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Traditional food diversity predicts dietary quality for the Awajún in the Peruvian Amazon

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Abstract

Objective: Our goal was to assess the potential for evaluating strengths of the Awajún traditional food system using dietary assessment, a traditional food diversity score and ranking of local foods.
Design: The method was used for dietary data obtained from mothers and children in the Awajún culture of the Peruvian Amazon where >90% of the dietary energy is derived from local, traditional food. Traditional food diversity scores were calculated from repeat 24-hour recalls. Group mean intakes of energy, fat, protein, iron, vitamin A and vitamin C from each food item were used to rank foods by nutrient contribution.
Setting: The study took place in six remote communities along the lower Cenepa River in the Amazonas District of Peru, South America.
Subjects: Dietary data were collected from 49 Awajún mothers and 34 children aged 3–6 years, representative of the six communities.
Results: Higher traditional food diversity was associated with greater protein, fibre, vitamin and mineral intakes when controlling for energy (partial correlations = 0.37 to 0.64). Unique sources for iron, total vitamin A and vitamin C were found in the Awajún traditional food system.
Conclusions: A traditional food diversity score was a useful tool for predicting nutrient adequacy for the Awajún. Promotion of the Awajún traditional food system should focus on dietary diversity and unique nutrient-dense local foods.

Keywords
Dietary diversity
Indigenous peoples
Traditional food
Indigenous food
Amazon
Aguaruna
Awajún

A traditional food system of indigenous peoples is defined as being comprised of all acceptable foods provided by the natural resources of a particular cultural group; this can include indigenous and introduced cultivated plants and animals[1]. In addition to supporting health, being affordable and often protective of the ecosystem, traditional food systems contain great cultural value for indigenous peoples[2]. To promote and protect the traditional food systems of indigenous peoples, local resources must be understood, with a need to document food diversity and understand its relationship to the health of communities[3].

Dietary diversity is often promoted in guidelines for healthy diets[4]. It can simply be defined as the number of unique foods, species or food groups within an individual or group diet. This measure of variety is usually calculated by a simple count of unique foods or food groups consumed over a given reference period[5], with reference periods ranging from 1 to 15 days[6]. Recent studies aimed at validating dietary diversity against nutrient adequacy in developing countries[7–9] have shown a positive relationship that has been documented in industrialised nations[10]. When there are difficulties in calculating individual intakes due to shared meals or lack of specific nutrient data for local foods, a dietary diversity score calculated from a dietary recall may be an appropriate predictor for evaluating dietary adequacy[8].

The Awajún† live in the remote hills of the northwestern Amazon of Peru, subsisting on a cassava-based diet complemented by hunting, gathering and fishing[11]. In a nutritional anthropology study reported in 1977, Berlin and Markell reported a generally healthy population (good nutritional status) with an adequate household

† Awajún is the preferred identity for this group of Indigenous People, who are also known as the Aguaruna.

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food intake[11]. Here we report dietary research with the Awajún thirty years later, and explore the relationship between dietary diversity of traditional foods and nutrient adequacy. We highlight unique local foods for Awajún women and children living in several communities near the Rio (River) Cenepa.

Methods

Study communities

The study took place in six communities in the lower Cenepa River area in the Amazonas District of Peru, South America: Cocoaushi [Annex of Wawaim (638 people, 101 families)], Mamayaque (350 people, 65 families), Nuevo Tutino (110 people, 22 families), Tuutin (350 people, 61 families), Pagki (60 people, 10 families) and Nuevo Kanam [Annex of Tuutin (217 people, 47 families)][12]. The study took place during the months of April and May 2004, known by the Awajún as the season of heavy rains and scarce fishing. Key informant interviews and focus groups established the list of traditional foods, and their pattern of use, that formed the basis of development of a food composition table for the area. All women with children 3–6 years of age were invited to participate in the study. Usually, there was one woman per household, and when there were two or more children between 3 and 6 years old, one child was randomly selected. Participation rates were approximately 80%. Lack of time for the study and scepticism towards it, as well as the need to care for a family member, were given as reasons for not participating. Follow-up with non-participants by an Awajún community health promoter indicated no obvious participation bias, and the final sample was judged to be representative of the communities in terms of livelihoods and family structure.

Dietary recalls

From March to April 2004, two standardised 24-hour dietary recalls were obtained from each of 49 mothers and 34 children with a separation of 3–4 days between repeat recalls[13]. The interviewers were trained and they were assisted by an Awajún interpreter. To improve quality of dietary recalls[14], several samples of cassava (*Manihot esculenta*), *sachapapa* (*Dioscorea trifida*), bananas and plantains with known weights were used as references during interviews. Cups, plates and bowls, and *pinig* (bowl for drinking) found in the communities were also used as references for quantifying food consumption. Community focus groups helped establish local portion sizes, preparation methods and cultural acceptability of food. Mothers reported foods consumed for themselves and for their children.

Dietary recall data were reviewed and checked for accuracy, and food codes were added that corresponded to the Instituto de Investigación Nutricional (IIN) food composition table of (raw) Peruvian foods. With respect to the vitamin A content of foods, the Peruvian food composition table used retinol equivalents (RE) at the time of this study; 11 food items were added from other tables using the international literature for food composition[15–18]. Information from the Peruvian food composition tables or the nutrient labels was taken at the time of the study for the small number of foods imported into these communities.

Daily total intake for each nutrient for each individual was obtained by averaging the two 24-hour recalls from non-consecutive days. No adjustments for bioavailability of nutrients were made as this was unknown for most of these foods.

Traditional food diversity

A traditional food diversity score (TFDS) was calculated by assigning a 1 point value to each unique local food in the diet reported in the two 24-hour recalls, and an individual's TFDS was the sum of points given. These traditional food items included all foods obtained through cultivating, hunting, gathering, fishing and raising animals. An individual's TFDS was then related to the mean daily nutrient intake calculated from the two 24-hour recalls using partial correlations controlling for energy intake of the women and children. Statistical analysis was performed with SPSS 11.0 for Windows (SPSS Inc., 2001).

Nutrient contributions of local foods

The 10 most significant contributors of overall energy, protein and fat, total iron, vitamin C and vitamin A (RE) were determined by ranking the mean amount of nutrient provided. Ranks were made independently for mothers' and children's diets.

Ethics

Ethics approval was given by the Faculty of Agricultural and Environmental Sciences Committee on Human Research Ethics at McGill University as well as from the Institutional Ethics Board for the IIN, in Lima, Peru. This study followed the guidelines for participatory health research with indigenous peoples established by the World Health Organization and the Centre for Indigenous Peoples' Nutrition and Environment (CINE)[19]. A community research agreement was in effect with the local village authority, the Organizacion de Desarrollo de las Communidades Fronterizas del Cenepa (ODECOFROC), the IIN and CINE. Verbal informed consent was obtained from mothers for both themselves and their children.

Results

Traditional food diversity

The TFDS ranged from 2 to 20 for the women, with a median of 9 and a mean (±standard deviation, SD) of 9.5 ± 3.5. For children the TFDS ranged from 2 to 17 with a median of 8 and mean (±SD) of 8.7 ± 3.6. Higher TFDS was correlated with higher nutrient intakes for many vitamins and minerals for both women and children (Table 1). Greater TFDS was associated with higher dietary protein, fibre, iron, thiamin, riboflavin and vitamin A among women and children. Higher dietary calcium, phosphorus, niacin, vitamin C and folate were correlated with greater diversity scores for women (partial correlations = 0.37 to 0.64). There was no relationship between TFDS and total energy intake in either group.

Table 1 Partial correlation of traditional food diversity scores and nutrient intakes controlling for energy for Rio Cenepa Awajún women and children

Nutrient	Women ($n = 49$)	Children ($n = 35$)
Protein	0.44**	0.53**
Fat	0.31 ($P = 0.30$)	0.18 ($P = 0.30$)
Fibre	0.66**	0.37*
Calcium	0.51**	0.30 ($P = 0.08$)
Phosphorus	0.47**	0.29 ($P = 0.09$)
Iron	0.49**	0.39*
Zinc	0.20 ($P = 0.16$)	0.25 ($P = 0.16$)
Thiamin	0.62**	0.64**
Riboflavin	0.49**	0.38*
Niacin	0.38**	0.20 ($P = 0.29$)
Vitamin C	0.40**	0.26 ($P = 0.13$)
Folate	0.38**	0.17 ($P = 0.35$)
Total vitamin A	0.43**	0.42*

*$P < 0.05$ (two-tailed); **$P < 0.01$ (two-tailed).

Nutrient contributions of local foods

The high-dietary-energy sources of cassava, banana, *sachapapa* (a tuber) and *masato* (thick traditional beverage made from pre-masticated cassava) were consumed daily in the research period by the majority of the population in large amounts (daily average consumption of over 1.0 kg of cassava by women and 0.65 kg by children) (Table 2) and consequently provided substantial nutrients. More nutrient-dense foods were successful in providing protein, fat, vitamins A and C, iron and zinc to the population, even though consumed in smaller portions by fewer individuals (Tables 3–7). This is highlighted by locally grown raw peanuts which were consumed in average amounts of 163 ± 145 g by five women (Table 4) and 116 ± 107 g by five children, yet provided twice the fat for women and five times the fat for children in comparison with cassava, consumed in average amounts of 1271 ± 879 g by all 49 women and 647 ± 504 g by all 35 children. The rank orders of the top

Table 2 Top 10 foods contributing energy for Rio Cenepa Awajún women and children

Women ($n = 49$)

Food	Total population/mean ± SD individual daily energy (kcal)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 98] (no. of women)
Cassava	95 806/1955 ± 1094	1271 ± 879	93 (49)
Banana	14 348/359 ± 310	629 ± 439	55 (40)
Masato	9572/309 ± 217	1176 ± 669	44 (31)
Sachapapa	8918/594 ± 527	838 ± 790	19 (15)
Plantain	6987/279 ± 175	340 ± 205	27 (25)
Sugar cane	3827/201 ± 214	406 ± 327	23 (19)
Raw peanuts	3187/637 ± 520	163 ± 145	7 (5)
White rice	3133/285 ± 154	134 ± 61	13 (11)
Peach palm *masato*	2763/395 ± 459	1470 ± 1790	8 (7)
Taro	2518/280 ± 150	548 ± 295	9 (9)

Children ($n = 35$)

Food	Total population/mean ± SD individual daily energy (kcal)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 70] (no. of children)
Cassava	33 558/959 ± 627	647 ± 504	64 (35)
Banana	9865/318 ± 247	495 ± 365	48 (31)
Sachapapa	8702/669 ± 720	863 ± 983	18 (13)
White rice	5136/321 ± 211	130 ± 65	22 (16)
Plantain	4639/258 ± 181	291 ± 193	21 (18)
Masato	3157/158 ± 79	569 ± 262	30 (20)
Raw peanuts	2595/519 ± 400	116 ± 107	8 (5)
Yellow beans	2124/177 ± 89	80 ± 31	16 (12)
Taro	2022/337 ± 328	566 ± 600	7 (6)
Sweet potato	1751/583 ± 571	755 ± 916	4 (3)

SD – standard deviation.
† Means calculated using as *n* the number of women or children who consumed the food (no. of women or children).

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Table 3 Top 10 foods contributing protein for Rio Cenepa Awajún women and children

Women (*n* = 49)

Food	Total population/mean ± SD individual daily protein (g)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 98] (no. of women)
Cassava	473/10 ± 5	1271 ± 879	93 (49)
Armadillo	261/29 ± 14	180 ± 104	10 (9)
Banana	260/7 ± 5	629 ± 439	55 (40)
Chicken	159/17 ± 9	174 ± 88	14 (14)
Sachapapa	144/10 ± 8	838 ± 790	19 (15)
Raw peanuts	138/27 ± 22	163 ± 145	7 (5)
Turkey	124/41 ± 28	164 ± 61	4 (3)
Evaporated milk	101/8 ± 4	191 ± 175	15 (8)
Palm heart	79/7 ± 7	387 ± 420	14 (13)
White rice	65/7 ± 4	134 ± 61	13 (11)

Children (*n* = 35)

Food	Total population/mean ± SD individual daily protein (g)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 70] (no. of children)
Banana	179/6 ± 4	495 ± 365	48 (31)
Cassava	166/5 ± 3	647 ± 504	64 (35)
Yellow beans	145/12 ± 6	80 ± 31	16 (12)
Sachapapa	140/11 ± 12	863 ± 983	18 (13)
White rice	118/7 ± 5	130 ± 65	22 (16)
Raw peanuts	112/22 ± 17	116 ± 107	8 (5)
Chicken	95/11 ± 6	109 ± 47	13 (10)
Turkey	91/30 ± 25	208 ± 146	4 (3)
Evaporated milk	82/7 ± 7	279 ± 212	10 (10)
Palm heart	58/5 ± 6	282 ± 325	12 (12)

SD – standard deviation.
† Means calculated using as *n* the number of women or children who consumed the food (no. of women or children).

Table 4 Top 10 foods contributing fat for Rio Cenepa Awajún women and children

Women (*n* = 49)

Food	Total population/mean ± SD individual daily fat (g)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 98] (no. of women)
Raw peanuts	275/55 ± 45	163 ± 145	7 (5)
Macambo seeds	188/23 ± 24	69 ± 77	10 (8)
Evaporated milk	125/9 ± 4	191 ± 175	15 (8)
Sachapapa	120/8 ± 7	838 ± 790	19 (15)
Cassava	119/3 ± 1	1271 ± 879	93 (49)
Chicken	113/13 ± 7	174 ± 88	14 (14)
Sachamango	78/17 ± 7	171 ± 79	5 (5)
Turkey	71/6 ± 4	164 ± 61	4 (3)
Banana	52/1 ± 1	629 ± 439	55 (40)
Armadillo	49/5 ± 3	180 ± 104	10 (9)

Children (*n* = 35)

Food	Total population/mean ± SD individual daily fat (g)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 70] (no. of children)
Raw peanuts	224/45 ± 35	116 ± 107	8 (5)
Sachapapa	117/9 ± 10	863 ± 983	18 (13)
Evaporated milk	97/8 ± 7	279 ± 212	10 (10)
Macambo seeds	93/23 ± 19	68 ± 41	5 (4)
Chicken	87/12 ± 7	109 ± 47	13 (10)
Sachamango	80/13 ± 10	125 ± 84	7 (6)
Cassava	42/1 ± 1	647 ± 504	64 (35)
Canned tuna	37/3 ± 1	19 ± 8	19 (13)
Banana	36/1 ± 1	495 ± 365	48 (31)
Suri	29/7 ± 3	38 ± 15	4 (4)

SD – standard deviation.
† Means calculated using as *n* the number of women or children who consumed the food (no. of women or children).

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Table 5 Top 10 foods contributing iron for Rio Cenepa Awajún women and children

Women ($n = 49$)

Food	Total population/mean ± SD individual daily iron (mg)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 98] (no. of women)
Cassava	296/6 ± 3	1271 ± 879	93 (49)
Masato	155/5 ± 4	1176 ± 669	44 (31)
Banana	104/3 ± 2	629 ± 439	55 (40)
Armadillo	98/11 ± 5	180 ± 104	10 (9)
Sachapapa	56/4 ± 3	838 ± 790	19 (15)
Maca	52/52	356	1 (1)
Palm heart	46/4 ± 4	387 ± 420	14 (13)
Agouti	41/8 ± 1	116 ± 17	5 (5)
Sugar cane	33/2 ± 2	406 ± 327	23 (19)
Taro	30/3 ± 2	548 ± 295	9 (9)

Children ($n = 35$)

Food	Total population/mean ± SD individual daily iron (mg)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 70] (no. of children)
Cassava	104/3 ± 2	647 ± 504	64 (35)
Banana	72/2 ± 2	495 ± 365	48 (31)
Sachapapa	55/4 ± 5	863 ± 983	18 (13)
Masato	51/3 ± 1	569 ± 262	30 (20)
Yellow beans	49/4 ± 2	80 ± 31	16 (12)
Palm heart	29/2 ± 3	282 ± 325	12 (12)
Taro	24/4 ± 4	566 ± 600	7 (6)
Cocona	17/2 ± 2	151 ± 164	15 (11)
Suri	16/4 ± 2	38 ± 15	4 (4)
Plantain	15/1 ± 1	291 ± 193	21 (18)

SD – standard deviation.
† Means calculated using as *n* the number of women or children who consumed the food (no. of women or children).

Table 6 Top 10 foods contributing vitamin C for Rio Cenepa Awajún women and children

Women ($n = 49$)

Food	Total population/mean ± SD individual daily vitamin C (mg)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 98] (no. of women)
Cassava	18 156/371 ± 207	1271 ± 879	93 (49)
Papaya	1650/115 ± 93	629 ± 351	11 (10)
Masato	1087/35 ± 25	1176 ± 669	44 (31)
Orange	952/119 ± 105	229 ± 125	9 (8)
Banana	744/19 ± 16	629 ± 439	55 (40)
Plantain	478/19 ± 12	340 ± 205	27 (25)
Cassava leaves	421/140 ± 59	97 ± 40	3 (3)
Peach palm *masato*	288/41 ± 48	1470 ± 1790	8 (7)
Eep‡	260/37 ± 39	22 ± 26	8 (7)
Sachapapa	247/16 ± 15	838 ± 790	19 (15)

Children ($n = 35$)

Food	Total population/mean ± SD individual daily vitamin C (mg)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 70] (no. of children)
Cassava	6360/182 ± 119	647 ± 504	64 (35)
Orange	981/196 ± 139	266 ± 162	8 (5)
Papaya	851/142 ± 109	510 ± 395	7 (6)
Banana	511/16 ± 13	495 ± 365	48 (31)
Masato	359/18 ± 9	569 ± 262	30 (20)
Plantain	318/18 ± 12	291 ± 193	21 (18)
Sachapapa	241/19 ± 20	863 ± 983	18 (13)
Sweet potato	151/50 ± 49	755 ± 916	4 (3)
Sachamango	121/20 ± 15	125 ± 84	7 (6)
Coco fruit	118/39 ± 22	66 ± 44	4 (3)

SD – standard deviation.
† Means calculated using as *n* the number of women or children who consumed the food (no. of women or children).
‡ *Eep* is a term to describe all green leaves (e.g. family Aracaceae, genus *Philodendron*).

Table 7 Top 10 foods contributing total vitamin A for Rio Cenepa Awajún women and children

Women ($n = 49$)

Food	Total population/mean ± SD individual daily vitamin A (μg RE)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 98] (no. of women)
Agouti	13 005/2601 ± 398	116 ± 17	5 (5)
Peach palm *masato*	11 581/1654 ± 1925	1470 ± 1790	8 (7)
Sweet potato	11 223/2245 ± 2512	618 ± 754	6 (5)
Paca	6908/1151 ± 736	51 ± 33	6 (6)
Plantain	5823/233 ± 146	340 ± 205	27 (25)
Collared peccary	3240/1620 ± 1527	48 ± 46	3 (2)
Evaporated milk	2087/58 ± 30	191 ± 175	15 (8)
Armadillo	2020/224 ± 108	180 ± 104	10 (9)
Banana	1729/43 ± 37	629 ± 439	55 (40)
Peach palm fruit	1507/251 ± 232	308 ± 291	7 (6)

Children ($n = 35$)

Food	Total population/mean ± SD individual daily vitamin A (μg RE)†	Mean ± SD daily food consumption (g)†	Days in 24-hour recall [max 70] (no. of children)
Sweet potato	9130/3043 ± 2980	755 ± 916	4 (3)
Paca	3983/797 ± 565	35 ± 25	5 (5)
Plantain	3866/215 ± 150	291 ± 193	21 (18)
Agouti	3713/1238 ± 113	55 ± 5	3 (3)
Peach palm *masato*	3468/578 ± 614	587 ± 623	6 (6)
Evaporated milk	1710/448 ± 332	279 ± 212	10 (10)
Banana	1189/38 ± 30	495 ± 365	48 (31)
Chicken liver	1172/1172	69	1 (1)
Papaya	655/109 ± 84	510 ± 395	7 (6)
Chicken egg	607/67 ± 42	53 ± 25	12 (9)

SD – standard deviation; RE – retinol equivalents.
† Means calculated using as *n* the number of women or children who consumed the food (no. of women or children).

10 foods providing these nutrients for women and children are given in Tables 3–7. The amount of nutrients contributed (by those who consumed the food), the mean weight of food consumed and the frequency of reports in recalls emphasise the critical importance of these items to daily food intake and nutrition of Awajún women and children. Donated white rice, evaporated milk (not fortified), canned tuna (in oil), vegetable oil, dried yellow beans, oats and sugar (unfortified) were the only foods in these tables imported from outside sources.

Suri (larvae of the order Coleopterus) was the only animal source of iron which ranked in the top 10 for children, while agouti (*Dasyprocta aguti*; a small rodent) and armadillo (*Tolypeutes mataco*) ranked highly for women. *Maca* (orange tuber; *Lepidium peruvianum* Chacon) is the most iron-dense of the tubers and was the sixth greatest contributor of iron, yet was consumed by only one mother in a portion size of 356 g. In addition to dietary staples other sources of iron for women were sugar cane, taro (*Colocasia esculenta*) and palm heart. Several palms were harvested (e.g. *Bactris gasipaes*, *Astrocaryum chambira*, *Socratea exhorriza*, *Mauritia flexuosa* and *Euterpe precatoria*). Beans, plantain, palm heart, taro and cocona (*Solanum* spp.) provided iron for children. Vitamin A was provided mainly by non-staple sources including agouti, peach palm *masato* (thick traditional beverage made from pre-masticated peach palm fruit, *B. gasipaes*), sweet potato (*Ipomea batatas*), paca (*Cuniculus paca*) and armadillo for both groups, as well as collared peccary (*Tayassu tajacu*) for mothers and, for children, chicken liver, chicken egg and papaya (*Carica papaya*). In both groups, evaporated milk contributed to vitamin A intakes.

Government-donated foods including white rice, beans, evaporated milk, canned tuna, vegetable oil, oats and sugar provided energy and nutrients for both women and children; however, these nutrients were also available in frequently consumed local foods.

Discussion

The nutritional importance of traditional food diversity during the study season was demonstrated through the relationship of greater nutrient intakes with higher TFDS for women and children. Various studies around the world have found positive associations between dietary diversity and nutritional intake, including among women and men in rural western Mali[9], Korean adolescents[20], and 10- to 18-year-olds in Tehran[7] and urban Mali[8]. Most other food diversity studies have focused on overall dietary diversity, measured either by food groups or individual food items over a fixed period of time[5]. The TFDS was an appropriate measure for the Awajún perhaps because of the high traditional food content of

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the diet and the high quality of several of their traditional foods.

It has been suggested that caution must be taken in the promotion of dietary variety in some environments. The message of diversity could be wrongly interpreted and result in the consumption of many different low-nutrient-density inexpensive foods, perpetuating the nutrition transition and its health consequences[21]. As an increasing variety and quantity of market foods may become available in the Cenepa region, community groups and leaders should promote the production and consumption of diverse, local, micronutrient-dense cultural foods and ensure the quality of food imported to the area, rather than simply encouraging overall dietary diversity. The TFDS could be a useful tool for assessing dietary quality of the Awajún in response to health promotion focusing on dietary variety.

Assessment of the dietary quality for women and children in the lower Cenepa River region indicated adequate intakes of energy, protein, fat, iron, zinc, vitamin C and vitamin A for women and 3–6-year-old children for the study season (reported elsewhere)[22]. The dietary intakes appeared to be adequate in the population studied. However, a limitation of this study was that we were unable to observe or weigh precisely the amount of food consumed by each individual; thus there may have been overestimation of intake through dietary recall in some cases because food was served communally and not on individual plates, or children did not eat all they were served. Nevertheless, the overreporting was most likely to have influenced quantity but not variety or proportions; thus we consider the relationships between nutrient intakes and diversity of the diet to be valid[22]. Here we report that the traditional food system of the Awajún in lower Cenepa River region offered several unique nutrient-dense food sources contributing to overall dietary sufficiency. Raw peanuts (*Arachis hypogaeaa*) were important for energy, protein and fat, with a portion size a fraction of that of cassava. In addition to cassava, other important tubers contributing energy as well as nutrients were *sachapapa* (a tuber), taro and sweet potato. Along with staple bananas, a variety of fruits contributed to nutrient intake, including papaya, *sachamango* (*Grias peruviana*), cocoa fruit (*Theobroma cocoa*), *macambo* seeds (*Theobroma bicolor*), peach palm (*B. gasipaes*) and Mauritian palm fruit (*M. flexuosa*).

Palms proved to be of high dietary and cultural value. The Mauritian palm (*M. flexuosa*) fruit was very high in fat (25 g/100 g) and vitamin A (763 μg RE/100 g), in addition to being a modest source of calcium (74 mg/100 g). Peach palm (*B. gasipaes*) was also a good source of total vitamin A (140 μg RE/100 g), as well as a nutritious variation of typical cassava *masato* when prepared into peach palm *masato*[23]. The high carotene value of genus *Elaeis* palm fruits and red palm oil (6140 μg RE/100 g) has been recognised in food-based approaches to prevent hypovitaminosis A in diets emphasising tubers[24]. Palm heart was an important source of protein and iron; in addition, the palm tree provided thatch for housing[25].

The cultivation of palm trees is related to another culturally cherished food: *suri*. These larvae, each weighing approximately 12 g, are assumed to be high in protein (34 g/100 g), fat (39 g/100 g) and iron (21 mg) based on food composition for beetle larvae of the same order (Coleopterus)[26–28]. In 1987, Dufour studied insect consumption among the Tukanoan indigenous people of the Vaupes region of Colombia, and found these insects contributed to diet in amounts comparable with other animal foods. Men and women obtained as high as 12% and 26% respectively of their daily animal protein from insects[29]. Invertebrate consumption is part of the traditional food system of 32 other Amerindian groups in the Amazon basin[30].

Tukanoans included invertebrates in the diet seasonally and consumed greater quantities when fish and game were less available[29]. Unlike the Tukanoans, in the low fishing season invertebrates were not consumed in great quantities by the lower Cenepa Awajún. However, *suri* deserves attention as a means of local food security because of the cultural acceptability and high taste appeal among women and children[25]. Berlin and Markell (1977) reported that 58% of Awajún monthly dietary household protein came from fish[11], but this was a negligible source of dietary protein for our season of heavy rain and resulting high rivers for the Awajún, which hindered local fishing methods.

Wild game had great nutritional significance for the lower Cenepa Awajún. Armadillo provided a source of dietary iron, protein, fat, zinc and vitamin A, especially for women (29 g of protein, 5.4 g of fat, 10.9 g of iron and 225 μg RE/100 g)[18]. Other important game meats in the study were agouti, paca, coati (*Procyonidae nasua nasua*)[14] and collared peccary. The importance of wild meat as a source of food security and protein for people subsiding in tropical forests has been recognised[31].

Conclusions

The TFDS may prove useful in assessing and promoting the potential of traditional food systems of indigenous peoples throughout the world. The value of diversity in the traditional food system to meet the nutrient needs of Awajún living in the lower Cenepa River area was reported, with emphasis on unique nutrient-dense components of the food system. Using a traditional food diversity score calculated from repeat 24-hour recalls, we demonstrated that greater diversity was associated with higher intakes of dietary protein, fibre, iron, thiamin, riboflavin and vitamin A among women and children. In addition, higher dietary calcium, phosphorus, niacin, vitamin C and folate were correlated with greater diversity scores for women.

Unique animal and plant foods were identified that provided outstanding nutrients for the Awajún. This biodiversity should be protected and promoted to support the Awajún right to subsistence lifestyle and good health. Not only is traditional food nutritionally beneficial to indigenous peoples, access to these resources is also a human right[2]. We affirm the suggestion that 'to deny the right to food is to deny the collective indigenous existence'[2].

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