COMPOSITION OF HAWAII FRUITS

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We are indebted to Dr. Florence Pen (deceased, 1958) and Mrs. Florence Kee Ng for about half of the unpublished analytical work from the Department of Foods and Nutrition, and to Mrs. Mildred Ige for assistance in the calculations.

The people who prepared the publications listed under sources of data (p. 8) have also contributed to this bulletin.

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NAO S. WENKAM and CAREY D. MILLER

INTRODUCTION

Hawaii residents are fortunate in having available many fruits of tropical and semitropical origin, in addition to the familiar mainland fruits. This publication brings together data on food energy, proximate composition, three minerals, and five vitamins in about 60 fruits. Coconuts and macadamia nuts, though not classed as fruits, have been included. This publication has been prepared in response to repeated requests from nutritionists, doctors, dietitians, homemakers, educators, and other allied workers who are concerned with the nutritive value of foods in Hawaii, Asia, and other Pacific-basin countries.

Most of the fruits included have been introduced into the Hawaiian Islands since their discovery by Captain Cook; only the mountain apple, ohelo berry, and some of the bananas are indigenous species. Introduction of new varieties and a few species continues. The fruits analyzed include the most important ones grown in Hawaii and some of the less important.

At present, there is no readily accessible publication on the composition of fruits grown in Hawaii, as data have been lacking, or information previously available is out of print or in libraries only. Since this bulletin is of a technical nature it will be most valuable as a reference.

Fruits are essential for a good diet as a source of vitamins, organic acids, basic ash, and roughage. Attention should be given to the high nutritive value of some easily grown and generally available Hawaii fruits such as avocado, papaya, guava, mango, and acerola. The greater use of fruits, especially for desserts and between-meal snacks in place of high-carbohydrate sweets and drinks, is highly recommended.
SOURCES OF DATA

The food composition values are from chemical analyses and vitamin assays originating in the Department of Foods and Nutrition,¹ University of Hawaii, under the direction of one of the authors (CDM), with a few exceptions. About one-half of the figures are unpublished data—the work of Dr. Florence Pen, Mrs. Florence Kee Ng, and Mrs. Nao Sekiguchi Wenkam.

The other half are based on the original analytical data, determined for past Hawaii Agricultural Experiment Station publications, which were still available for use. About two-thirds of the published values are from analyses done for Technical Bulletin 30, *Vitamin Values of Foods Used in Hawaii* (18), and about one-third are from the proximate composition and mineral analyses done for Bulletin 77, *Some Fruits of Hawaii* (17). A small portion is taken from "The Composition of Hawaiian Fruits and Nuts," in the Report of the Hawaii Agricultural Experiment Station (27).² Parts of the data for coconut were taken from Bulletin 110, *Some Tropical South Pacific Island Foods* (20), and for macadamia nut from "Nutritive Value of Macadamia Nuts" (15). Most of the descriptive material is taken from *Fruits of Hawaii* (16).

To simplify the main tables, only one figure is given for each nutrient, although more than one assay may have been made. When analyses for a single fruit were done on more than one sample, i.e., vitamin values on one sample and the remaining nutrients on another sample, then the values were recalculated to a single moisture basis. Where more than one assay was done for a nutrient, adjusted mean averages are reported, except in a few cases where the combined judgment of the authors indicated that one or more should be omitted. Samples of each fruit are described in the Appendix.

EXPERIMENTAL PROCEDURE

Preparation and Sampling

The edible portions only were used for analyses. A list of the fruits analyzed, with a description of sample size, condition of fruit, portion considered refuse, and percentage of refuse, is given in the Appendix and in table 4.

In general, preparation involved washing the fruit with tap water and drying with cheesecloth or with an electric fan. The edible portions were thoroughly mixed and subsamples withdrawn for the individual nutrient analyses in a manner most conducive to the retention of each nutrient. For large items such as pineapples, papayas, avocados, etc., opposite lengthwise sectors were taken, cut into 1-inch pieces, thoroughly mixed, and subsamples taken for each nutrient.

¹ Now called the Division of Nutrition, Department of Home Economics.
² The analytical methods used for the latter two publications (17 and 27) were essentially those of the official chemists at that time.
Analytical Methods

**Moisture.** The percentage of moisture of fruits was determined in duplicate or triplicate. From 5 to 50 grams of comminuted sample were dried for 48 hours in an electric oven at 70°C or lower. The samples were held *in vacuo* in a desiccator over silica gel for another 24 hours. Loss in weight was reported as moisture.

**Protein.** The Winkler boric acid modification of the Kjeldahl method was used (11). The organic nitrogen is converted to NH₃, which combines with H₂SO₄ to form (NH₄)₂SO₄; NH₃ is liberated by NaOH and combines with boric acid to form ammonium borate. This is measured by standard HCl. The factor 6.25 was applied to convert the nitrogen content to protein for all fruits.

**Fat.** Ether extract was determined by the 1955 Association of Official Agricultural Chemists method for plants (1). The dry material was extracted with anhydrous ethyl ether for 4 hours in the Goldfisch fat extraction apparatus and the extract dried at 100°C to constant weight. Fat includes, in addition to the true fats, various fatty acids, sterols, chlorophyll, and other substances of similar solubility.

**Crude Fiber.** Crude fiber was determined by the 1955 Association of Official Agricultural Chemists method for plants (1). The ether extract residue was treated with boiling acid and with alkali for 30 minutes each. The residue was dried to constant weight at 110°C, weighed, ignited, and the loss in weight reported as crude fiber. It is made up largely of cellulose, hemicellulose, and lignin.

**Total Ash.** This refers to the total mineral matter residue after ignition of the sample. Samples of fresh material, weighing from 100 to 200 grams, were ashed in tared silica dishes in an electric muffle at about 525°C until a white or light gray ash was obtained, then cooled in a desiccator and weighed to determine total ash. When iron was to be determined, a reagent blank and recovery sample were added. Each ash was dissolved in HCl (1+4) and filtered. The residue and ashyless filter paper were reheated in the muffle until a white ash was obtained. This was treated like the first ash, added to the filtrate, and made to volume. Aliquots were used for calcium and iron determinations.

**Calcium.** A modification of the McCrudden method for calcium, by Ingols and Murray (7), as recommended by the Human Nutrition Research Branch, Agricultural Research Service, U.S. Department of Agriculture (28), was used.

**Phosphorus.** A modification of the Fiske and Subbarow method (5), recommended by the Human Nutrition Research Branch, Agricultural Research Service, U.S. Department of Agriculture (28), was used.

**Iron.** Utilizing the ash solutions and blanks prepared as outlined under total ash, iron was estimated by the Saywell and Cunningham o-phenanthroline colorimetric method (26).
Carotene (provitamin A). The chromatographic method described by the Association of Vitamin Chemists (2) was used with slight modifications. This procedure depends upon the separation of the biologically active carotenoid pigments from the nonactive pigments in an extract by an adsorbent with varying affinities for the different pigments. The extracting solvents were 1% alcoholic potassium hydroxide, acetone, and petroleum ether (B.P. 60°-70°C) in equal proportions; the adsorbent, a 1:1 mixture of magnesium oxide and Hyflo Super-Cel; and the eluent, 3 to 10% acetone in petroleum ether. The color intensity was measured in an Evelyn colorimeter, using a 440 μm filter, and the carotene concentration determined by reference to a calibration curve (90% beta- and 10% alpha-carotene mixture dissolved in petroleum ether). Three to 20 grams of sample were assayed in triplicate with a fourth aliquot for a recovery test.

Thiamine. The thiochrome procedure outlined by the Association of Vitamin Chemists (2) was used. This procedure depends upon the oxidation of thiamine to thiochrome, which fluoresces in ultraviolet light. Under standard conditions and in the absence of other fluorescing substances, the fluorescence is proportional to the thiochrome present and hence to the thiamine in the original solution. Triplicate aliquots and a recovery test were done on each sample.

Riboflavin. The fluorometric method outlined by the Association of Vitamin Chemists (2) was used. Riboflavin fluoresces and the intensity of fluorescence is proportional to the concentration in dilute solutions. Riboflavin is measured in terms of the difference between the fluorescence before and after chemical reduction. Triplicate aliquots and a recovery test were done on each sample.

Niacin. The microbiological assay method, as given by the Association of Vitamin Chemists (2), was used to determine niacin. The method is based on the observation that certain microorganisms require specific vitamins for growth. Using a medium complete in all requirements except niacin, the growth responses of Lactobacillus arabinosus are compared quantitatively in standard solutions and in sample extracts. The acid produced by the organism is measured to determine the extent of growth and thereby the amount of vitamin in the sample extracts. Duplicate aliquots and a recovery test were done on each sample.

Ascorbic Acid. Reduced ascorbic acid was determined by the dye (2, 6-dichloro-phenolindophenol) visual titration method or photoelectric colorimeter method as given by the Association of Vitamin Chemists (2). The method is based upon the reduction of the dye by an acid solution of ascorbic acid. In the absence of interfering substances, the capacity of a sample extract to reduce a standard solution of the dye is directly proportional to the ascorbic acid content. Duplicate aliquots were done on each sample.

Conversion Factors and Notes on Nutrients

Protein, Carbohydrate, and Food Energy. Protein values were calculated from the total nitrogen content by applying the conversion factor of 6.25, as the proteins in fruits contain 16 percent nitrogen (13).
Carbohydrate, representing total carbohydrate by difference, was calculated by subtracting the sum of the percentages of water, protein, fat, and ash from 100 percent. It does not represent carbohydrate as defined chemically. The term includes sugars and starches, which the body uses almost completely; fiber and pentosans, which are used less completely; and organic acids, which are not carbohydrates in the chemical sense.

Food energy, expressed in terms of the large or kilogram calorie, was calculated using the factors 3.36, 8.37, and 3.60 for protein, fat, and total carbohydrate, respectively, as recommended by the U.S. Department of Agriculture (13). For lime juice, the factor 2.70 for total carbohydrate was used. For coconut and macadamia nut, the factors 3.47 and 4.07 were used for protein and total carbohydrate, respectively.

Vitamin A Value. The values for vitamin A are expressed in micrograms or International Units. Since plants contain no preformed vitamin A, the values are derived from the carotenoid pigments. One microgram of the yellow pigments, presumably biologically active carotenoids, was considered to be equivalent to 1 International Unit of vitamin A. It was the opinion of one of the authors (CDM) that this factor gave figures more nearly representative of the true nutritional values than to consider 0.6 microgram of pigments as equivalent to 1 International Unit, for the following reasons: (1) the method used does not differentiate between beta-carotene, its isomers, cryptoxanthin, and some other pigments which have a lower biological value than beta-carotene, or have no vitamin A value (2, 3); (2) the utilization (absorption and conversion) of the pigments by the animal body is influenced by a number of other factors in the diet (23); (3) the utilization of carotene in foods, in a series of human digestive experiments, was found to be so poor that a standard for carotene three times that for vitamin A was recommended (6); and (4) the Advisory Committee for the Food Composition Table for Use in Latin America (9) recommended that 0.9 microgram of carotene, when the isomers of carotene are unspecified, be used for the conversion of 1 International Unit of vitamin A.

Calcium, Phosphorus, and Iron. The mineral contents in the tables represent the total amounts of minerals as determined analytically; no attempt was made to determine their availability.

DESCRIPTION AND NUTRITIVE VALUE

A brief description of each fruit is given. Most are familiar fruits, but a few are somewhat uncommon. For more detailed descriptions, publications on pomology should be consulted.

The nutritive value of the fruit samples is discussed. Fruits are no longer classed as luxuries, for it has been recognized, with the discovery of vitamins, that man is dependent upon fruits for some vitamins, especially ascorbic acid. They are also important sources of organic acids, basic ash, and roughage.
Some fruits furnish only small amounts of nutrients, but the variety of flavor, texture, and color combines to make them a refreshing addition to any diet.

Most fruits analyzed have a relatively high moisture content. In this study, some contain over 90% water (more than milk or apple juice), e.g., acerola, carambola, grapefruit, mountain apple, roselle, strawberry, tangerine, and watermelon. On the other hand, avocado, banana, breadfruit, cherimoya, and green sapote have less water than most fruits, about 70%, and ripe tamarind, about 35%.

Most fruits contribute less than 2% protein. Only tamarind contains 3%, but this fruit is consumed infrequently and in small quantities in Hawaii.

The fat content is less than 1% with the notable exception of the avocados, which show a range of 10 to 25%. The highest value is found in the Beardslee, a Guatemalan–West Indian hybrid avocado.

The carbohydrate values range from 6% in items such as avocado and watermelon to 30 or 35% in banana and breadfruit. The carbohydrate is present mostly as starches and utilizable sugars. Cellulose and other forms of carbohydrate which are not well utilized are represented by the crude fiber value.

Calories are derived mainly from carbohydrates, as most fruits are low in protein and fat. Compared with equal weights of other foods, many fruits (e.g., acerola, the citrus fruits, mountain apple, strawberry, and watermelon) contribute fewer calories—an important consideration in reducing diets.

Fruits on the whole are poor sources of calcium, phosphorus, and iron. Nutritionists recommend that the daily diet of an adult male aged 25 should supply 0.8 gram of calcium and 10 milligrams of iron (21). The body requires at least as much phosphorus as calcium; but, generally, if dietary calcium and protein are adequate, the phosphorus requirement also will be covered (21). For comparison of the fruits in this bulletin, the following arbitrary scale has been used to rate the mineral content (16).

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>milligrams per 100 grams of edible fruit</td>
</tr>
<tr>
<td>Calcium</td>
<td>more than 30</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>more than 40</td>
</tr>
<tr>
<td>Iron</td>
<td>more than 1.0</td>
</tr>
</tbody>
</table>

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Cactus fruit, green sapote, whole red Cattley guava, macadamia nut, mulberry, papaya, and tamarind are good sources of calcium, containing over 30 milligrams per 100 grams. The Beardslee and Nabal avocados, breadfruit, coconut cream, macadamia nut, poha, sweetsop, and tamarind are good sources of phosphorus. Iron is high in carissa, coconut cream, whole common guava, macadamia nut, mulberry, and strawberry. Although tamarind contains large quantities of calcium and phosphorus, this fruit is not widely used—and then in such small quantities—that its total contribution to the diet is negligible as compared to such fruits as papaya which may be eaten every day.

The National Research Council recommends that the daily diet of a 25-year-old man should supply 5,000 International Units of vitamin A, 1.2 milligrams of thiamine, 1.7 milligrams of riboflavin, 19 milligrams of niacin equivalents, and 70 milligrams of ascorbic acid. For the needs of different age groups of men, women, and children, consult the NRC recommendations (21). For comparison of fruits in this bulletin, the following arbitrary scale has been used to rate the vitamin content (16).

<table>
<thead>
<tr>
<th>VITAMIN</th>
<th>RATING</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Vitamin A value*</td>
<td>more than</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>more than</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
</tr>
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<td></td>
<td>more than</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>more than</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>more than</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>more than</td>
</tr>
<tr>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

* One milligram = 1000 micrograms

Fruits have no vitamin A, but those having yellow, orange, or red color contain carotenoid pigments. These can be changed by the body to vitamin A and are referred to as provitamin A. This term is used in this bulletin to indicate the vitamin A value. Foods with no color, such as lychee, are assumed to have little or no vitamin A value. Excellent sources of provitamin A are the Beardslee avocado, loquat, Haden and Pirie mangos, papaya, yellow passion fruit, poha,
and Surinam cherry. Good sources of provitamin A are Nabal avocado, Popoulu banana, green sapote, orange, purple passion fruit, persimmon, and tangerine.

On the whole, fruits are poor sources of the B vitamins when compared with other food groups. Macadamia nut is an excellent source of thiamine; good sources are breadfruit, cherimoya, orange, poha, sweetsop, tamarind, and tangerine. For riboflavin, excellent sources are the Beardslee avocado and tamarind. Eight others—Nabal avocado, Maiamoli banana, cherimoya, macadamia nut, mulberry, purple passion fruit, yellow passion fruit, and soursop—are good sources. Only the yellow passion fruit is an excellent source of niacin. Twelve others—Hulumanu avocado, breadfruit, cherimoya, green sapote, common guava, Kwai Mi lychee, macadamia nut, purple passion fruit, poha, soursop, tamarind, and wi-apple—are good dietary sources of niacin.

Fruits make their greatest contribution as a source of ascorbic acid. Acerola is probably the most potent source, containing 50 times as much as an equal weight of a good orange. Also, some guavas contain 7 or 8 times as much vitamin C as the orange. Some other fruits that are superior sources of ascorbic acid are carissa, grapefruit, ketambilla, lychee, orange, papaya, poha, strawberry, and wi-apple. In addition, cactus fruit, carambola, green sapote, red Cattley guava, Java plum, lime, mulberry, purple passion fruit, pummelo, sweetsop, and tangerine are good dietary sources of this vitamin.

**Acerola** (*Malpighia glabra*)

*Description.* This small, cherrylike fruit, which is native to tropical and subtropical America, is often referred to as the Barbados, the West Indian, or the Puerto Rican cherry. The fruit is borne on short stems on a shrublike tree which will grow to approximately 12 feet in height. The fruit varies in size from about ½ to 1 inch in diameter, and weighs from 2 to 10 grams. The thin skin may be light reddish-yellow or deep red when ripe. The flesh is usually of a reddish-yellow hue, although some types with dark-red skins also have dark-red flesh. The three-winged seeds are large in comparison to the flesh, but because they are light and pithy they constitute only about 20% of the weight. The fruit is sweet to acid in taste (depending upon the genetic type), with no distinct or pronounced flavor. Some think the flavor of the thoroughly ripe acerola and the fresh, raw juice made from it resembles that of tart strawberries. Although commonly called a cherry, the odor and flavor of cooked acerola are more like those of tart apples or crab apples than cherries. Malic acid, the only organic acid (other than ascorbic acid) which acerola contains, is also the principal acid in apples (25).

*Nutritive Value.* Acerola is an exceptionally rich source of ascorbic acid. It contains approximately 30 to 50 times as much ascorbic acid as orange juice on an equal weight basis, so that one or two cherries, depending on the size and on the concentration of ascorbic acid, will furnish sufficient vitamin C to supply the recommended daily allowance.
**Avocado (Persea americana and P. drymifolia)**

*Description.* There are three races of avocados represented in Hawaii, with the following characteristics:

1. **West Indian race.** Summer and fall maturing; fruit large; skin smooth and leathery in texture, and not more than $\frac{3}{4}$ inch in thickness.

2. **Guatemalan race.** Winter and spring maturing; fruit large; skin rough and woody in texture, and $\frac{3}{8}$ to $\frac{1}{2}$ inch in thickness.

3. **Mexican race.** Leaves and immature fruit anise-scented; fruit small; skin smooth and thin.

Many of the avocados found in Hawaii are of hybrid origin and may not be readily identifiable with the three races. The fruit is pear-shaped, round or obovoid, and sometimes weighs more than 3 pounds. The green skin, which changes in some varieties to red, purple, or purplish-black as the fruit matures, varies from smooth to warty in texture. The yellow or light-green flesh which surrounds the single large seed is smooth in texture. The best varieties have very little fiber in the flesh and a characteristic nutty flavor.

*Nutritive Value.* With the exception of the olive, no other fruit contains as large a percentage of fat as the avocado. The fat content varies from 9 to over 25%, according to variety and race.

In experiments on human digestion, the digestibility of the oils in fresh avocados was first found to be 93.7% (12), a value comparable to that for butter, but later experiments gave a value of 82.5% (4).

Avocados are a fair to good source of phosphorus, a good source of pro-vitamin A, riboflavin, and niacin.

**Banana (Musa spp.)**

*Description.* The banana is now one of the best-known fruits throughout the world. Of the common varieties, the cylindrical fruit varies in size from the small Chinese (Cavendish), 4 to 5 inches in length, to the large Bluefields (Gros Michel), 8 to 9 inches in length. The tough outer peel, though commonly yellow, may also be greenish-yellow or reddish-brown when ripe. The edible portion is generally creamy white in color, or creamy pink in some varieties. Dessert bananas may be eaten raw or cooked, but the plantains are more palatable after being cooked.

*Nutritive Value.* Greater use should be made of bananas because they are economical, nutritious, and available everywhere in Hawaii. In the half-ripe stage, one-half to one-third of the total carbohydrate may be in the form of starch and may cause digestive disturbances. When fully ripe, practically all the carbohydrate is in the form of sugars, and the fruit is readily digested even by infants.

Steaming whole cooking bananas for 20 minutes did not reduce the vitamin content appreciably (18).
Breadfruit (*Artocarpus communis*)

*Description.* The seedless type of breadfruit commonly found in Hawaii and known as the Hawaiian breadfruit is a large, round or oblong fruit 4 to 8 inches in diameter. The rind, green in the unripe stage, acquires a greenish-brown or yellow tint as the fruit matures. The slightly fibrous pulp surrounds a tough central core. The pulp is white, bland, and starchy in the green stage; light yellow and sweet in the ripe stage.

*Nutritive Value.* Breadfruit has about the same quantity of total carbohydrate (starch and sugar) as sweetpotato and taro, and more than the white potato. Like banana, breadfruit when fully ripe gives no test with iodine, indicating that all the starch has been changed to sugar.

The calcium content of breadfruit is higher than that of white potato and about the same as that of sweetpotato and taro. Compared with other fruits, breadfruit is considered to be only a fair source of calcium, but when eaten in large quantities it can supply a good proportion of the day’s needs.

Breadfruit is a good source of phosphorus, thiamine, and niacin. Baking for 1 hour at 325°F did not reduce the vitamin content appreciably (18).

Cactus Fruit (*Opuntia megacantha*)

*Description.* The cactus fruit is ovoid or pear-shaped, about 3 inches long, and 2 to 3 inches in diameter. It is yellow or dark purple and covered with fine spines and bristles. The pulp is sweet but bland and contains many hard seeds.

*Nutritive Value.* The cactus fruit is a good source of calcium and ascorbic acid.

Carambola (*Averrhoa carambola*)

*Description.* The carambola is a translucent yellow or yellow-green fruit 4 to 5 inches long and 2 to 3 inches in diameter. It has five prominent ribs which make it distinctly star-shaped in cross section. The thin waxy skin encloses a very juicy pulp and several smooth brown seeds. There seem to be two types—the sweet and the sour. Both are mild flavored.

*Nutritive Value.* The carambola is a good source of ascorbic acid.

Carissa (*Carissa grandiflora*)

*Description.* The fruit of the carissa is ovoid or round and varies in size and shape. A medium-size fruit is about 1 inch in diameter and 1½ inches long. The skin of the fully ripe fruit is bright crimson and sometimes streaked with darker red; it is thin and bruises easily. The flesh is deep red, or crimson, with white mottling. In the center there are about 12 small, brown, flat seeds. The fresh fruit has a mild, slightly pungent flavor, is slightly granular in texture, and is somewhat astringent.
When bruised, broken, or cut, the fruit and branches exude a white latex that is harmless, except that it may be irritating if it comes in contact with the eye.

**Nutritive Value.** The carissa has relatively large quantities of sugar and sufficient acid and pectin to make a good jelly. It is an excellent source of ascorbic acid, containing somewhat more than the average orange, and a good source of iron.

**Cherimoya (Annona cherimola)**

*Description.* The cherimoya is a green, heart-shaped fruit, 3 to 7 inches long, and has a smooth custardlike consistency. It contains from a few to many dark-brown seeds. The pulp is white, well flavored, slightly acid, with a characteristic pattern of rounded protuberances and indentations over the surface of the skin.

**Nutritive Value.** The cherimoya is a good source of thiamine, riboflavin, and niacin.

**Coconut (Cocos nucifera)**

*Description.* The coconut is the large, one-seeded fruit of the coco palm. The endosperm within the nut is the edible portion. A fibrous husk encloses the brown, hard-shelled nut, which is usually 4 to 5 inches in diameter.

G. P. Wilder states: "After being fertilized by the adjacent staminate flowers, the hollow interior of the shell becomes filled with sweet water. The spherical fruits gradually increase to from 4 to 8 inches in diameter. The endosperm, at first an opaque, jellylike substance, forms in the inner walls of the shell, and gradually absorbs the water; it attains a firm thickness of from 0.25 to 0.5 inch. This is known as the 'coconut meat' and forms an important article of diet for the Polynesian people." (29).

In the early stages the meat is soft and jellylike. Later, the meat becomes crisp and firm. In this bulletin, the watery liquid within the coconut is called "water" and the juice obtained by squeezing the grated coconut meat is called "cream."

**Nutritive Value.** The chemical composition of the edible portion of the coconut varies with the stage of development.

Immature nuts contain from 300 to 700 milliliters of water, and the average pH is 4.7 (17). The meat begins to form when the nut is 6 months old; that is, 6 months after the spathe has opened. As the meat develops, its water content gradually decreases, the fat and total ash increase, and the protein and sugar content show less marked changes (8). The mature nuts contain a relatively large amount (5.4%, fresh weight) of crude fiber (27).

Analyses of expressed coconut cream show it to be high in fat (25 and 35%) and low in protein (3 and 4%). It is a good source of phosphorus and iron. It has been pointed out that neither coconut water nor coconut cream is comparable to cow's milk in organic nutrients or calcium or phosphorus content (14).
Fig (*Ficus carica*)

*Description.* The leading variety of fig grown in Hawaii is known as the Turkish Brown or Brown Turkey, commonly called Turkey. It is pear-shaped, 1½ to 3 inches in diameter, and of mahogany-red color if exposed to the sun. The thin, easily bruised skin encloses a soft, pinkish-white pulp and many tiny seeds. The fruit matures from a large number of small flowers which develop within a protecting shell. This accounts for the small hollow in the center of the pulp, around which can be seen a layer of seeds and tiny dried flowers. The flavor is sweet and pleasing.

*Nutritive Value.* Brown Turkey figs are a fair to poor source of all the minerals and vitamins studied.

Grape, Isabella (*Vitis labrusca × V. vinifera*)

*Description.* The Isabella grape is an American type slipskin grape. The bunches are from 4 to 6 inches long and are very firmly packed. When ripe, the individual grapes are a deep purple-black with a light-blue bloom, and are about ½ inch in diameter.

*Nutritive Value.* Grapes have a distinctive flavor and refreshing qualities. The acids of Concord grapes (a related variety) consist of approximately 60% malic acid and 40% tartaric acid, a large portion of which exists in the form of alkali salts (22). Isabella grapes are a poor to fair source of the minerals and vitamins studied.

Grapefruit (*Citrus paradisi*)

*Description.* The grapefruit is globose, yellowish-green in color, and 3 to 4 inches in diameter. The pulp is pale yellow, greenish-yellow, or pink, and is composed of large distinct sacs; it varies in degree of juiciness and acidity according to variety and environment. The term pomelo is sometimes used instead of grapefruit, but the latter term has come to be the one most favored. (*See also* Pummelo, p. 25.)

*Nutritive Value.* The grapefruit is an excellent source of ascorbic acid.

Green Sapote (*Calocarpum viride*)

*Description.* The green sapote fruit resembles some persimmons, ovoid and pointed at the blossom end. It is 3 to 4 inches in length and tawny brown in color when mature. The fruit is astringent when green but sweet when thoroughly ripe.

*Nutritive Value.* The green sapote is a good source of calcium, provitamin A, niacin, and ascorbic acid.

Guava, Cattley (*Psidium cattleianum*)

*Description.* In addition to the common guava, there are two kinds of strawberry guavas in Hawaii—the dark-red strawberry guava (*Psidium cattleianum*)
and the yellow (*Psidium cattleianum* var. *lucidum*). The fruit is round, and \(\frac{3}{4}\) to 1½ inches in diameter. The center of the fruit is filled with a very juicy pulp and numerous small, hard seeds. It has a sweet and somewhat acid flavor. The yellow Cattley guava resembles the red but is a larger fruit.

**Nutritive Value.** The Cattley guava is a good source of ascorbic acid and calcium.

**Guava, Common (*Psidium guajava*)**

**Description.** The guava is a medium-size, round or lemon-shaped fruit, 1½ to 3½ inches in diameter, with a thick, coarse, edible rind surrounding a mass of seeds imbedded in a firm, soft pulp. The flesh color varies from white to yellow to red. Though the fruit may be either sweet or sour, it always has a distinct characteristic flavor and aroma.

**Nutritive Value.** The guava is a good source of niacin. The fruits vary greatly in ascorbic acid content, some having 2 to 5 times as much as others, but all may be considered excellent sources of this vitamin. The thick rind portion contains more ascorbic acid than the pulp and seeds, because there is a greater proportion of the rind than pulp in each guava, and because the rind is richer in ascorbic acid per unit of weight (19).

**Java Plum (***Eugenia cuminii**)**

**Description.** The Java plum, or jambolan, is a small, dark-maroon or purple fruit about the size and shape of an olive. There are at least two types in Hawaii, one with small, somewhat irregular-shaped fruit and one with slightly larger, symmetrical, olive-shaped fruit. The smaller variety has purple flesh, and the larger type has whitish flesh. The white-fleshed Java plum is sweeter and less astringent than the purple-fleshed variety. The astringent quality is believed to be due to the presence of tannins (16).

**Nutritive Value.** The Java plum is a good source of ascorbic acid.

**Ketambilla (***Dovyalis hebcarpa**)**

**Description.** In size and shape the ketambilla resembles a small plum or cherry. It is globose and varies from ½ to slightly more than 1 inch in diameter. The ketambilla has a thin, tough, deep-purple skin covered with short, gray-green hairs which give it a velvety or frosted appearance. There are 9 to 12 small seeds imbedded in the fibrous, deep-maroon or purple flesh. It has a strong acid flavor and stains a deep red or purple. The fruits hang by short stems on the underside of the thorny branches of a shrub that grows to a height of 10 to 15 feet.

**Nutritive Value.** The ketambilla is an excellent source of ascorbic acid.
Lime (*Citrus aurantiifolia*)

*Description.* The acid lime is a small citrus fruit of characteristic flavor. Several varieties are grown successfully in Hawaii. The common Chinese lime, also known as Mexican, or Key, lime is a small, globose or ovoid fruit about 1½ to 2½ inches in diameter. Its thin skin varies in color from light yellow to green. The flesh, yellow-green and very juicy, contains large quantities of citric acid.

*Nutritive Value.* The small quantities of limes used in the average diet make their nutritive value of minor importance. They yield an alkaline ash in the body because their high acidity is due to citric acid and its basic salts. They are good antiscorbutics, though the different varieties vary somewhat in their content of ascorbic acid.

Loquat (*Eriobotrya japonica*)

*Description.* The yellow, downy, loquat fruit is globose or ovoid, from 1½ to 2½ inches long. The white or yellow flesh enclosing a few large seeds has a pleasant acid flavor. Ripe clusters are sold in the markets.

*Nutritive Value.* The loquat is an excellent source of provitamin A. Although its acidity might suggest to some that it should be a good source of ascorbic acid, two samples showed only traces of ascorbic acid, which is confirmed by published values (9).

Lychee (*Litchi chinensis*)

*Description.* The lychee is a small, ovoid fruit about 1½ inches in diameter. The outer shell-like covering is red and the flesh surrounding the single brown seed is translucent white. The size of the seed varies considerably. The sweet and slightly acid flavor of the fresh lychee reminds many people of the Muscat grape. The dried fruits, known as "lychee nuts," are very different from the fresh, bearing somewhat the same relationship to the fresh fruits as raisins to grapes.

*Nutritive Value.* Of the two varieties analyzed, the Brewster and Kwai Mi, the latter is considered superior in flavor and quality, although it is a smaller fruit. Both are excellent sources of ascorbic acid. Kwai Mi is a good source of niacin.

Macadamia Nut (*Macadamia integrifolia*)

*Description.* The macadamia nut is enclosed in a smooth, extremely hard shell. Although the raw, white kernel has a delicious flavor, resembling hazelnuts or almonds, cooking in hot oil enhances the flavor. Consequently, practically all commercial macadamia nuts in Hawaii are marketed cooked, with or without salt.

*Nutritive Value.* Like all nuts, macadamia nuts are a concentrated food, low in moisture and high in fat, protein, and carbohydrate. They are a good source
of calcium, phosphorus, and iron, and of the B vitamins, thiamine, riboflavin, and niacin.

**Mango (Mangifera indica)**

*Description.* Many recognized varieties of mangos as well as unnamed hybrids are grown in Hawaii. In general, the mango can be described as a medium-size fruit from 2 to 4 inches in diameter and from 3 to 7 inches in length. The skin, which is smooth and thick, is strong enough in some varieties to be pulled from the flesh when the fruit is ripe. In most varieties, as the fruit matures, the green skin changes to more brilliant colors—purplish-red shading to green, deep crimson, or yellow with red spots.

The flesh varies in color from pale lemon to deep apricot. In the most prized varieties, it is juicy, smooth, and free from fiber. The flavor, which varies greatly, may be insipid or sweet, or reminiscent of turpentine. In the better varieties, the flavor and texture are excellent. Though sometimes compared to good peaches, mangos have a characteristic, delicious flavor of their own.

*Nutritive Value.* Mangos have sufficient yellow pigment to make them good to excellent sources of provitamin A. Different varieties of mangos vary greatly in ascorbic acid content. For example, two favorites, the Pirie and Haden, are only fair sources, whereas others, including some of the common types, are excellent sources of ascorbic acid. All varieties tested contained more ascorbic acid in the green stage than in the half-ripe stage and more in the half-ripe stage than in the ripe stage (table 7). For detailed information regarding the ascorbic acid content of various varieties of mangos grown in Hawaii, see table 5.

**Mountain Apple (Eugenia malaccensis)**

*Description.* The mountain apple is an ovoid fruit from 2 to 3 inches long. It has a very thin, crimson skin shading to pink or white. The crisp, white flesh is juicy and of pleasant though not distinctive flavor. Each fruit contains one or two large, brown seeds. The fruit is easily bruised and stains the hands deep purple.

*Nutritive Value.* The mountain apple is a poor to fair source of the minerals and vitamins studied.

**Mulberry (Morus nigra)**

*Description.* The black mulberry, a native of Persia and the Caucasus, is a small fruit that varies greatly in size but rarely exceeds 1¼ inches in length and ½ inch in diameter. Perhaps due to lack of cross pollination, it often appears in Hawaii in a seedless form, which may become a permanent variety. The seedless type is an excellent, well-flavored, subacid fruit that should be more widely cultivated. Mulberry trees will grow to a height of 20 to 30 feet in Hawaii, but
for fruit production they may be trimmed to the size of a small tree or even a shrub and used as a hedge. The best quality fruit is produced when the tree is well trimmed and well watered.

Nutritive Value. The mulberry is a good source of calcium, iron, riboflavin, and ascorbic acid.

Ohelo Berry (*Vaccinium reticulatum*)

Description. The ohelo belongs to the cranberry family. Its fruit is globose, red or yellow in color, may or may not be covered with bloom, and contains a considerable number of small, flattened seeds. The size varies from ¼ to ½ inch in diameter. It is edible either raw or cooked.

Nutritive Value. Ohelo berries are a poor to fair source of the minerals and vitamins studied.

Orange (*Citrus sinensis*)

Description. Several varieties of oranges have been introduced into Hawaii. At the present time, the Washington Navel is the principal variety grown commercially. This orange is medium to large in size, with the characteristic navel on the blossom end. In Hawaii's climate the skin does not develop the bright orange color seen in cooler climates. The flesh is juicy and varies from acid to sweet according to maturity.

Nutritive Value. The food composition of the Hawaii-grown oranges is similar to that of oranges grown on the Mainland. They are a good source of provitamin A and thiamine, and an excellent source of ascorbic acid.

Papaya (*Carica papaya*)

Description. The papaya is a melonlike fruit which varies greatly in size and shape. The Solo variety is a small fruit from 3 to 5 inches in diameter. The skin is smooth and thin, shading from green to deep orange. The flesh varies in thickness from 1 to 2 inches and from pale yellow to deep salmon-pink in color. Numerous round, black, wrinkled seeds, each enclosed in a gelatinous membrane, cling to the inner wall. The flavor and odor of the fruit are distinctive. The white latex that exudes from the leaves, stems, and unripe fruit is very irritating if it comes in contact with the eye.

Nutritive Value. Green, unripe papaya contains papain, a protein-splitting enzyme, but the ripe fruit is believed to contain little or none of this enzyme. The papain is probably not of any nutritional significance in aiding the digestion of protein, but it may be the reason that a few people experience some digestive distress after eating papaya.

The Solo variety is a good source of calcium and an excellent source of provitamin A and ascorbic acid.

Weekly tests were made for a year on the ascorbic acid content of Solo papayas from two localities on Oahu, Poamoho and Kailua. The ascorbic acid
content ranged from 60 to 122 milligrams per 100 grams, mean 84 milligrams (19). In papaya, ascorbic acid increases as the fruit ripens. When the skin is dark green and the flesh pale yellow, the fruit contains only 60 to 70% as much ascorbic acid as when ripe (table 7).

**Passion Fruit** (*Passiflora edulis*)

*Description.* The passion fruit is a medium-size oval fruit from 2 to 3 inches long. There are three types common in Hawaii, the purple (*Passiflora edulis*), the yellow (*Passiflora edulis* forma *flavicarpa*), and the orange (*Passiflora ligularis*), commonly called sweet granadilla or water lemon. Several other species are seen only occasionally. In these three types, the brittle shell encloses a juicy, yellow pulp and many small seeds. Although the shell dries up and becomes wrinkled after the fruit has matured, the pulp remains in good condition for several weeks.

*Nutritive Value.* The juice of the yellow passion fruit is an excellent source of provitamin A and niacin and a good source of riboflavin.

The juice of the purple passion fruit is a good source of provitamin A, riboflavin, niacin, and ascorbic acid.

The passion fruit juice keeps well because of its natural high acidity. The acidity of the purple and yellow juices was found to be 2.3 and 3.9%, respectively, calculated as citric acid (17).

**Persimmon** (*Diospyros kaki*)

*Description.* The persimmon fruits are ovoid to flattened globose, orange-red or yellow in color, thin-skinned, and 2 to 3 inches in diameter. The fruits of most varieties are astringent when green, sweet when thoroughly ripe, and contain one to ten large, flattened seeds. Some are seedless.

*Nutritive Value.* The persimmon is a good source of provitamin A.

**Pineapple** (*Ananas comosus*)

*Description.* The pineapple is a collection of small fruits, so it is called a multiple fruit. In the flower stage, the corollas are separate but the ovaries are fused, giving the appearance of a cluster of flowers on a single stalk.

The mature pineapple, a large fruit shaped like a pine cone, is about 6 to 10 inches in height and weighs 5 to 8 pounds. It grows on a stalk, or peduncle, that is a continuation of the plant stem of the low, cactuslike pineapple plant. The tough and horny rind is composed of small hexagonal sections, fitted together like pieces of tile. Each of these sections marks a botanically individual fruit.

The skin of a ripe pineapple may be deep yellow, chocolate-green, or mottled green and brown. The flesh is very juicy and has a somewhat fibrous texture.
It varies in color from pale to deep yellow. The edible portion surrounds a tough central core, which was originally the flower stalk.

**Nutritive Value.** The pineapple has long been valued for its distinctive flavor and refreshing qualities. Fresh, ripe pineapple is a good source of sugar. The Smooth Cayenne variety is a poor to fair source of the minerals and vitamins studied. The Pineapple Research Institute of Hawaii is developing new varieties that contain larger quantities of ascorbic acid than the Smooth Cayenne.

Of the nonvolatile acids in pineapple juice, about 87% is citric and about 13% is l-malic (22).

Some people find that eating large quantities of fresh pineapple causes a soreness of the mouth and esophagus. It has been suggested that this irritation may result from the combined action of the acid, the protein-splitting enzyme (bromelin), and the calcium oxalate crystals.

Pineapple does not increase in sweetness after it is harvested because there is no starch stored in the fruit which will change to sugar. The sugars are formed in the leaves of the pineapple plant and transferred to the fruit. Pineapple is usually sweeter in the summer months, when the days are longer and the sunshine more abundant.

**Plum, Methley (Prunus cerasifera × P. salicina)**

*Description.* The only variety of plum grown extensively at higher elevations in Hawaii is the Methley. The fruits vary in shape; some are globose, and others tend to be slightly ovoid with a distinct point at the blossom end. The size also varies, but good plums are 1½ to 2 inches in diameter.

The dark-red skin has a light bloom and the flesh, which is a rich red color, adheres rather tightly to the seed. When picked prematurely, the plums may be very sour, but when fully ripe the flesh is sweet, though tart, and of good flavor. The skin, like that of many other plums, is bitter.

**Nutritive Value.** The Methley plum is a poor source of the minerals and vitamins studied.

**Poha (Physalis peruviana)**

*Description.* The poha is a small, yellow-green or orange fruit resembling a cherry in size and shape. It is enclosed in a thin, cream-colored, paperlike husk. The skin of the fruit is thin and waxy and surrounds a juicy pulp which contains many small seeds. The poha, also called Cape gooseberry or husk tomato, is related to the ground cherry.

**Nutritive Value.** Pohas are a good source of phosphorus. They are an excellent source of provitamin A and ascorbic acid, and a good source of thiamine and niacin.
Pummelo or Shaddock (*Citrus grandis*)

*Description.* The pummelo fruit is globose to pear-shaped, 5 to 7 inches in diameter, with thick, smooth, pale-yellow skin. The pulp is often dry, subacid, and yellow or slightly pink in color. This fruit should not be confused with pomelo, for which grapefruit is the preferred term.

*Nutritive Value.* The pummelo is an excellent source of ascorbic acid.

Roselle (*Hibiscus sabdariffa*)

*Description.* The roselle is an annual plant that commonly grows to a height of 5 to 8 feet in Hawaii. The fleshy, bright-red calyx is the portion of the plant that is used as a fruit.

*Nutritive Value.* The roselle is very acid to taste and has little or no sugar. It is a poor to fair source of the vitamins studied.

Soursop (*Annona muricata*)

*Description.* The soursop is a large, irregularly heart- or kidney-shaped fruit. A single fruit may weigh 5 pounds or more and measure 10 inches or more in length. The thick skin, or rind, is a deep green and covered with numerous, soft, curved spines. The flesh resembles cotton soaked in a sweet, aromatic liquid. The pulp contains many shiny, brown seeds.

*Nutritive Value.* The juicy pulp of soursop is a good source of riboflavin and niacin.

Strawberry (*Fragaria spp.*)

*Description.* The cultivated strawberry is a juicy, red fruit which grows on a low, herbaceous plant. Structurally, it is an enlarged fleshy receptacle from ½ to 1½ inches in diameter, on the outside of which are imbedded many small seeds. The flavor combines acidity and sweetness in proportions pleasing to most people. Some varieties are more strongly flavored than others.

*Nutritive Value.* Strawberries are a good source of iron. The value is higher than that reported in the literature. Local strawberries of an unknown variety are an excellent source of ascorbic acid.

Surinam Cherry (*Eugenia uniflora*)

*Description.* The Surinam cherry is a small bright-red fruit about 1 inch in diameter, oblate in form, and conspicuously eight-ribbed. When ripe, it varies in color from a glistening light red to a very dark red. The flesh surrounding the single, large seed is soft and juicy. The fruit from most plants is distinctly acid and slightly bitter, but some plants produce subacid, sweet fruit.
**Nutritive Value.** The acidity of Surinam cherries is great compared with other fruits in this series; it is exceeded only by the tamarind and the yellow passion fruit. Two samples of expressed juice had pH values of 2.7 and 3.0 (17). Surinam cherries are an excellent source of provitamin A.

**Sweetsop (Annona squamosa)**

*Description.* The sweetsop fruit is ovoid and covered with large knobs which separate into sections when ripe. The pulp is creamy white, granular, and sweet with a pleasant flavor.

*Nutritive Value.* The sweetsop is a good source of phosphorus. It is a good source of thiamine and ascorbic acid.

**Tamarind (Tamarindus indica)**

*Description.* The fruit of the tamarind tree consists of a brittle brown pod, varying from 2 to 6 inches in length and from ½ to 1 inch in width. The pod encloses a very sticky, acid pulp which surrounds from 1 to 12 shiny, brown seeds. In maturity, the edible pulp shrinks slightly from the pod.

*Nutritive Value.* Analyses from the Department of Foods and Nutrition indicate that tamarind pulp, as compared with all other fruits, has an unusually high acid and high sugar content. The acid is reported to be largely tartaric (24). The acid of the sample analyzed in this department was calculated as 14% tartaric, or as 12% citric acid. One investigator (24) reports an invert sugar content of 41.2% for tamarind pulp, and analyses from this department show a carbohydrate by difference of 59.8%. The calcium and the phosphorus content are also unusually high; the value of 0.113% for calcium is one of the highest reported in the literature for any fruit and is equivalent to that reported for some vegetables. Whether the calcium is well utilized by humans is unknown. The ripe tamarind is a good source of thiamine and niacin, and an excellent source of riboflavin. Though its high acidity might suggest to some that it should be a good source of ascorbic acid, numerous tests of the fruit in both the ripe and green stages have shown the variety grown in Hawaii to contain trace amounts only.

**Tangerine (Citrus reticulata)**

*Description.* The tangerine fruit is flattened-globose, 2 to 3 inches in diameter, with a loose skin which may shade from green to orange in color at maturity. The flesh is orange-colored, sweet, and usually contains numerous seeds.

*Nutritive Value.* The tangerine is a good source of provitamin A, thiamine, and ascorbic acid.
Watermelon (*Citrullus vulgaris*)

*Description.* The watermelon, a large, smooth, green melon, is cultivated in many sections of the world. The rind varies from ¾ to 1½ inches in thickness and, from the outside in, shades from green to white to pink in color. The crisp, juicy, pink flesh contains many flat, slippery, black or white seeds. In good melons, the flavor is delicate, sweet, and refreshing. The watermelons grown in Hawaii average from 10 to 30 pounds. The Chilean Black Seeded variety has a thin rind. The Charleston Gray, a larger variety, has a thicker rind, from ½ to 1 inch in thickness.

*Nutritive Value.* Watermelons, like strawberries and mountain apples, contain 90% or more of water and 7 to 8% of carbohydrate in the form of sugar. Watermelons are a poor to fair source of the minerals and vitamins studied.

Wi-apple (*Spondias cytherea*)

*Description.* The wi-apple is apple-shaped, 2 to 3 inches long, and pale yellow in color when ripe. The yellow fibrous pulp surrounds a large central pit which contains seeds.

*Nutritive Value.* The wi-apple is a good source of niacin and an excellent source of ascorbic acid.

**RESULTS AND DISCUSSION**

The tables present values for nutrients that are of importance in evaluating diets and planning meals. These nutrients are: protein; fat; and carbohydrate; two minerals—calcium and iron; and five vitamins—vitamin A, thiamine, riboflavin, niacin, and ascorbic acid. The percentage of water, the food energy expressed in calories, and the phosphorus values are also shown.

Table 1 gives the food composition per 100-gram quantities of the edible portion, the unit widely used in research.

In table 2, the quantities of nutrients are expressed in household units and common portions, a form useful to dietitians, doctors, nutritionists, and homemakers. The size measurement is for each fruit “as purchased,” abbreviated AP, and the weight in grams for the “edible portion” as described. But in a few cases inedible parts are included in the description (e.g., acerola, grape, and roselle, 1 cup AP, and grapefruit, ½ medium AP), in which case the weight includes the inedible parts. The nutritive value is for the edible portion only.

In table 3, the 100-calorie portion is the basis for the amount of food listed. This unit is commonly used by the Hawaii Cooperative Extension Service agents, as it is easily understood by a wide group of women.

Table 4 presents the portions considered refuse and percentage of refuse.

In using tables of food composition such as these, it is important to remember that variations exist in the amounts of nutrients present in different samples.
of the same kind of food. The nutrients are affected by many factors, such as
environment (i.e., soil and climate), cultural practices, genetics, and treatment
after harvest (i.e., storage conditions or processing). Thus, the history of the
sample is a useful adjunct to the table (see Appendix). However, in terms of
practical nutrition, for the average individual who eats a good variety of foods,
variations in composition are usually not significant. Transportation and refood-
eration have enabled most people to include foods from different areas in their
diet, and farming and marketing practices have been improved in order to
supply the best quality foods to the consumer.

Comparison with Fruits Grown Elsewhere

Because there are many inquiries as to whether the nutritive values of
Hawaii-grown fruits are equivalent to those of fruits grown elsewhere, com-
parisons were made where possible with values published in the Food Composition
Table for Use in Latin America (9) and Composition of Foods Used in Far Eastern
Countries (10). The compilers of these two publications used original analyses,
which in their judgment were considered reliable in calculating the representat-
ive values.

To make a comparison, an arbitrary means of measuring differences was
devised on the basis of the Recommended Dietary Allowances (21) abbreviated to
RDA. For vitamins, differences greater than one-twentieth of the RDA were
considered to be nutritionally significant. One-twentieth of the RDA is, for
vitamin A, 250 micrograms; thiamine, 0.06 milligram; riboflavin, 0.08 milligram;
niacin, 1.0 milligram; and ascorbic acid, 4 milligrams.

For minerals in fruits, differences large enough to rate one source good and
another source poor (p. 12) were arbitrarily considered real differences. These
were: for both calcium and phosphorus, 15 milligrams; and for iron, 0.5 milli-
gram.

On this basis, the following published values were greater than those found
in this study: the calcium content of cherimoya and tangerine; the iron in
cactus fruit, Java plum, and ketambilla; and the ascorbic acid in ketambilla and
pineapple. Values of Hawaii-grown fruits which were greater than those
reported in the literature were as follows: vitamin A value of green sapote,
loquat, orange, poha, Surinam cherry, and tangerine; the calcium in tamarind;
and the iron in strawberry.

The data presented in this bulletin offer scientific evidence that the nutritive
values of fruits grown in Hawaii are comparable to those of fruits grown
elsewhere, based on the arbitrary criteria used.

Ascorbic Acid Variation

The variations existing in the nutrient content of different varieties and
samples of the same kind of fruit and at different stages of maturity are well
illustrated by the ascorbic acid studies on mangos (tables 5, 6, and 7, pp. 66–67).
One variety contained more than 20 times as much ascorbic acid as another variety (table 5). Not only was there variation between varieties, but individual fruits of the same variety showed wide variations (table 6). The data given in table 7 show that all varieties of mangos tested had more ascorbic acid in the green and half-ripe stages than in the ripe. On the other hand, in papayas and pohas, there was an increase in ascorbic acid as the fruit ripened.

**SUMMARY AND CONCLUSIONS**

About 41 species of fruits were studied, but often a number of horticultural varieties of the same species were analyzed separately so that the total number of samples was about 60. The fruits, of tropical, semitropical, and Asian origin, as well as some common American fruits, were all grown in Hawaii. Nutrients studied were: protein; fat; carbohydrate; three minerals—calcium, phosphorus, and iron; and five vitamins—vitamin A, thiamine, riboflavin, niacin, and ascorbic acid. Percentage of water and the food energy expressed in calories are given.

The analytical methods used and the conversion factors are described. A brief description and the nutritive value of each fruit are given.

The major results are summarized in three tables—in 100-gram quantities for research workers; in household units and common portions for doctors, dietitians, and nutritionists; and in 100-calorie portions for homemakers. For each nutrient studied, there are brief discussions regarding the best sources for each nutrient. For each fruit studied, comparisons are made with values reported in standard tables.

It is reaffirmed that the nutritive values of Hawaii-grown fruits are in general agreement with values reported for fruits grown elsewhere. A number of Hawaii-grown fruits, namely, acerola, common guava, Brewster lychee, and papaya, are superior to citrus fruits as sources of ascorbic acid.