630 US ISSN 0197-9310 June 1984

Use of Tropical Vegetables to Improve Diets in the Pacific Region

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Research Series 028

HITAHR · College of Tropical Agriculture and Human Resources · University of Hawaii

Library of Congress Cataloging in Publication Data

Evensen, Stacy K. (Stacy Kanoelani),
Use of tropical vegetables to improve diets in the Pacific Region.

(Research series Hawaii Institute of Tropical Agriculture and Human Resources ;)
Bibliography: p.
1. Diet—Pacific Area. 2. Vegetables—Tropics.
3. Tropical crops—Pacific Area. I. Standal, Bluebell R. (Bluebell Reade). II. Title.
III. Series: Research series (Hawaii Institute of Tropical Agriculture and Human Resources);
TX360.P17E94 1983 641.3'5 83-18629

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Stacy K. Evensen
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ABSTRACT

The content of five essential nutrients (protein, calcium, iron, ascorbic acid, and vitamin A) and the caloric value of 11 temperate-zone vegetables and 11 tropical vegetables were compiled from data reported in earlier publications. The composition of amino acids and the content of oxalic acid (an antinutrient that binds calcium) of selected tropical and temperate-zone vegetables were compared. Recipes using tropical vegetables were developed incorporating various ethnic cooking methods and were taste-tested by a multi-ethnic group of men, women, and children. Finally, calculations of NDpCal% were made for each meal containing a temperate-zone vegetable and for the same meal with a tropical vegetable substituted. NDpCal% allowed for comparisons of protein-quality change when tropical vegetables replaced temperate-zone vegetables.

The findings of this study suggested that the tropical vegetables studied could supply more of the five essential nutrients than were available from the commonly eaten temperate-zone vegetables tested. Comparisons of amino acid scores and NDpCal% resulted in sets of values indicating higher protein quality for tropical vegetables. The problematic antinutrient oxalic acid was higher in tropical vegetables. Recipes using tropical vegetables were rated as appealing.

Keywords: tropical vegetables, nutrients, protein content, protein calories, protein quality, vitamins, minerals, tropical diets, diet quality, oxalic acid, calcium unavailability.

INTRODUCTION

Malnutrition is a problem of enormous proportions, affecting human resources, work performance, and the economic output of nations. The vast majority of people suffering from this health problem are concentrated in the developing countries, and more than 75 percent of them live in the tropics. It has been estimated that within these developing nations between 600 and 800 million people are suffering from malnutrition (*1*, *2*).

Many attempts have been made in the past to alleviate malnutrition through dietary improvement and increased food production. The "green revolution" introduced in the mid-1960s was one such attempt. This was a technological approach to increase yields of certain basic food crops. The green revolution was based on the production of high-yielding varieties (HYV) of crops, notably wheat and rice, developed through genetic manipulation and coupled with extensive use of water for crop irrigation, use of insecticides, herbicides, and fuels, and farmers' access to credit for buying necessary inputs such as fertilizer (*3*).

In certain regions of the world, the green revolution has increased the production of grains dramatically. Many problems were associated with this approach, however, both in consumer acceptance of the HYV grains and in the capital investment needed for their production. In certain Asian countries, the production of protein-rich legumes (beans and peas) declined in the past decade as farmers replaced these crops with the HYV grains. Although nutritious, these HYV grains were unfamiliar to farmers and were grown as a cash crop instead of being used to enrich their diet. Additionally, this capital-intensive method of farming was not feasible for most small farmers in places where the continual increase in oil prices has increased the price of fertilizer, making it almost impossible for small farmers to pay for it.

For reasons such as these, the green revolution has failed in many regions where malnutrition is most rampant. Agriculturists and nutritionists have, therefore, been forced to look elsewhere for a solution to the problem of feeding the hungry. Some researchers have become reacquainted with indigenous vegetables of the tropics, and studies indicate that many such vegetables may be good sources of needed nutrients.

A report by the National Academy of Sciences (*4*) described many plants that show promise for improving the quality of the diet in the tropics. Many of these tropical plants are, like the winged bean, indigenous to areas in the tropics, but they have never been fully exploited or thoroughly investigated. These vegetables, unlike the genetically manipulated HYV crops, are not new discoveries: they have been cultivated in backyard gardens of villages in many parts of the tropics for years. According to Masefield (*5*), the protein content of the mature winged bean rivals that of the soybean. Certainly, in tropical countries where malnutrition is most prominent, an indigenous vegetable such as the winged bean could make an important contribution to local diets. Martin and Ruberte indicated that certain edible tropical leaves showed promise as sources of protein (*6*) and vitamins and minerals (*7*).

Crops grown during the green revolution failed to solve the hunger problem partly because the unfamiliar taste and texture of foods prepared from them hindered dietary acceptance by local consumers. Indigenous tropical vegetables often have low prestige in many parts of the world since they are looked upon as "poor man's food" and as less desirable than the introduced vegetables from the Western world (*8*). On the other hand, indigenous vegetables have a unique advantage over introduced vegetables. Besides being already a part of people's diets, the tropical vegetables that grow locally are more adaptable to the local agricultural conditions and are less sensitive to the prevalent plant diseases and pests. They are easier to grow in home gardens, and their productivity could make them a good contribution to the nutrient supply for the family (*9*).

The emerging recognition among scientists is that these vegetables may be highly nutritious and could become major sources of nutrients for people in the tropics (*4, 10*) and elsewhere. The purpose of this study is to assess the use of tropical vegetables in improving diet quality when compared with nontropical or imported vegetables, and to devise recipes for successful introduction of these vegetables into the diets of people in the Pacific region. The Pacific region, in this study, includes Hawaii, the Pacific island countries, and the Pacific rim countries.

MATERIALS AND METHODS

Tropical plants mentioned in the literature as having "promising nutritional value" were identified and located on the island of Oahu. Many of these are being cultivated on the Kokokahi Hunger Mission Model Tropical Agriculture Farm in Kaneohe, Oahu, Hawaii. A list of these crops was compiled, including their botanical names and food uses in Hawaii and the tropics (Table 1). In order to minimize identification problems in the literature, since different names are used in various countries, common names used for these plants by different groups of people in the tropics are also given. Once the plants were identified, an extensive search was made of nutritional information available in the literature. Specific nutrients evaluated were protein, calcium, iron, ascorbic acid, and vitamin A equivalent, as well as essential amino acid compositions and caloric values.

A modified version of the food composition table used in East Asia (*11*) enabled nutrient assessment of recipes and menus. To maintain consistency, nutrient information available for each plant was reported and literature sources indicated (Appendix 1). The values were then averaged, and these were used in the analyses of menus. Although the averaged values were not considered a valid representation of these foods, they were the best values available and were used to facilitate comparisons.

A question may be raised concerning the comparison of leafy tropical vegetables with the predominant nonleafy vegetables of the temperate zones. It was felt that choice of vegetables should be based on popularity and common use by peoples of the two areas rather than type of vegetable.

Information on an important antinutrient, oxalic acid, found in leaves, was searched for the tropical vegetables surveyed and for some common temperate-zone vegetables as well.

The cooking methods of different ethnic groups in tropical regions were studied through personal communication and through reading various ethnic-food preparation books (*15, 16, 17, 18, 19, 20, 21, 22*). Visits were made to groups such as the senior citizens at the Makua Alii Retirement Home and the congregation of the Kokokahi Church, where informal surveys were made of cooking methods, since many of these people were from Asian backgrounds. After learning that the information was needed to develop recipes for use with tropical vegetables, many people provided recipes from their own collections. These recipes and those developed through adaptation of traditional Western recipes were tested by members of the Kokokahi congregation at their Sunday after-service meal. One or two different recipes were prepared on each of a series of Sundays. While the participants varied from Sunday to Sunday, there were consistently between 12 and 23 samplers of various ages and ethnic backgrounds. Participants sampled the recipes at will and were asked to complete a simple questionnaire (Appendix 2) to evaluate their acceptance of each recipe. They were asked to answer honestly and to make suggested improvements where applicable. As shown on the questionnaire, samplers were also asked if they would like to grow these vegetables at home, and if they had ever seen them growing or in markets.

In addition to developing recipes for each vegetable, the contribution to diets

Table 1. Eleven indigenous tropical vegetables, their common names and edible parts

Botanical name	Common names by locality[a]	Edible parts
Amaranthus gangeticus[b]	Amaranth (US); Chinese spinach (Ch.); African spinach, African bush greens (Afr.); Kolitis (Phil.); Chaulai sag, Gagta sag (Ind.)	leaves, stems
Artocarpus incisus[b]	Breadfruit (US); Mei (Tonga); Ulu (Haw.); Madar, Kadachakka (Ind.)	leaves, fruits
Basella rubra[c]	Ceylon spinach, Malabar nightshade (US); Alugbati (Phil.); Basala, Erra bachchali (Ind.)	leaves, stems
Cajanus cajan[c]	Pigeon pea (US); Kadyos (Phil.); Gandule (Lat. Amer.); Toor dhal, Red gram dhal (Ind.)	peas
Colocasia esculenta[b]	Taro (US); Luau leaves (Haw.); Gabi (Phil); Lu (Tonga); Kochu sag (Ind.)	leaves
	Taro (US); Dalo (Samoa)	corms
Hibiscus manihot[b]	'Sunset' or edible hibiscus (US); Aibika (PNG); Bele (Fiji); Pele (Tonga); Bush spinach (Poly.)	leaves
Ipomoea aquatica[b]	Swamp cabbage (US); Ung choy (Ch.); Kangkong (Phil.); Kamli (Ind.)	leaves, stems
Ipomoea batatas[b]	Sweet potato (US); Kamote (Phil.); Kumala (Tonga); Genasina yele (Ind.); Kaukau (PNG)	leaves, stems, roots
Manihot esculenta[b]	Cassava (US); Kamoteng-kahoi (Phil.); Manioke (Tonga); Manioc (Afr.); Marachini (Ind.)	leaves, roots
Moringa oleifera[b]	Horseradish tree (US); Marunggay (Phil.); Saijan patta, Sajna sag (Ind.)	leaves, stems, pods, flowers
Psophocarpus tetragonolobus[b]	Winged bean, Goa bean, Asparagus bean (US); Aglmong (PNG); Charkonisem (Ind.); Seguidillas, Palang (Phil.); Tua-pu (Thai.); Katjang botor (Indo.); Haricot de la foret (Fr.)	leaves, flowers, pods, roots, mature beans

[a] Locality abbreviations are United States (US), India (Ind.), China (Ch.), Philippines (Phil.), Papua New Guinea (PNG), Indonesia (Indo.), Africa (Afr.), France (Fr.), Hawaii (Haw.), Latin America (Lat. Amer.), Polynesia (Poly.), and Thailand (Thai.).

[b] Nonseasonal.

[c] Seasonal.

Source: References *16, 23, 24, 25, 26*.

was assessed through menu analysis. Ten menus were developed using the taste-tested tropical vegetable recipes. Each menu contained vegetable recipes of different ethnic groups and other foods that might also be consumed in traditional tropical diets. By necessity, most menus contained no "mixed" dishes. Most meals were composed of a standard source of carbohydrate, such as rice or taro; a standard source of fat, such as nuts or coconuts; and a standard source of protein, such as meat or fish. The proportions suggested in each menu were decided after surveying a number of persons who had lived in tropical areas. These quantities reflect the large amount of starch and the relatively small amount of protein consumed in many tropical diets. Usually the quantity of food in a normal diet would vary somewhat; however, for the purpose of this study, quantities were kept fairly constant. Each menu was designed to meet at least one third of the Recommended Dietary Allowances (RDA) for Asian adult males for five nutrients: protein, calcium, iron, ascorbic acid, and vitamin A, as well as kilocalories[1] *(11)*.[2] Ten menus using nontropical vegetables also were analyzed for their nutrient content to determine changes in nutrient value due to substitution of tropical vegetables.

In addition to nutrients, the protein quality was evaluated by computing the net dietary protein-calories percentage (NDpCal%) of the suggested menus. A sample worksheet for this evaluation is shown in Appendix 3. This calculation was compared to the NDpCal% of a similar menu using temperate-zone vegetables to assess any change in protein quality due to substitution.

In the calculation of the NDpCal%, total calories, protein concentration, and protein quality were taken into consideration. The total calorie content of a diet must be adequate; otherwise, protein will be used to provide calories. The protein concentration of the diet is the percentage of total dietary calories that is derived from the protein components:

$$\text{protein concentration} = \frac{\text{protein calories}}{\text{total metabolizable calories}} \times 100.$$

The protein quality depends on its digestibility (D), which is the percentage of the ingested nitrogen absorbed by the body when food is eaten, and on its biological value (BV), which is the percentage of the absorbed nitrogen subsequently utilized and retained (e.g., not wasted in the urine or from the skin). The product of D × BV, expressed as a percentage, gives the net protein utilization (NPU), which is the percentage of ingested food nitrogen that is actually retained in the body. In a controlled laboratory environment, this should be measured under standard conditions in which the protein level is just enough to maintain nitrogen equilibrium while the diet is adequate in all other respects. Under these conditions, NPU has its maximum value and is designated NPU_{st}. In field and home conditions, the determination of NPU_{st} is not possible.

Under the operative conditions when a meal is actually eaten, the NPU_{op} may be less than NPU_{st} because the protein concentration in the diet can be too low or too high. The protein value of a diet is therefore obtained as the product of two factors, protein concentration and protein quality (NPU). Since NPU is a percentage, this product is also a percentage, termed

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[1]The term "kilocalorie" refers to the potential energy of food. It is not a nutrient but rather a unit of measure of heat.

[2]For an adult male, moderately active, living in East Asia, weighing 55.0 kg, recommended daily intakes of the following nutrients were protein, 32 g; calcium, 0.4–0.5 g; iron, 9 mg; ascorbic acid, 30 mg; vitamin A value, 2500 IU; and calories, 2530 kcal.

the net dietary protein-calories percentage (NDpCal%):

$$\underset{\text{(protein value)}}{\text{NDpCAl\%}} = \frac{\text{protein calories}}{\text{total metabolizable calories}} \times \text{NPU}_{\text{op}}.$$

Where data for NPU are not available, an estimate of protein quality can be made from the amino acid composition of foods where the content of all essential amino acids is known. This method was employed in this study and is shown in Appendix 3, Part B.

The recommendation for protein should be specified in terms of protein-calories (percentage of calories from protein), rather than grams, since it is meals and nutrients, rather than individual foods and nutrients, that are under consideration (*9*).

Two separate NDpCal% calculations were made for each menu: one using the values for the eight essential amino acids and the other using these values plus those of cystine (Cys) and tyrosine (Tyr). While it is known that only eight amino acids are essential for the adult human, Cys and Tyr can partially spare the amino acids methionine (Met) and phenylalanine (Phe), respectively. Therefore, taking into consideration the sparing effect of Cys and Tyr, it was thought that averaging these two calculations would give a more realistic evaluation of protein quality.

In the calculations of the NDpCal%, the essential amino acid values determined by the column chromatographic method are used. Where these are not available, the microbiologically determined values for essential amino acids are used instead.

The NDpCal% was also determined for menus in which temperate-zone vegetables were substituted for tropical vegetables, and the percentage of change was reported along with any change in the values of the five nutrients under evaluation.

RESULTS

Eleven tropical vegetables, used by one or more ethnic groups of Hawaii and grown at the Kokokahi Hunger Mission Model Tropical Agriculture Farm, are listed in Table 1 along with their scientific names, regional common names, and edible parts. Most of these are green leafy vegetables with edible stems. Breadfruit and cassava, although used mainly for their edible fruits and tubers, have young leaves that are used as vegetables. Winged bean, marunggay, and taro have more than one edible part, such as pods, seeds, leaves, corms, and roots. Most tropical crops are perennials and can be harvested year-round. The widespread use of these plants in the tropics is undeniable.

Evaluation of Nutrients and Oxalic Acid

The average values for calories, protein, calcium, iron, ascorbic acid, and vitamin A equivalents are listed in Table 2 and were averaged from reported values (Appendix 1) for both the raw and the cooked parts. For comparison, the nutritional composition of 11 common temperate-zone vegetables is listed in Table 3.

The most obvious differences in nutrient content of the two groups of vegetables are in protein, calcium, and vitamin A equivalents. The 11 tropical vegetables show consistently higher concentrations of these nutrients than do the 11 temperate-zone vegetables except spinach (*Spinacia oleracea*), which is equivalent to the tropical vegetables. For example, the average value of crude protein found in the leaves of eight tropical plants[3] was 4.2 g/100 g raw food, compared to the average value of 1.2 g protein in the 11 temperate-zone vegetables in Table 3. The average values for 10 tropical[4] and 11 temperate-zone vegetables, respectively, for the following

Table 2. Eleven indigenous tropical vegetables, nutrient composition per 100 grams raw food

Vegetable	Calories	Protein (g)	Calcium (mg)	Vitamin A equivalent (IU)	Iron (mg)	Ascorbic acid (mg)
Amaranth, leaves	26	2.8	176	5,684	2.8	41.3
Breadfruit, fruit	126	1.4	22	35	0.4	13.0
Cassava, leaves[a]	56	7.0	160	8,578	2.4	219.0
Ceylon spinach, leaves	18	1.8	85	3,752	1.4	126.0
Hibiscus, leaves	45	4.8	407	9,000	2.2	74.0
Kamote, leaves	42	3.2	74	4,528	4.6	23.0
Marunggay, leaves	74	7.2	342	11,806	3.7	191.0
Pigeon pea, green seeds	118	7.4	33	269	1.4	33.0
Taro, leaves	40	3.3	96	5,769	0.95	27.5
Ung choy, leaves	25	3.2	60	5,632	2.5	59.0
Winged bean, young pods	22	2.3	69	375	1.8	20.0

[a]Raw values for cassava leaves are reported for comparative reasons only; the leaves should never be eaten without cooking.
Source: Average values are compiled from references *6, 7, 9, 11, 12, 13, 14, 15, 16*.

Table 3. Eleven common temperate-zone vegetables, nutrient composition per 100 grams raw food

Vegetable	Calories	Protein (g)	Calcium (mg)	Vitamin A equivalent (IU)	Iron (mg)	Ascorbic acid (mg)
Asparagus	26	2.5	22	900	1.0	33
Bean, string	28	1.7	49	530	0.7	17
Beet	21	0.8	8	10	0.3	51
Cabbage, head	24	1.3	49	130	0.4	47
Carrot	33	0.9	29	8,580	0.5	6
Eggplant	20	1.0	10	8	0.6	4
Lettuce,						
Manoa	12	0.8	44	1,215	0.9	36
Head	14	1.2	35	970	2.0	8
Romaine	18	1.3	68	1,900	1.1	18
Onion, white	35	1.4	25	35	0.5	9
Spinach	17	2.0	57	4,940	1.9	31
Sugar pea	27	2.4	32	313	0.5	50
Tomato	20	1.0	12	820	0.5	21

Source: Reference *27*.

Table 4. Cost per serving of 10 tropical and 10 temperate-zone vegetables commonly in use

Vegetable	Average cooked serving size[a] (g)	Cost/serving[b] (U.S. dollar)
Amaranth	85	free[c]
Bean, string	95	.29
Beet	80	.20
Breadfruit	100	free
Cabbage, head	44	.03
Carrot	76	.08
Cassava, leaves	85	free
Ceylon spinach	85	free
Eggplant	100	.18
Hibiscus	85	free
Kamote,		
roots	100	free
leaves	85	free
Lettuce,		
Manoa	37	.06
Head	37	.05
Romaine	37	.06
Marunggay,		
pods	95	free
leaves	85	free
Onion, white	45	.08
Pigeon pea	90	free
Spinach	85	.11
Sugar pea	85	.71
Taro,		
corms	100	free
leaves	85	free
Tomato	37	.05
Winged bean,		
imm. pods	95	free
mat. pods	90	free
dry beans	100	free
leaves	85	free

[a]Average serving size data are taken from reference *8*.

[b]The cost of vegetables was determined from a three-market survey conducted on the island of Oahu in April 1980. The three markets surveyed were Star Market in Kaneohe, Safeway in Manoa, and Times on King Street. The cost/lb data from the three markets were averaged and used in determining the cost per specific serving size.

[c]"Free" indicates the vegetable is among those tropical vegetables that can be grown easily in a backyard garden at little or no cost to the cultivator.

nutrients per 100 g raw food were calcium, 146 mg and 27 mg; vitamin A equivalent, 5505 IU and 1672 IU; iron, 2.2 mg and 0.8 mg; and ascorbic acid, 81 mg and 20 mg.

Table 4 gives a comparison of the cost/serving of 10 tropical and 10 temperate-zone vegetables. The cost/serving is listed as "free" for those tropical vegetables that grow easily in backyard gardens and may or may not be purchased in a food market. Some vegetables such as Manoa lettuce can also be grown in home gardens but need additional care and pesticides. Lettuces are listed as purchased items. This table pinpoints the savings that are possible on homegrown vegetables.

In Table 5, the protein content, chemical scores, and first limiting amino acids of the 11 tropical vegetables are listed, along with those of a group of 11 temperate-zone vegetables. Most scores were obtained directly from the FAO Nutritional Studies No. 24 (*29*). Scores not found in that publication were calculated from the essential amino acids content published there and elsewhere. The leaves of cassava, 'Sunset' hibiscus, and marunggay contain generous amounts of protein, and their chemical scores indicate medium to good protein quality. In the tropics a wide variety of leaves from trees, vines, and bushes are used for vegetables and are collectively called "spinach" or "cabbage." If toxins or antinutrients prove to be absent or minimal in these leaves, the tropics are endowed by nature with a generous supply of nutrients through leaves. This remains to be evaluated.

The content of oxalic acid in the tropical and temperate-zone vegetables is listed in

[3]These were leaves of amaranth, cassava, Ceylon spinach, hibiscus, marunggay, kamote, taro, and ung choy.

[4]Of the 11 tropical vegetables, nutrient values of winged bean leaf were not included in these averages because of incomplete data.

Table 5. Protein content, chemical scores, and limiting amino acids of 11 tropical and 11 temperate-zone vegetables

Vegetable	Protein (%)	Chemical score	Limiting amino acid	References
Tropical				
Amaranth	2.2	76[a]	Methionine	*13*
Breadfruit	1.4	35[a]	Methionine	*12*[b]
Cassava, roots	1.6	42	Isoleucine	*29*
leaves	7.0	73	Isoleucine	*29*
Ceylon spinach	1.8	47	S-C[c]	*29*
Hibiscus	4.8	51[a]	Methionine	*9, 7*
Kamote, roots	1.3	53	Lysine	*29*
Marunggay, leaves	8.2	69[a]	Methionine	*9, 7*
Pigeon pea, dry	20.9	35	Tryptophan	*29*
Taro, corms	1.8	60	Lysine	*29*
leaves	3.3	55[a]	Methionine	*11*[d]
Ung choy	4.0	45	S-C	*29*
Winged bean	20.6	41[a]	Methionine	*16, 30*
Temperate-zone				
Asparagus	2.1	40	S-C	*29*
Bean, string	2.4	56	Isoleucine	*29*
Beet, root	1.8	36	Isoleucine	*29*
leaves	2.1	32	S-C	*29*
Cabbage	1.6	46	Isoleucine	*29*
Carrot	1.1	44	Tryptophan	*29*
Eggplant	1.2	64	Tryptophan	*29*
Lettuce	1.3	25[d]	Tryptophan	*29*
Onion	1.4	64[d]	Isoleucine	*29*
Spinach	2.2	73	Isoleucine	*29*
Sugar pea, seeds	6.6	62	Isoleucine	*29*
Tomato	1.1	27	Isoleucine	*29*

[a]Chemical scores and limiting amino acids were not given in reference cited; however, amino acid compositions were given and chemical scores were calculated by authors.
[b]From this reference, only protein content was cited. The amino acid composition was obtained from reference *35*.
[c]S-C indicates sulfur-containing amino acids.
[d]From this reference, only protein content was cited. The amino acid composition was obtained from reference *36*.

Table 6, which shows great variation of values reported in different publications. The tropical vegetables contain a much higher concentration of oxalic acid than do the temperate-zone crops except for spinach. The highest concentrations of oxalic acid were found in amaranth (*Amaranthus*), Ceylon spinach (*Basella rubra*), ung choy (*Ipomoea aquatica*), and spinach (*Spinacia oleracea*). Since diets in general do not contain adequate calcium, a study of oxalates in "calcium rich" vegetables is being pursued in this Department.

Evaluation of Recipes

In the recipes (Apppendix 4), the cooking techniques of Japanese, Chinese, Tongans, Koreans, Filipinos, and East

Table 6. Oxalic acid content of 8 tropical and 7 temperate-zone vegetables

Vegetable	% oxalic acid on fresh-cooked basis	References
Tropical		
Amaranth (*Amaranthus gangeticus*), leaves	0.88, 0.77	*31, 26*
Cassava (*Manihot esculenta*), leaves	0.517	*32*
Ceylon spinach (*Basella rubra*), leaves	0.56, 1.0	*31, 32*
Kamote (*Ipomoea batatas*), leaves	0.18, 0.83	*31, 32*
Marunggay (*Moringa oleifera*), leaves and tips	0.08, 1.33, 0.101	*31, 32, 26*
Taro (*Colocasia esculenta*), leaves	0.36, 0.77, 0.043	*31, 32, 26*
corms	0.10, 0.145	*31, 32*
Ung choy (*Ipomoea aquatica*), leaves	0.94	*32*
Winged bean (*Psophocarpus tetragonolobus*), pods	0.037	*32*
Temperate-zone		
Asparagus (*Asparagus officinalis*), stalks	0.0017	*33*
Bean (*Phaseolus vulgaris*)	0.03, 0.031	*33, 26*
Cabbage (*Brassica oleracea*)	0.002, 0.003	*33, 26*
Carrot (*Daucus carota*), roots	0.0227, 0.005	*33, 26*
Onion (*Allium cepa*), bulbs	0.003[a], 0.001	*33, 26*
Sugar pea (*Pisum sativum*)	0.0013, 0.014	*33, 26*
Spinach (*Spinacia oleracea*)	0.78, 0.685	*33, 26*

[a]This value was obtained from raw onion.

Table 7. Taster responses to 12 recipes using tropical vegetables

Recipe[a]	No. of responses	% of responses in each category[b]				
		1	2	3	4	5
1. Hibiscus Gulay	23	—	—	9	17	74
2. Pigeon Peas with Rice	23	—	—	—	9	91
3. Korean-style Cassava Leaves	12	—	—	—	33	67
4. Japanese-style Hibiscus Greens	23	—	—	—	13	87
5. Stir-fried Amaranth and Tofu	15	—	—	—	20	80
6. Luau and Coconut Cream	19	—	—	—	16	84
7. Indian-style Ceylon Spinach	18	—	—	—	28	72
8. Chicken Picadillo	17	—	—	6	35	59
9. Confetti Breadfruit[c]	23	—	—	—	—	100
10. Chinese Ung Choy	17	—	—	24	24	52
11. Savory Spinach[c]	17	—	—	—	24	76
12. Stuffed Papaya[c]	12	—	—	8	17	75

[a]Complete recipes are given in Appendix 1.
[b]Categories 1–5 indicate responses to the question "How did you like the dish?" 1 = not at all, 2 = not too bad, 3 = neither like nor dislike, 4 = like somewhat, 5 = very much. Complete questionnaire is given in Appendix 2.
[c]These recipes were not included in the nutritional evaluation of menus.

Indians were utilized. Variations among recipes occur in the cooking method (e.g., stir-frying, boiling, etc.) and seasonings.

Ten recipes were used for the NDpCal% analysis and nine of these were "taste-tested" by members of the Kokokahi Church congregation (Table 7). The number of people who tasted each recipe varied; however, there were consistently between 12 and 23 people who tasted each recipe and responded by completing the recipe questionnaire shown in Appendix 2.

Altogether, 12 recipes were taste-tested, and the number of responses in each of the five categories from 1 (do not like at all) to 5 (like very much) are shown in Table 7. None of the recipes received a rating of 1 or 2. Of the 12 recipes that were tested, only four received a rating of 3 (neither like nor dislike). The highest rating, 5, was given most often, indicating that the testers liked the recipe very much. The reasons given for rating the recipe less than 5 varied from disliking the texture of the food to disliking the seasonings used.

Most respondents had never seen the tropical vegetables used in the recipes except ung choy (swamp cabbage), which is fairly common in local markets. Those who were acquainted with them either were from tropical areas (such as the Philippines or Polynesia) or remembered seeing them on the Kokokahi Farm.

Nutritional Evaluation of Menus

Most of the recipes tested for appeal were used in the nutritional evaluation of Pacific region menus. In Table 8, 10 menus (1–10) using tropical vegetables and 10 identical menus (1A–10A), except for one vegetable that was replaced by a temperate-zone vegetable, were tested. Each of the tropical-vegetable menus met one-third of the RDA for protein, calcium, iron, ascorbic acid, and vitamin A value. Most met one-third of the RDA for kilocalories. Substituting a temperate-zone vegetable for one of the tropical vegetables generally caused a drop in NDpCal% and in the nutrient content. Since menus 8 and 8A exchanged carbohydrate, only nine substitutions will be discussed here.

Ascorbic acid decreased in seven of the nine substitutions. Increases occurred when cabbage replaced ung choy (menus 10A and 10) and when asparagus replaced amaranth (menus 5A and 5). The vitamin A equivalence decreased for seven of the nine substitutions, but increased when carrots were substituted for taro leaves (menus 6A and 6) and garden peas were substituted for pigeon peas (menus 2A and 2). Except for a small increase in menu 10A, calcium decreased in all substitutions. Because of the generous presence of oxalates in cassava leaves (menu 3), amaranth (menu 5), taro leaves (menu 6), Ceylon spinach (menu 7), ung choy (menu 10), and possibly marunggay leaves (menu 9), however, the evaluation of calcium content is uncertain.

A significant increase in protein score was obtained when garden peas were substituted for pigeon peas (menu 2A) and when carrots were substituted for taro leaves (menu 6A). A small increase resulted from substituting string beans for hibiscus leaves (menu 4A). There was no change in menus 3A, 5A, and 10A. Protein scores decreased when lettuce was substituted for hibiscus leaves (menu 1A), cabbage for Ceylon spinach (menu 7A), and garden peas for marunggay leaves (menu 9A). NDpCal% decreased in eight of the nine substitutions and increased only in menu 2A, in which garden peas were substituted for pigeon peas. All menus had NDpCal% greater than 5 percent, which is the smallest amount that will support adult

Table 8. Gain or loss in nutrient values when tropical vegetables were replaced by temperate-zone vegetables in Pacific region menus

Menu number	Food (g)	Vegetable (g)	Calories	Protein (g)	Protein cal. (%)	Protein score	NDpCal%	Calcium (mg)	Vitamin A equivalent (IU)	Iron (mg)	Ascorbic acid (mg)
1	Rice 280, fish 30, coconut 60	Hibiscus leaves 200	841	29	14	84	9.8	849	18,000	6	148
1A	Same as menu 1	Lettuce 200	778	22	11	81	8.0	71	1,478	3	8
Nutrient differences, tropical 1 - temperate 1A			-63	-7	-3	-3	-1.8	-778	-16,522	-3	-140
2	Ung choy 150, rice 165, peanuts 50, milk 244	Pigeon peas 60	831	36	17	69	9	386	4,457	5	48
2A	Same as menu 2	Garden peas 60	821	33	16	79	10	385	4,571	5	19
Nutrient differences, tropical 2 - temperate 2A			-10	-3	-1	+10[a]	+1	-1	+114	NC[b]	-29
3	Rice 280, fish 40, coconut candy 100	Cassava leaves 200	849	29	13.5	81	9.0	275	13,155	5.4	336
3A	Same as menu 3	Eggplant 200	800	20	9.8	81	7.2	100	372	2.6	7
Nutrient differences, tropical 3 - temperate 3A			-49	-9	-3.7	NC	-1.8	-175	-12,783	-2.8	-329
4	Taro corm 200, fish 30, coconut 70, coconut cream 70	Hibiscus leaves 200	935	27.5	12.0	65	7.0	920	18,000	10.0	159
4A	Same as menu 4	String beans 200	901	21.7	9.6	67	6.1	256	539	8.4	47
Nutrient differences, tropical 4 - temperate 4A			-34	-5.8	-2.4	+2	-0.9	-664	-17,461	-1.6	-112
5	Tofu 50, rice 280, nuts 50	Amaranth 150	902	28.0	12.3	84	9.0	325	3,471	5.6	18
5A	Same as menu 5	Asparagus 150	884	26.5	12.0	84	8.8	199	904	3.8	40
Nutrient differences, tropical 5 - temperate 5A			-18	-1.5	-0.3	NC	-0.2	-126	-2,567	-1.8	+22

—*Continued*

Table 8. Gain or loss in nutrient values *(continued)*

Menu number	Food (g)	Vegetable (g)	Calories	Protein (g)	Protein cal. (%)	Protein score	NDpCal%	Calcium (mg)	Vitamin A equivalent (IU)	Iron (mg)	Ascorbic acid (mg)
6	Fish 30, taro leaves 300, 300, coconut cream 100	Taro leaves 200	787	22.0	11.0	64	6.6	320	11,538	7.8	72
6A	Same as menu 6	Carrots 200	770	16.7	8.7	69	6.0	195	20,988	7.1	29
Nutrient differences, tropical 6 - temperate 6A			-17	-5.3	-2.3	+5	-0.6	-125	+9,450	-0.7	-43
7	Milk 120, coconut 200, peanuts 25, rice 250	Ceylon spinach 200	899	24.8	11	77	8	300	4,767	5.9	153
7A	Same as menu 7	Cabbage 200	903	23.6	10	74	7	276	359	4.0	69
Nutrient differences, tropical 7 - temperate 7A			+4	-1.2	-1	-3	-1	-24	-4,408	-1.9	-84
8	Chicken 40, marunggay leaves 100, papaya 100, coconut 60	Rice 280	862	29	13.5	88	10.0	335	10,061	5.7	139
8A	Same as menu 8	Taro corm 280	685	24	14.0	69	8.1	435	10,061	7.4	154
Nutrient differences, tropical 8 - temperate 8A			-177	-5	+0.5	-19	-1.9	+100	NC	+1.7	+15
9	Fish 40, rice 280, coconut 60	Marunggay leaves 150	850	31	14.5	71	8.5	463	13,175	6.4	99
9A	Same as menu 9	Garden peas 150	865	29	13.4	68	7.6	72	810	4.6	30
Nutrient differences, tropical 9 - temperate 9A			+15	-2	-1.1	-3	-0.9	-391	-12,365	-1.8	-69
10	Fish 40, rice 280, papaya 100, candy 100	Ung choy 150	840	22	10.6	83	8.0	123	5,473	4.7	94
10A	Same as menu 10	Cabbage 150	845	21	9.9	83	7.3	129	1,619	3.0	128
Nutrient differences, tropical 10 - temperate 10A			+5	-1	-0.7	NC	-0.7	+6	-3,854	-1.7	+34

[a] A positive value corresponds to a nutrient gain due to substitution of a temperate-zone vegetable for a tropical vegetable in these menus.
[b] NC = no change.

needs. Although changes in NDpCal% appeared small, a change of ±1 percent can be meaningful, since a diet that supplies less than 8 percent of calories as utilizable protein (i.e., an NDpCal% below 8 percent) is incapable of meeting the needs of children (*9*).

DISCUSSION

Reports on nutritious tropical vegetables suggest that certain plant foods indigenous to tropical areas may contain some important nutrients often lacking in tropical diets (*6, 7, 5, 4, 8, 9*). The results of this study substantiate these claims.

Of the five nutrients compared, all were found at much higher concentrations in the tropical vegetables than in temperate-zone vegetables. The caloric content, however, was lower. Some of these differences were substantial and suggest that tropical vegetables may indeed improve diet quality.

The fact that these vegetables are indigenous to the tropics is of great advantage: they have adapted to the soil and climate and are less susceptible to fungi, diseases, and other pests of the tropics. Therefore, their cultivation requires little herbicide and pesticide treatment, and less disease control than is needed in the adoption of temperate-zone vegetables for the soils and climate of the tropics. Many tropical vegetables yield abundantly throughout the year, and the effect that their cultivation can have on a family's food supply when combined with their nutritional potential should not be ignored.

The essential amino acid comparison between tropical and temperate-zone vegetables shows that the limiting amino acid for both types of vegetables is often methionine or sulfur-containing amino acids. The chemical score for methionine was found to be greater in tropical vegetables than in the temperate-zone vegetables studied, however. From the viewpoint of protein needs, tropical vegetables would make better choices in the tropics than the temperate-zone vegetables. This is shown to be true in the menu analysis, where the protein score and NDpCal% of eight out of the nine menus increased when tropical vegetables were substituted for temperate-zone vegetables.

While this study has shown the nutritional advantage offered by tropical vegetables in terms of nutrient content, it has also pointed out the possible disadvantage of tropical vegetables. It is known that green, leafy vegetables generally contain larger amounts of oxalic acid. Since most of the common tropical vegetables are leafy, their oxalates place a dampening effect on their nutrient worth. Research in progress at this Department, however, strongly indicates that varieties and parts of plants may differ widely in oxalate content. Although most tropical vegetables contain more calcium than do temperate-zone vegetables, the oxalates present can interfere with the utilization of calcium (and other minerals as well) by combining with dietary calcium to form insoluble calcium oxalates. These insoluble oxalates are excreted in the feces, rendering the calcium unavailable to the body.,Serious effects of ingestion of large amounts of oxalic acid might not occur, however, unless there were also a deficiency of calcium in the diet (*34*). Because the calcium status of many tropical diets is usually low, and tropical vegetables generally contain large amounts of oxalic acid, prudence is recommended in planning diets using tropical vegetables.

The results of the NDpCal% analysis of the 10 menus using tropical vegetables are a significant indication of how the use of these vegetables can improve diet quality.

In the calculation of NDpCal%, the individual essential amino acids (EAA) composition for each food in the meal was tabulated. The totals for the individual EAA (A) of the menu and the totals of all EAA (E) were determined (see Appendix 3). (A/E) × 100 was calculated for each menu. This figure was divided by the (A/E) × 100 value for whole egg (which is considered a standard protein food) and multiplied by 100. The value obtained is the percentage score for each individual EAA of the menu, and the EAA with the lowest score indicated that it was the limiting EAA for the menu and, thus, was the protein or chemical score. While comparisons of nutrients and EAA content of individual vegetables indicate the nutritional worth each food offers, they do not show the collective effect a food has when used with other foods. Therefore, in order to obtain a more realistic evaluation of how a food can alter diet quality (specifically protein quality), the NDpCal% was felt to be a better analytical tool. In eight out of the nine meals analyzed, the NDpCal% was decreased when tropical vegetables were replaced by temperate-zone vegetables; this demonstrates the effect tropical vegetables could have on diet quality.

SUMMARY AND RECOMMENDATIONS

The results of this study substantiate the literature claims that many tropical vegetables have untapped potential and could dramatically improve diet quality in areas where these crops are indigenous. Tropical vegetables surveyed in this work had a much higher concentration of protein, calcium, iron, ascorbic acid, vitamin A equivalent, and essential amino acids per 100 grams of food than did their temperate-zone counterparts. These same tropical vegetables, however, contained higher concentrations of the antinutrient oxalic acid than observed in temperate-zone vegetables.

The NDpCal% of the 10 menus using tropical vegetables, compared to the same menus using temperate-zone vegetables, indicated that tropical vegetables may indeed improve the protein quality of a meal. The fact that the vegetable recipes used in these menus were highly acceptable to people of varied ethnic backgrounds and ages suggests the possibility of successfully reintroducing these vegetables to different tropical areas.

Many gaps in information on nutrient content for several tropical vegetables were found in the literature. For instance, while some reports of EAA content in tropical vegetables were found, the primary source of information of these reports was the FAO publication (*29*). The notable gap is the absence of data for tryptophan content. Some values for the sulfur-containing amino acids were also missing. Analyses of nutrients, antinutrients, and amino acids for many of the tropical vegetables are needed to facilitate evaluation of nutritional values of tropical food resources.

Along with determining the nutrient composition of the tropical vegetables, a study should be made of the factors that affect nutrient availability. It has already been shown that tropical vegetables contain oxalic acid, which may greatly affect calcium availability. Biological testing is needed to determine the extent to which oxalic acid interferes with the calcium contribution of tropical vegetables. Other factors such as phytate content and presence of natural toxins need to be evaluated.

The fact that most hunger occurs in tropical areas suggests the need for studies on the use or rejection of traditional foods as contributory factors in the nutritional status of people in these areas. Food habits, food taboos, and food preparation should be investigated to learn how people have removed or minimized harmful characteristics of certain foods.

The results of this study are also useful for the people of Hawaii. This state is unique as a highly developed area located in tropical America. Much of the produce consumed by the population is imported from the West Coast of the U.S. mainland at increased cost. This cost is, in turn, passed on to the consumers every time oil prices are increased. This study has shown that some tropical vegetables can be nutritionally superior to the commonly imported mainland vegetables. The fact that these vegetables grow abundantly and easily in Hawaii (*10*) suggests the wisdom of increasing their availability through home and community gardens as a means of economizing as well as improving the nutritional quality of diets. Many of these indigenous tropical vegetables are already in use by members of various ethnic groups who have traditionally cultivated them in their home countries. Since the recipes using indigenous vegetables were well received, successful introduction of these vegetables to diets is feasible. Therefore, it is recommended that serious attempts be made by home economists and nutritionists to utilize these indigenous vegetables in their deliveries of extension education to homemakers, school teachers, school children, and others. It is recommended that extension agriculturists also emphasize the growing and utilization of indigenous vegetables. These vegetables have habitually been excluded from promotion efforts by agriculturists whose emphasis has been on temperate-zone vegetables.

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APPENDIX 1: ELEVEN TROPICAL VEGETABLES, NUTRIENTS IN 100 GRAMS, FROM REFERENCES CITED

Vegetable	Calories	Protein (g)	Calcium (mg)	Vitamin A equivalent (IU)[a]	Iron (mg)	Ascorbic acid (mg)
Amaranth leaves, raw	26 *(11)*[b]	3.6 *(11)*	154 *(11)*	10,908 *(11)*	2.9 *(11)*	23 *(11)*
	18 *(12)*	1.8 *(12)*	116 *(12)*	1,890 *(12)*	2.0 *(12)*	24 *(12)*
	36 *(9)*	3.5 *(9)*	267 *(9)*	6,090 *(9)*	3.9 *(9)*	80 *(9)*
	23 *(13)*	2.2 *(13)*	168 *(13)*	3,845 *(13)*	2.5 *(13)*	50 *(13)*
Average value	26	2.8	174	5,684	3.8	44
Amaranth leaves, boiled	16 *(11)*	1.6 *(11)*	105 *(11)*	— *(11)*	1.8 *(11)*	12 *(11)*
	16 *(12)*	1.6 *(12)*	105 *(12)*	2,311 *(12)*	1.8 *(12)*	11 *(12)*
Average value	16	1.6	105	2,311	1.8	11.5
Breadfruit, ripe fruit, raw	126 *(12)*	1.4 *(12)*	22 *(12)*	35 *(12)*	0.4 *(12)*	13 *(12)*
Average value	126	1.4	22	35	0.4	13
Breadfruit, ripe fruit, boiled	121 *(11)*	1.4 *(11)*	17 *(11)*	— *(11)*	0.3 *(11)*	14 *(11)*
	134 *(12)*	1.4 *(12)*	24 *(12)*	26 *(12)*	0.4 *(12)*	10 *(12)*
Average value	127.5	1.4	20.5	26	0.4	12
Cassava leaves, raw[c]	60 *(11)*	6.9 *(11)*	144 *(11)*	13,733 *(11)*	2.8 *(11)*	82 *(11)*
	55 *(9)*	7.2 *(9)*	175 *(9)*	2,000 *(9)*	2.0 *(9)*	275 *(9)*
	53 *(13)*	7.0 *(13)*		10,000 *(13)*		300 *(13)*
Average value	56	7.0	160	8,578	2.4	219
Cassava root, cooked	138 *(11)*	1.0 *(11)*	40 *(11)*	trace *(11)*	1.4 *(11)*	19 *(11)*
						— *(12)*
						— *(9)*
	131 *(13)*	0.7 *(13)*				30 *(13)*
Average value	134.5	0.9	40	trace	1.4	24.5

—*Continued*

APPENDIX 1 *(continued)*

Vegetable	Calories	Protein (g)	Calcium (mg)	Vitamin A equivalent (IU)[a]	Iron (mg)	Ascorbic acid (mg)
Ceylon spinach leaves, raw	19 *(11)*	1.6 *(11)*	106 *(11)*	5,817 *(11)*	1.6 *(11)*	86 *(11)*
	17 *(12)*	1.9 *(12)*	64 *(12)*	1,686 *(12)*	1.2 *(12)*	166 *(12)*
Average value	18	17.5	85	3,752	1.4	126
Ceylon spinach leaves, cooked	21 *(11)*	1.7 *(11)*	56 *(11)*	3,058 *(11)*	1.0 *(11)*	75 *(11)*
	15 *(12)*	1.7 *(12)*	56 *(12)*	1,610 *(12)*	1.0 *(12)*	75 *(12)*
Average value	18	1.7	56	2,334	1.0	75
Hibiscus leaves, raw	47 *(9)*	5.7 *(9)*	580 *(9)*	13,000 *(24)*	3.0 *(24)*	118 *(24)*
	47 *(24)*	5.7 *(24)*	580 *(24)*	5,000 *(13)*	1.3 *(13)*	30 *(13)*
	42 *(13)*	3.1 *(13)*	62 *(13)*	—	—	
Average value	45	4.8	407	9,000	2.2	74
Kamote leaves, raw	42 *(11)*	3.2 *(11)*	86 *(11)*	4,500 *(11)*	4.5 *(11)*	21 *(11)*
	36 *(12)*	4.0 *(12)*	37 *(12)*	941 *(12)*	1.0 *(12)*	11 *(12)*
	47 *(9)*	3.5 *(9)*	70 *(9)*	6,000 *(9)*	8.0 *(9)*	25 *(9)*
	34 *(13)*	2.6 *(13)*	70 *(13)*	5,635 *(13)*	3.7 *(13)*	25 *(13)*
	53 *(14)*	2.8 *(14)*	107 *(14)*	5,565 *(14)*	6.0 *(14)*	32 *(14)*
Average value	42	3.2	74	4,528	4.6	23
Kamote leaves, cooked	41 *(11)*	2.6 *(11)*	24 *(11)*	2,908 *(11)*	0.6 *(11)*	1.0 *(11)*
	23 *(12)*	2.6 *(12)*	24 *(12)*	888 *(12)*	0.6 *(12)*	1.0 *(12)*
Average value	32	2.6	24	1,898	0.6	1.0
Kamote tuber, boiled	114 *(11)*	1.0 *(11)*	36 *(11)*	0–5,000[d] *(13)*	0.9 *(11)*	11 *(11)*
	121 *(13)*	1.5–2.0 *(7)*				20 *(7)*
Average value	118	1.5	36	2,500	0.9	15.5

—Continued

APPENDIX 1 *(continued)*

Vegetable	Calories	Protein (g)	Calcium (mg)	Vitamin A equivalent (IU)[a]	Iron (mg)	Ascorbic acid (mg)
Marunggay leaves,						
raw	72 *(11)*	7.4 *(11)*	297 *(11)*	14,758 *(11)*	3.6 *(11)*	167 *(11)*
	75 *(12)*	9.4 *(12)*	365 *(12)*	7,564 *(12)*	4.0 *(12)*	134 *(12)*
	75 *(9)*	5.9 *(9)*	353 *(9)*	12,450 *(9)*	3.5 *(9)*	232 *(9)*
	75 *(15)*	5.9 *(15)*	353 *(13)*	12,450 *(13)*	3.5 *(15)*	232 *(13)*
Average value	74	7.2	342	11,806	3.7	191
Marunggay leaves,						
boiled	70 *(11)*	6.6 *(11)*	284 *(11)*	8,942 *(11)*	3.0 *(11)*	37 *(11)*
	54 *(12)*	6.8 *(12)*	264 *(12)*	5,893 *(12)*	2.9 *(12)*	26 *(12)*
	60 *(15)*	6.5 *(15)*	303 *(13)*	11,515 *(13)*	3.0 *(15)*	134 *(13)*
Average value	61	6.6	284	8,783	3.0	66
Marunggay pods,						
boiled	33 *(12)*	1.9 *(12)*	27 *(12)*	70 *(12)*	0.3 *(12)*	126 *(12)*
Average value	33	1.9	27	70	0.3	126
Pigeon peas, green,						
raw	117 *(11)*	7.2 *(11)*	42 *(11)*	140 *(11)*	1.6 *(11)*	39 *(11)*
	119 *(12)*	7.5 *(12)*	29 *(12)*	397 *(12)*	1.3 *(12)*	26 *(12)*
			29 *(6)*		1.3 *(6)*	
Average value	118	7.4	33	268.5	1.4	32.5
Pigeon peas, green,						
cooked	119 *(12)*	7.5 *(12)*	29 *(12)*	350 *(12)*	1.3 *(12)*	48 *(12)*
Average value	119	7.5	29	350	1.3	48
Taro leaves,						
cooked	48 *(11)*	3.3 *(11)*	110 *(11)*	7,825 *(11)*	0.8 *(11)*	27 *(11)*
	32 *(12)*	3.3 *(12)*	81 *(12)*	3,713 *(12)*	1.1 *(12)*	28 *(12)*
Average value	40	3.3	95.5	5,769	1.0	27.5

—Continued

APPENDIX 1 *(continued)*

Vegetable	Calories	Protein (g)	Calcium (mg)	Vitamin A equivalent (IU)[a]	Iron (mg)	Ascorbic acid (mg)
Taro corm, boiled	124 *(11)*	1.9 *(11)*	48 *(11)*	—	0.9 *(11)*	4 *(11)*
	104 *(12)*	1.3 *(12)*	24 *(12)*		1.3 *(12)*	7 *(12)*
Average value	114	1.6	36		1.1	6
Ung choy leaves, raw	30 *(11)*	2.7 *(11)*	60 *(11)*	4,775 *(11)*	2.5 *(11)*	47 *(11)*
	19 *(12)*	2.4 *(12)*	40 *(12)*	1,261 *(12)*	1.4 *(12)*	44 *(12)*
	30 *(9)*	3.9 *(9)*	71 *(9)*	4,825 *(9)*	3.2 *(9)*	49 *(9)*
	30 *(15)*	3.9 *(15)*	71 *(15)*	13,000 *(7)*	3.2 *(15)*	49 *(15)*
	17 *(7)*	4.0 *(7)*	59 *(13)*	4,825 *(15)*	2.0 *(13)*	140 *(7)*
	23 *(13)*	2.4 *(13)*		5,105 *(13)*		26 *(13)*
Average value	25	3.2	60	5,682	2.5	59
Ung choy leaves, boiled	21 *(11)*	2.4 *(11)*	40 *(11)*	3,375 *(11)*	1.4 *(11)*	10 *(11)*
	19 *(12)*	2.4 *(12)*	40 *(12)*	2,024 *(12)*	1.4 *(12)*	10 *(12)*
Average value	20	2.4	40	2,700	1.4	10
Winged bean, young pod, raw	22 *(12)*	2.7 *(16)*	80 *(16)*	420 *(16)*	3.1 *(16)*	trace *(12)*
		1.8 *(12)*	57 *(12)*	330 *(12)*	0.5 *(12)*	20 *(27)*
Average value	22	2.3	69	375	1.8	20
Winged bean, young pod boiled	22 *(16)*	2.5 *(16)*	59 *(16)*	64 *(16)*	0.5 *(12)*	4 *(27)*
		1.8 *(12)*	17 *(12)*	387 *(12)*	3.1 *(16)*	
Average value	22	2.2	58[d]	226	1.8	4
Winged bean leaves, raw	—	8.1 *(16)*	205 *(16)*	9,730–19,300 *(16)*	1.3 *(16)*	73 *(27)*
Average value		8.1	205	11,515	1.3	73

—*Continued*

Vegetable	Calories	Protein (g)	Calcium (mg)	Vitamin A equivalent (IU)[a]	Iron (mg)	Ascorbic acid (mg)
Winged bean leaves,						
boiled	—	5.8 *(16)*	125 *(16)*	—	3.2 *(16)*	—
Average value		5.8	125[e]		3.2	
Winged bean, whole seed,						
boiled	—	20.6 *(16)*	17·1 *(16)*	—	1.4 *(16)*	—
Average value		20.6	17·4		1.4	

[a] Authors of the eight references cited in the vitamin A column differed in their choice of units to report vitamin A values of food plants. The authors of this bulletin have converted reported values of carotene to vitamin A equivalents using 1.666 IU as equivalent to one mcg of beta carotene (reference *26*, page 28). The conversions have resulted in widely different vitamin A values of equivalents for the same food plant. Reference *12* is a compilation of two previous publications; in one of these (HAES Tech. Bull. 30, 1956), the authors used one mcg of yellow pigments as equivalent to one IU of vitamin A. Since all yellow pigments are not carotenes or beta carotene, earlier reported vitamin A values are unreliable, if such generalizations were made by authors. To bring the information up to date, current analytical chemical methods need to be applied for data correction.

[b] Reference number in parentheses follows each value.

[c] Raw values for cassava leaves are reported for comparative reasons only; the leaves should never be eaten without cooking.

[d] Variations are due to color (see footnote a).

[e] Calcium values are higher for steamed and stir-fried pods and leaves.

APPENDIX 2: RECIPE ACCEPTANCE QUESTIONNAIRE

Date ____________

Please answer the following questions about the recipe that was prepared for you today:

1. How did you like the dish? Please circle the appropriate response.

not at all	not too bad	neither like nor dislike	like somewhat	very much
1	2	3	4	5

2. Would you use this recipe in your home?

   ______ YES ______ NO If NO, why not?

3. Would you serve this recipe to guests?

   ______ YES ______ NO If NO, why not?

4. Would you like to learn to prepare this dish?

   ______ YES ______ NO If NO, why not?

5. Please suggest ideas for improving the FLAVOR, TEXTURE, or APPEARANCE of this recipe (if necessary).

6. Additional comments: for example, have you seen this vegetable in your "home" country? Have you seen this in your local markets? Would you like to grow this vegetable in your own garden? Etc.

Ethnicity ____________

Age ____________

APPENDIX 3: EXAMPLE OF THE CALCULATION OF THE NDpCal%, PROTEIN SCORE, AND NUTRIENT CONTENT OF A MENU USING A TROPICAL VEGETABLE

Menu: Hibiscus Gulay, coconut, rice, fish.
Serving: 'Sunset' hibiscus (200 g), rice (280 g), fish (30 g), coconut (60 g).

Part A: Nutrients in menu

Food	Kcal	Protein (g)	Calories from protein	Calcium (mg)	Vitamin A equivalent (IU)	Iron (mg)	Ascorbic acid (mg)
Hibiscus	91	9.6	38.4	814.0	18,000	4.4	148
Rice	496	9.4	37.9	11.2	0	0.3	0
Fish	38	6.3	25.1	11.3	0	0.4	0
Coconut	216	4.0	16.0	12.0	0	1.2	0
Total	841	29.3	117.4	848.5	18,000	6.3	148

1/3 RDA is met in this menu.

Part B: Calculation of protein quality of menu (protein score and NDpCal%)

Food	Essential amino acids (EAA)								Total of all EAA for each food (E)
	Ile	Leu	Lys	Met	Phe	Thr	Trp	Val	
Hibiscus	352	610	434	108	400	372	80	450	3,218
Rice	1,020	1,876	730	750	1,168	960	244	1,542	9,624
Fish	300	481	570	179	245	287	63	383	2,812
Coconut	183	311	163	90	210	158	50	251	1,596
Total of each EAA in all foods (A)	1,855	3,278	1,897	1,127	2,023	1,777	437	2,626	17,250
$100\frac{A}{E}$ (X)	10.7	19.0	11.6	6.5	11.7	10.3	2.5	15.2	
$100\frac{A}{E}$ (Y) (for egg)[a]	12.9	17.2	12.5	7.5	12.8	9.9	3.1	14.1	
$100\frac{X}{Y}$	84	112	89	88	92	105	81	109	

Protein score = 81
Protein calories % = 14.0
NDpCal% = 9.2 (using the nomogram Figure A. 2.1 on page 231 of reference 9)

[a]The protein score (A/E) of egg is the accepted standard to which protein scores of other foods are compared.

APPENDIX 4: RECIPES USING TROPICAL VEGETABLES[1]

Recipes for Use in Tropical Areas

1. Hibiscus Gulay (Filipino)

2 lb. 'Sunset' hibiscus leaves
2 large tomatoes, sliced thin
1 small round onion, sliced thin
1 tsp. salt
2 Tbsp. patis
1 tsp. salad oil

Pick off tender hibiscus leaves and stems; blanch in boiling water. Do not overcook. Drain. Combine all ingredients in a bowl and toss lightly but thoroughly. Serves 4.

(Submitted by Y. H. Yang, East-West Center, University of Hawaii, Honolulu, Hawaii)

2. Pigeon Peas with Rice (Tongan-Puerto Rican)

1¼ cups rice, presoaked
¼ cup melted butter or margarine
1 medium onion, chopped
1½ tsp. salt
1 tsp. basil
1 tsp. oregano
1½ cups peas or beans (such as pigeon peas, winged beans, etc.), precooked
2½ cups chicken bouillon or broth
1 clove garlic, minced

Clean and wash the rice; soak it for half an hour. Heat butter or margarine and fry onions until golden. Fry garlic, then add drained rice, salt, and peas; continue to cook for 5 minutes, stirring. Gradually add hot bouillon, mix thoroughly, and bring to a boil. Simmer, covered, for 20-25 minutes or until liquid has been absorbed and rice is tender. Any of the following spices can be used: cloves, cinnamon, caraway seeds, turmeric, ginger, red pepper, coriander, parsley, or cumin. Serves 6.

3. Korean-style Cassava Leaves (Korean)

1 Tbsp. toasted sesame oil
¼ tsp. cayenne pepper
2 Tbsp. fresh grated ginger
¼ tsp. salt
2½ Tbsp. lemon juice
3 Tbsp. honey
1 lb. tender young cassava leaves

Combine first four ingredients and saute in a wok to bring out the flavor of the spices. Mix in the next two ingredients, add the leaves, and stir fry until slightly wilted. Serves 6.

(Adapted from a recipe by Kathy Hoshijo, Honolulu, Hawaii)

4. Japanese-style Hibiscus Greens (Japanese)

½ lb. young, tender edible hibiscus leaves
3 Tbsp. sesame seeds
3 Tbsp. sesame oil
2 Tbsp. shoyu
2 Tbsp. vinegar
1 Tbsp. sugar

In a large skillet or wok, heat the sesame oil. When fairly hot, add the sesame seeds and toast in the oil until they begin to pop. Add the shoyu and vinegar to the skillet mixture. Toss in the greens and stir fry until just wilted looking. The sugar may be added at this final stage and tossed with the greens. Serves 4-6.

(Recipe idea suggested by Sue Shimoda, Honolulu, Hawaii)

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[1]Although many of the recipes call for salt, the authors suggest leaving it out.

5. Stir-fried Amaranth and Tofu (Chinese)

2 cups tofu, cut into 1-inch cubes
Oil as needed
1 lb. amaranth, cut into small pieces
½ cup toasted sesame seeds
1 clove garlic, minced
½ cup diced onion
Shoyu to taste

Saute garlic and onion in the oil. Add the tofu, tossing in the mixture for 5 minutes. Push tofu to the center and add the amaranth around the edges. Sprinkle the sesame seeds over the mixture, add shoyu to taste, and steam, covered, to wilt the greens. Do not overcook. Remove from heat. The excess cooking liquid may be served with the amaranth mixture over rice. Serves 3-4.

6. Luau and Coconut Cream (Tongan-Hawaiian)

Coconut cream from 2 or 3 nuts
1 bunch taro leaves (luau)
1 onion, chopped
2 tsp. curry powder water
2 tomatoes, chopped
Salt to taste

Bring coconut cream and about 2 cups water to boil (if there is a lot of water in the cream, do not add more). Add luau either whole or sliced; submerge. Add onion and simmer until cooked, approximately 20 minutes. Add curry and tomatoes and reheat. Turn leaves only once during cooking, and shake pot rather than stir. Add salt as needed. Serves 4-6.

(Recipe from reference *17*)

7. Indian-style Ceylon Spinach (East Indian)

3 Tbsp. peanut oil
1 tsp. turmeric
1 tsp. mustard seed
½ tsp. salt
4 cups Ceylon spinach, chopped fine

Heat oil; add turmeric, mustard seed, and salt. Simmer until mustard seeds pop. Then add the finely chopped Ceylon spinach. Stir briskly over heat. Serves 4.

(Adapted from a recipe in reference *17*)

8. Chicken Picadillo (Filipino)

2 Tbsp. cooking fat
1 tsp. minced garlic
2 Tbsp. sliced onion
½ cup chopped tomatoes
1 cup diced chicken meat
4 cups water
2 tsp. salt
Dash of pepper
3 cups marunggay leaves, washed and separated from stem

Saute garlic, onion, and tomatoes. Add chicken meat. Cover and cook 5 minutes over low heat. Add water and bring to a boil. Season with salt and pepper. Add marunggay leaves and cook 5 minutes longer. Serve with rice. Serves 6.

(Adapted from a recipe in reference *15*)

9. *Confetti Breadfruit (Hawaiian-American)*

3½ lb. (or 7 cups) breadfruit, cooked and mashed
1 cup milk, heated
4 Tbsp. butter or margarine
1½ to 2 tsp. salt
¾ to 1 tsp. pepper
2 cups fresh comfrey, chopped and steamed
1 cup diced sweet red pepper

Wash green, unripe breadfruit. Do cutting under running water to prevent hands and knife from getting very sticky from sap. Cut off stem and cut breadfruit into quarters, cutting out the core as you would an apple. Cut quarters in half. Cover with lightly salted water and boil one hour until soft. Drain and mash, and add remaining ingredients. Mix well and serve. Serves 8-10.

(Adapted from a recipe by Kathy Hoshijo, Honolulu, Hawaii)

10. *Chinese Ung Choy (Chinese)*

9 cups ung choy, cut into 4-inch lengths
1 small slice fresh ginger root
1½ Tbsp. peanut or salad oil
⅓ Tbsp. fish sauce, preferably shrimp
1 clove garlic, mashed
1 Tbsp. sugar

Wash ung choy and discard the toughest portions of the stems. Cut tender stems into 4-inch lengths. Heat the oil, add mashed ginger and garlic, and fry until golden brown. (These may be removed after frying or left in to be fried with the ung choy if a stronger flavor is desired.) Add the fish sauce to the oil; cook for 2 minutes, stirring constantly. Add ung choy stems, and cook for 5 minutes. Add the sugar and the leafy ung choy and cook for 10 minutes (or until tender), stirring frequently. Serve hot. Serves 4-6.

(Recipe from reference *25*)

Recipes for Use in Nontropical Areas[2]

11. *Savory Spinach (Tongan-European)*

1½ lb. 'Sunset' hibiscus, amaranth, or luau (taro leaves)
¼ cup butter or margarine
½ cup chopped onion
1 clove garlic, crushed
½ tsp. salt
½ tsp. pepper
2 eggs, well beaten
½ cup soft bread crumbs
¼ cup grated cheese

Wash leaves and remove tough stems. Melt butter in saucepan. Add onion, garlic, "spinach," salt, and pepper. Cook with lid on until spinach is soft. Remove the lid and cook until moisture has evaporated. Cool. Combine cooked spinach with well-beaten eggs. Place mixture in baking dish. Brown soft bread crumbs in a little butter. Combine with ¼ cup grated cheese and sprinkle over spinach. Bake in moderate oven (350°F) for 45 minutes. Serves 4.

[2]Many of these recipes call for ingredients and cooking methods not often used in the tropics.

12. Stuffed Papaya (Southeast Asian)

2 large green papayas
½ cup peanuts
4 hard-boiled eggs
½ cup shelled green peas (if using winged beans or pigeon peas, parboil first)
½ cup cooked rice
8 small sweet potatoes
Salt and pepper to taste

Wash, peel, and cut sweet potatoes into small pieces. Peel the papaya. Cut out a piece from the top and remove the seeds. Peel and slice the hard-boiled eggs. Mix together the eggs, rice, sweet potatoes, peas, peanuts, and seasonings. Put the mixture inside the papaya. Put back the top piece and tie tightly with string. Boil in a pot of water until the papaya flesh is soft. To serve, cut into three pieces. Eat hot or cold. Serves 3–6.

13. Easy Ung Choy Salad (Filipino)

2 cups ung choy, steamed
2 large tomatoes, sliced
½ cup marunggay leaves, steamed
2 sweet red and green peppers
1 cup shredded green papaya
½ cup French dressing

Soak ingredients in half of the French dressing for a few minutes and chill if possible. Arrange on a plate, putting ung choy and marunggay mixture at the center, with sweet peppers, green papaya, and tomatoes alternating. Pour remaining French dressing over the dish and serve. (Winged bean leaves can be used instead of ung choy.) Serves 3–4.

(Recipe from reference *22*)

14. Shrimp Stew

¾ lb. fresh shrimps (as purchased)
½ cup sliced tomato
1 cup amaranth, chopped
2 cups boiling water
1 clove garlic, mashed
1 cup winged beans, cut into 1-inch pieces
1⅓ cups sliced onion
2¼ tsp. salt

Slice the onion and amaranth fine, and cut the tomato into eight or 10 sections. Clean the shrimps by removing the shell and the black vein that runs along the back. Cut the shrimps in two. Combine the vegetables except the amaranth, add the water, and boil for two minutes. Add the shrimps, amaranth, and salt. Cook for several minutes until the shrimps are done. Serve hot with rice. Serves 6.

(Recipe from reference *25*)

15. Amaranth with Eggs Japanese Style (Japanese)

¼ cup iriko
2 cups water
2 Tbsp. shoyu
1/16 tsp. monosodium glutamate, if desired
½ tsp. salt
2 bunches amaranth leaves (2 lb.)
6 eggs

Wash the amaranth thoroughly and cut it into 1-inch lengths. Wash the iriko and boil it in the water for 15 minutes. (Two cups of beef broth may be substituted for the iriko and water.) Drain and discard the iriko. Add the shoyu and salt and bring the liquid to the boiling point. Add the amaranth and boil 8 to 10 minutes. Beat the eggs slightly, add to the amaranth, mix thoroughly, and cook slowly until the eggs are partially firm. Serve hot. Serves 6.

16. Luau Souffle

2 cups taro leaves (2 bunches as purchased)
2 Tbsp. butter or margarine
¼ cup flour
⅔ cup milk
3 eggs, separated
¼ tsp. salt
Dash of pepper

Cook and season the taro leaves as follows: Wash the taro leaves thoroughly. Remove the stem and strip the membrane from the large vein on the back of each leaf. Add taro leaves to a kettle with enough water to partially cover the leaves. Allow to simmer for 1 hour or until the liquid has evaporated and there is no longer any "sting" from the luau noticeable on the tongue. Press the taro leaves through a coarse sieve. Melt the butter, add the flour, and make a smooth paste. Pour in the milk gradually and cook until the mixture is thick. Add the leaf pulp, slightly beaten egg yolks, and seasonings. Fold in the stiffly beaten egg whites and pour the mixture into a slightly oiled baking dish. Place the dish in a pan of water and bake it in a moderate oven (300° to 350°F) for 50 minutes. Serve immediately. 1 Tbsp. bacon fat may be used to season the luau if added flavor is desired. Serves 5.

(Recipe from reference 25)

17. Pork Kamote (Filipino)

3 Tbsp. oil
2 cloves garlic, crushed
1 large onion, chopped
1 lb. pork, cut into small pieces
¾ tsp. salt
¼ tsp. pepper
1½ cups water or broth
2 lb. young kamote leaves, washed

Heat the oil in a frying pan. Saute the garlic and onion. Add the pork and saute. Add the salt, pepper, and water. Simmer 5 minutes. Add greens; cover and cook for 3 minutes. Serves 4.

18. Winged Beans Basque Style (Basque)

1 lb. fresh winged beans, washed and broken into 1-inch lengths
4 Tbsp. olive oil
2–4 cloves garlic, minced
1 large onion, chopped
1 lb. tomatoes, peeled and coarsely chopped, or 1 small can tomato sauce
½–¾ tsp. salt
Freshly ground black pepper to taste
¼ tsp. oregano
½ tsp. turmeric

Heat olive oil in a saucepan or skillet and saute the onions and garlic until golden. Add tomatoes with all their juice (or the tomato sauce) and simmer. Meanwhile, bring a medium-sized pot of salted water to a boil. Plunge beans into the boiling water and boil for 5 minutes; drain. Add beans to the simmering sauce. If sauce seems too thick, a very small amount of water can be added; it should barely cover the beans. Add salt, pepper, and turmeric. Simmer, covered, for about ½ hour or until beans are fork tender. Stir in the oregano; taste and adjust seasoning if needed. Cook a few minutes more, uncovered, and serve hot. Serves 4.

(Adapted by Dave Jones, Kokokahi Church, Kaneohe, Hawaii)

19. Stewed Winged Beans and Tomatoes (American)

1½ cups sliced winged beans
1 cup diced fresh tomatoes
1 Tbsp. bacon fat
3 Tbsp. chopped onion
¼ cup chopped green pepper
1⅓ cups canned tomatoes
¼ cup canned corn
½ tsp. salt
Dash of pepper

Wash winged beans and cut into small, bite-sized pieces. Peel fresh tomatoes and dice. Heat fat, add onion and green pepper, and fry until slightly brown. Add all other ingredients, cover, and cook 15–20 minutes, or until winged beans are tender. Serves 5-6.

20. Winged Bean and Corn Soup (American)

½ lb. tomatoes, diced
1 slice bacon
¼ lb. winged beans, sliced
1 cup cream-style or whole corn
1¾ cups water
1 tsp. salt
Pepper to taste

Cut the bacon into small pieces and fry. Add the remaining sliced and diced vegetables, corn, water, and salt. Cook 10-15 minutes, or until winged beans are tender. Serves 4.

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