS groups in the Central Highlands population

Nutrients	Kinh (n = 44)		Pa–Ko (n = 29)		Ca–Tu (n = 30)	
	Low FVS[1] (n = 12)	High FVS[1] (n = 17)	Low FVS[1] (n = 14)	High FVS[1] (n = 5)	Low FVS[1] (n = 15)	High FVS[1] (n = 7)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Energy (MJ/day)	8.3	9.6	9.9	9.5	6.6	8.7
CHO (g)	369	420	515	410	341	385
Protein (g)	47	59*	38	65**	27	58**
Protein (E%)	9.6	10.3	6.4	11.5	6.9	11.2
Fat (g)	29	35	11	33***	7	24**
Fat (E%)	13.2	13.8	4.2	26	4.0	10.5
Calcium (mg)	388	486	723	537	423	828*
Iron (mg)	11	15**	21.3	16.7*	13.3	18.7*
Zinc (mg)	10.0	13.6	16.2	13.8	7.3	9.6
Vitamin A RE (μg)[2]	324	298	318	363	319	508
Thiamine (mg)	0.87	1.12*	1.48	1.36	0.8	1.5***
Riboflavin (mg)	0.71	0.84	1.26	1.04	0.6	0.9*
Niacin (mg)	11.9	15.0*	16.6	19.2	9.0	14.5***
Folate (mg)	409	443	973	607*	322	361
Vitamin C (mg)	181	245	624	336***	301	334
Wild veg. (no.)	2	4	3	6***	2	4
Wild veg. (g)	52	100	185	180	71	90

[1] Lowest food variety tertile = FVS ≤15; highest food variety tertile = FVS ≥21–39. [2] Calculated retinol +1/26 carotene for wild vegetables (veg.) and 1/12 carotene for other.
Statistical significance (Student's t-test): *0.05 > P > 0.01, **0.01 > P > 0.001, ***P < 0.000. CHO, carbohydrate; FVS, food variety score.

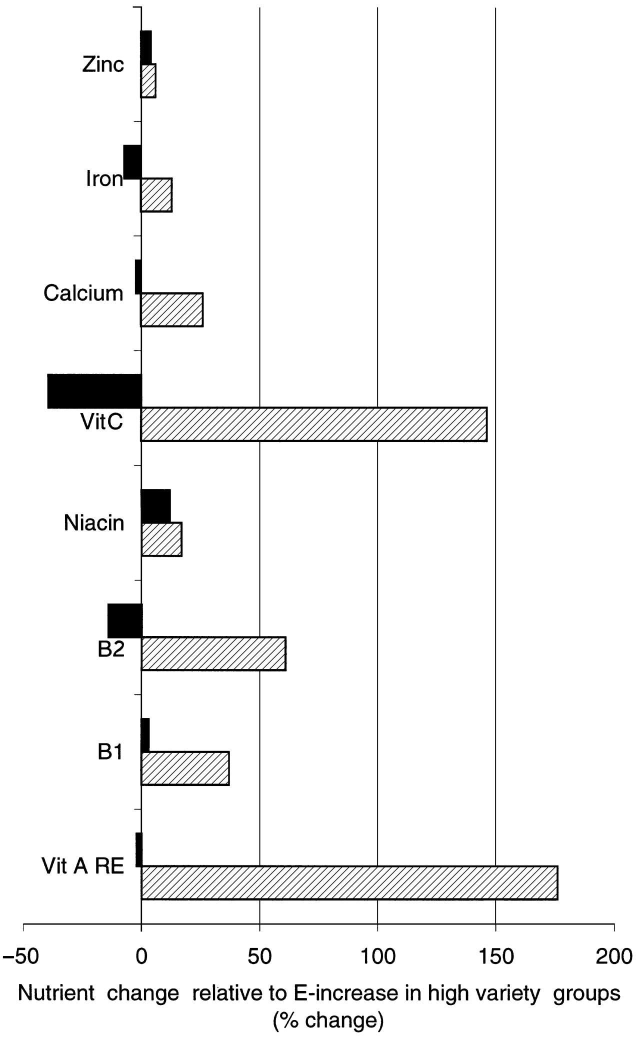

Figure 1. Food variety and nutrient density: a comparison of Mekong Delta and Central Highlands. (■), Central Highlands; (▨), Mekong.

groups. Pa–Ko women, who consumed proportionally a greater variety and larger quantities of wild vegetables, also had significantly higher proportions of their iron and carotene intakes from wild vegetables (0.05 > P < 0.001).

In both regions the high FVS groups used a significantly greater variety of vegetables, including wild vegetables, than the low FVS groups (Table 6, Table 4c). In the Mekong Delta, the high FVS group also consumed larger quantities of vegetables including wild vegetables (0.05 > P < 0.01). In contrast, the high FVS group in the Central Highlands used less vegetables and less wild vegetables, but the difference was not significant. In both regions the relative proportion of nutrients from wild vegetables was significantly higher only for carotene (P < 0.03). In both regions older women consumed a larger variety of wild vegetables than did the younger women (P < 0.02).

Within the diverse group of wild vegetables we also analysed the relative importance of more widely used species. For each region we selected the species used by more than 20% of the women to determine their share in overall micronutrient contribution from wild vegetables. The result is presented in Fig. 2, illustrating that there was a considerable difference between the regions also in the proportional role of 'major wild species'.

Food variety, health and nutrition status

The analysis between food variety and selected health/nutrition status parameters indicated that the associations were weak. There was a correlation between Hb status (P < 0.01), serum retinol status (P < 0.02) and variety of wild vegetables consumed, but no significant association to other blood parameters or to BMI.

Discussion

In the context of rural communities in Vietnam, our data show that a food variety analysis can be a useful predictor of

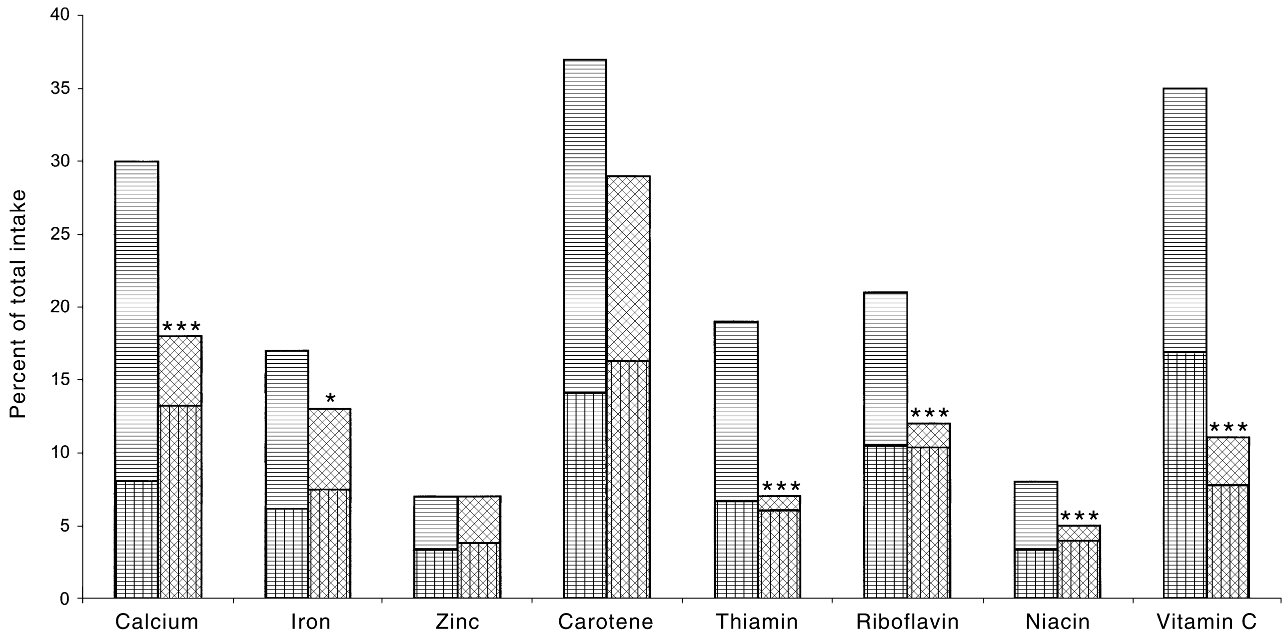

Figure 2. Nutrient contribution from wild vegetables. (▤) and (▥)Mekong Delta; (▥) and (▩), Central Highlands. The lower parts of all columns indicate the proportion of the wild vegetable contribution that comes from the major wild species listed. From major species: species from Table 2 analysed as 'major wild vegetables'. Mekong Delta: *Ipomoea aquatica*, *Centella asiatica*, *Eleocharis dulcis*, *Sauropus androgynus*, *Limnocharis flara*, *Nymphea lotus* and *Commelina communis.* Central Highland: *Centella asiatica*, *Nasturdium officinale*, *Homalomena occulta*, *Houttuynia cordata*, *Basella rubra*, *Polygonum odorum* and *Schisotachyum aviculare.* Statistical significance (Student's *t*-test): *0.05 > *P* 0.01, ****P* <0.001.

Table 5. A subgroup analysis of the Central Highlands population

Parameter/ethnic group	Kinh (*n* = 44)	Pa–Ko (*n* = 29)	Ca–Tu (*n* = 30)
Wild vegetables, % of total quantity of vegetables	35	49*	35
No. wild vegetables	2	4***	2
Wild vegetables (g)	71	204**	76
Major wild vegetables (g)	53	120**	60

Statistical significance (Student's *t*-test): *0.05>*P*>0.01, **0.01>*P*>0.001, ****P* <0.000.

Table 6. A comparison between the groups with lowest and highest food variety

	Mekong Delta		Central Highlands	
Parameter	Low FVS[1] (*n* = 30)	High FVS[1] (*n* = 34)	Low FVS[1] (*n* = 41)	High FVS[1] (*n* = 29)
Vegetables, total no.	3	8**	4	7**
Wild vegetables, no.	2	4**	2	4**
Total vegetables (g)	182	320**	248	234
Wild vegetables (g)	142	203*	104	110
Major wild vegetables (g)	131	186	72	64

[1] Lowest food variety tertile = FVS ≤15; highest food variety tertile = FVS ≥21–39. Statistical significance (Student's *t*-test): *0.05>*P* >0.01, ***P*<0.000. FVS, food variety score.

nutrient intake and nutrient adequacy. The nutrient adequacy ratios were closely related to the food variety score, and women in the high FVS group had diets that were fairly adequate for most of the analysed nutrients (Table 4a). The exception was the low iron and riboflavin intake in both regions (in the Central Highland region also vitamin A intake), even in the high FVS groups. There are no established levels for 'cut-off points' for food variety adequacy or for food group adequacy. Hatloy *et al.* have suggested that a FVS of at least 20 items and a DDS of at least five food groups were necessary for an overall nutrient adequacy ratio of 0.75 RDA.[5] This agrees fairly well with our analysis where the high FVS group had intakes of 21–39 food items. As only 5% of the women had used less than five food categories we did not explore the usefulness of the DDS analysis further.

With respect to the significance of wild vegetables, there are several important observations in our study. First, the analysis shows that wild vegetables contribute significantly to the overall micronutrient intake (Fig. 2). Secondly, the complexity and site specificity in their consumption cannot be ignored. Several important differences between sites and sociocultural backgrounds emerged in our analysis, for example the greater variety of wild vegetables consumed by the high FVS groups and the variation between regions in the contribution of the 'major species'. The analysis of the Central Highlands population shows that within the same villages there can be major ethnic differences in the nutritional significance of wild foods. Overall, it signals the need to pay greater attention to local and cultural variations in the use of wild vegetables.

In both regions we found the use of a greater variety of wild vegetables parallel to a higher dietary diversity in general in the high FVS groups. This shows that wild edible plants are well integrated in the farming systems and food systems, as proposed earlier.[32,33] It makes sense to rural women to continue to use them if it demands less labour and time than alternative procurement methods. For relatively poor households, it also makes economic sense to use gathered vegetables instead of market vegetables. Nutritional advantages of such local practices need to be taken more seriously also in dietary guidelines.

An important practical implication of our study is that we have shown that a food variety analysis can be used to capture the role of wild foods and that it is essential to pay attention to their contemporary use in nutrition and food security assessments. In situations where food composition data are limiting and socioeconomic conditions make it difficult to use standard dietary analysis, a rapid food variety analysis can be a useful tool to help identify individuals or groups with inadequate diets.

It is, however, also important to keep in mind some limitations in the use of food variety analysis. The basis for our dietary analysis was a simple 7dFFQ relying on recall methodology and household measures. Weaknesses in recall methodologies are well known and further accentuated in combination with limited food composition data.[34] The biochemical and health parameters that we tested had no strong association with food variety. This may partly be due to such weaknesses in the dietary assessment methodologies.

Overall, however, our study confirms that it is possible to predict nutrient adequacy fairly well through a food variety analysis also in diverse agro-ecological and sociocultural settings such as our study areas. It is a useful tool for broader studies of food security and nutrition where it can capture the significance of neglected foods such as wild vegetables.

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