SOME TROPICAL SOUTH PACIFIC ISLAND FOODS
Composition and Nutritive Value
MURAI PEN MILLER

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Some Tropical
South Pacific
Island Foods
Fig. 1. Coconut and pandanus trees surrounding thatched houses with neat graveled courts at Arno Atoll, Marshall Islands.
Some Tropical South Pacific Island Foods

description, history, use, composition, and nutritive value

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FOREWORD

This work has been a joint project of, and financially supported by, three agencies.

The Pacific Science Board of the National Research Council provided a fellowship under which Mary Murai did the field work and made some of the analyses for proximate composition and minerals. Miss Murai contributed much valuable information from her field notes and is responsible for the validity of her observations in the Marshall and Caroline Islands.

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The Foods and Nutrition Department of the Hawaii Agricultural Experiment Station, University of Hawaii, furnished the laboratory, the equipment, and the necessary overhead. The University also bore the financial cost of my salary during the time when I planned and supervised the work, did the library research, organized the material, and wrote the manuscript. For opinions expressed throughout the bulletin (especially regarding nutritive values) and for any errors of judgment, I take sole responsibility.

Carey D. Miller
Head, Foods and Nutrition Department
May, 1956
Hawaii Agricultural Experiment Station

* Deceased, February 17, 1958.
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INTRODUCTION

According to the reports of early explorers in the Pacific, the natives of the various tropical islands were a sturdy, healthy people (8, 10, 11, 13, 18, 31, 68), though the superior physique of the chiefly class noted by some was no doubt at least in part the result of their assured and better food supply.

Several hundred years of contact with people from presumably more civilized countries did little to improve the natives' lot nutritionally. Introduction of foreign diseases to which the islanders had little or no resistance (6) and the bad influence of some foreigners of low principles and bad morals could hardly be expected to improve the health and raise the standards of conduct of primitive people.

Though there were doubtless times of plenty and periods of food shortage, especially in areas subject to hurricanes and typhoons, the natives had devised some methods of food preservation (see pp. 18, 22, 72, and 73), and they utilized seasonal foods when available (breadfruit and pandanus) and kept others (root crops) for periods between seasonal foods.

The quantities of foods reported as taken by ships in the late 1700's and throughout the 1800's could well have reduced the local food supplies on some islands.

Like most other primitive people, the islanders had a diet limited to relatively few foods, but through generations of experience they worked out combinations of foods which the environmental conditions of the islands fostered. These facts, plus the ability to cultivate and select the best varieties of indigenous foods or ones which they had brought to the islands with them, must have afforded a reasonably adequate diet and promoted the good physical condition and good teeth noted by the early explorers and scientists.
Knowledge of the nutritive value of the most important foods of the islanders is not only of historical interest but should also be of some practical aid in attempting to assist them in subsistence agriculture under present conditions. Two modern observers, Buck (7) and Spoehr (57), believe that when the natives industriously cultivate their own foods, their health and general vitality are better than when so-called "civilized foods" replace to any extent the local native ones. Another modern observer, Williams (67), who studied the dental status of children and adults in Western Samoa, feels confident that the condition of the teeth of the island people who subsist largely on the native foods is far superior to the teeth of those who rely upon imported foods.

The apparent nutritional deficiencies found by Alpert in parts of Micronesia in 1946 (1) cannot rightly be attributed to the aboriginal type of diet but more likely to the disruptions of war and several generations of Western and Oriental influence.

Although it would seem to have been an ideal situation to have had medical and dental records on the people of the islands where food samples were collected and the dietary studies were made, that was not feasible. Moreover, it would have been practically impossible to have obtained a reliable record of the food consumed in the past which would have contributed to the present physical and dental status of the individuals. Dietary studies of a number of families and of several schools in the Marshall and Caroline Islands have indicated that the diets in 1951 were inadequate in a number of respects, using for comparison our American Recommended Dietary Allowances (22). Whether or not these standards can be properly applied to the people living in the tropical Pacific islands or whether they should be modified can only be determined by long and detailed study.

Original data on the composition and nutritive value of some of the principal foods used in the tropical Pacific islands are presented in this bulletin. We are aware that these are incomplete in some respects, but they probably represent the most extensive set of figures that has been gathered to date. We have endeavored to point out some of the shortcomings of our analyses and the need for additional research. We believe, however, that the material
here presented can be of real value to agriculturists and public health people interested in the welfare of the natives. Most of the foods analyzed were collected in the Marshall and Caroline Islands by one of the authors (M.M.), but there are also analyses of some foods from American Samoa, the Gilbert Islands, and Hawaii.

Collection of Food Samples

A glance at a map of the Pacific (p. xii) showing the great distances between island groups gives some idea of the transportation problems which may arise when one attempts to collect food samples in sufficient quantity for chemical analyses. However, this does not convey an adequate picture of the difficulties because travel between the islands and on the islands themselves is slow, irregular, and fraught with various hazards, and the climate is not conducive to maintaining food samples in proper condition to preserve the more labile vitamins. More than once, foods were collected in one area with the intention of transporting them to a base where they could be frozen and shipped on Navy or other vessels in the frozen state, only to have the plans completely disrupted by failure of the native boats to arrive or unusual weather with high seas which prevented the unloading of samples that had been gathered. When sailboats between islands were becalmed in hot weather, some of the samples deteriorated so that they had to be discarded. Transportation of the food samples by water or by air 2500-4500 miles to Honolulu was only a small part of the total problem of collection and transportation.

It is not always easy to get a good sample of a plant for botanical identification, but when quantities needed for analyses are required the problem is much more difficult. It was always necessary to get permission to gather the food samples because they were privately owned, and it was hard for the natives to understand why we should want three breadfruits, each from a different tree, when it was much simpler to pick them all from one tree. (Three breadfruits from three trees constitute a much more representative sample.) It was only the fine co-operation of the local people that permitted the collection of such satisfactory samples. We are especially indebted to the follow-
Local names of foods and food products in the Marshall and Caroline Islands were spelled as they sounded to one of the authors (M.M.) and may differ from the spelling used by others who have worked in these areas.

**Analytical Methods**

**Sampling.** Every effort was made to have uniform and representative samples for analyses. The procedures used for each sample are given in the Appendix, under the subhead, Preparation for Analysis.

The methods used for the analyses of each nutrient are outlined below, or references for each item are stated. Most of the analyses were made in triplicate, the others in duplicate. In some cases there was not sufficient material for triplicate analyses of all nutrients.

Details of all methods used are on file in this laboratory and will be furnished upon request.

**Moisture.** From 4.5 to 5.5 grams of finely chopped, fresh sample were dried for 48 hours in an electric oven at 70° to 80° C., except fruits which were dried below 70°. The samples were cooled in a vacuum desiccator (over dehydrite or silica gel) which was evacuated for 15 minutes and allowed to stand for 24 hours. The loss in weight was reported as moisture. For 75 percent of the foods the determinations were on triplicate samples.

**Protein.** Protein was determined by the Winkler boric acid modifications of the Kjeldahl method (41); 75 percent were triplicate analyses.

**Fat.** Ether extract was determined by the 1950 A.O.A.C. method 22.25 (2, p. 346); 90 percent were triplicate analyses.

**Crude Fiber.** Crude fiber was determined by the 1950 A.O.A.C. method 22.31 (2, pp. 346-347). All analyses were in triplicate.

**Total Ash.** Duplicate or triplicate samples of fresh material weighing from 100 to 200 grams were ashed in
tared silica dishes in an electric muffle below 750°F until a white or light-grey ash was obtained, cooled in desiccator, and weighed to determine the total ash. When iron was to be determined, two additional dishes were used, one a complete blank and the other with a known quantity of pure iron and 1 gram of the sample. Each ash was dissolved in HCl (1 + 4), filtered into a volumetric flask, and the residue and ashless filter paper reheated in the muffle until a white ash was obtained. It was dissolved in HCl, added to the first filtrate, and made to 250 milliliters at 27°C. Used for calcium and for iron determinations. Seventy-five percent of the total ash figures are averages of triplicate determinations.

Calcium. A modification of the McCrudden method (28) for calcium as recommended by the Human Nutrition Research Branch, Agricultural Research Service, U. S. Department of Agriculture (personal communication 71), was employed, utilizing the prepared ash solution above. All analyses were in triplicate.

Phosphorus. A modification of the Fiske and Subbarow method (20) recommended by the Human Nutrition Research Branch, Agricultural Research Service, U. S. Department of Agriculture (personal communication 71), was used. All analyses were in triplicate.

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 (56) taking all possible precautions in the laboratory to prevent contamination with iron. Sixty-five percent of the foods were analyzed in triplicate, the others in duplicate.

pH Determinations. The pH of fruit pulp or juice was measured on a Beckman pH meter. A pH 7 buffer was used to standardize the meter.

Vitamins. The methods outlined by the Association of Vitamin Chemists (3) were used. For carotene, thiamine, and riboflavin, triplicate samples were used with a fourth for recovery; for niacin, samples were assayed in duplicate with a third aliquot as a recovery test; and for ascorbic acid, duplicate or triplicate samples were used.

Carotene. The carotene content was measured physically by the chromatographic method of the Association, except that the extraction procedure was facilitated by using a mixture of solvents (petroleum ether, acetone, and
alcoholic KOH) in the Waring blender, followed by centrifuging (3, p. 52).

Thiamine. The thiochrome procedure described in Methods of Vitamin Assay was used (3, p. 111).

Riboflavin. The fluorimetric method as outlined in Methods of Vitamin Assay was used (3, p. 166).

Niacin. Niacin was determined by the microbiological assay procedure using Lactobacillus arabinosus (3, p. 180).

Ascorbic Acid. The reduced form of ascorbic acid was determined by use of the dye (2, 6-dichlorophenolindophenol) titration method (3, p. 76).

Calorie Values. For the calculation of the energy value of foods, factors were based on data published by Merrill and Watt (42). The factors for potatoes and other starchy roots were used for the mature green breadfruit as well as for the starchy aroids, sweetpotatoes, and arrowroot starch. The factors for fruits were used for breadfruit paste, which represents fully ripened breadfruit, and for pandanus. Factors based on (a) the heat of combustion values for fruit and (b) the digestibility coefficients of wheat bran (protein, 1.58; fat, 8.37; and total carbohydrate by difference, 2.24) were used in calculating the calories in pandanus flour, since more fiber is ingested in the case of pandanus flour than in pandanus fruit. The factors for mature legumes were used for mature and immature coconuts and for the protein and carbohydrate portions of coconut cream; but the factor for "other vegetable fats and oils" was employed in the case of the separated fat of the coconut, including the cream.

In a number of instances, the nutritive values of the samples analyzed were compared with the average values for some temperate climate foods published in United States Department of Agriculture Handbook 8, hereafter referred to as AH 8 (62).
BREADFRUIT

Description and Geographical Distribution

The breadfruit tree, with its large lobed leaves, is very handsome with or without its round or elliptic fruit. The fruit of the various varieties exhibit marked differences in size and shape (see Figs. 4 and 5) as well as differences in texture and flavor. The color and character of the rind varies with maturity and variety, but in the mature stage it tends to be light to medium green and changes to a yellow-green or yellowish brown when ripe. The rind is checked in a small, somewhat irregular, pentagonal or hexagonal pattern, corresponding to the tips of the ovaries, and may be smooth or rough depending on whether the faces are flat or elevated and pointed.

All the fruits have a soft core attached to the stem which can easily be removed when the fruit is soft and ripe. Fibers extending from the outside to the core may be coarse or very delicate, and they markedly influence the texture and quality of the flesh which, in the best varieties, is tender and bland and varies in color from pure white to a light cream in the mature starchy stage. The flesh becomes more yellow in color as the fruit ripens. (See Use, p. 10, for characteristics of stages of ripeness.)

According to Dr. Harold St. John, Professor of Botany at the University of Hawaii (76), the various kinds of breadfruit all belong to the species Artocarpus incisus (also known as A. communis and A. altilis). Since breadfruit has long been a cultivated plant, the local names given by the island people correspond to horticultural varieties, although the same variety will sometimes be given a different name in a different locality.

Throughout the tropical and semitropical islands of the
Pacific, breadfruit constitutes an important foodstuff wherever it can be grown, which is likely to be on all but the smaller and drier islands. Breadfruit can tolerate less salt in the subsoil than can pandanus and coconuts. Cox (12), after studying the hydrology of Arno Atoll, concluded that the distribution of productive breadfruit trees corresponds closely with the pattern of salinity of the ground water.

Folklore indicates the major place that breadfruit held as a food in pre-European days, and many accounts of the creation of man include the breadfruit (50, 66). Except for the seeded variety, the breadfruit must be propagated by rhizomes or suckers. The ingenuity and ability of the Polynesian, Micronesian, and Melanesian peoples in selecting and growing this tree, and its transportation and successful introduction into new islands as they were occupied by the migrating peoples evoke the admiration of the Westerner.

Almost all the breadfruit varieties are seedless, and, according to Dr. Kenneth P. Emory of the Bishop Museum and the University of Hawaii, only the seedless types grow in eastern Polynesia (70). But in Kapingamarangi and throughout Micronesia, Melanesia, and western Polynesia, as well as in southeast Asia, there are one or more varieties of breadfruit with seeds (54). In contrast to the seedless types which are never eaten raw, some seeded breadfruits are as commonly eaten raw as cooked (7). The edible seeds are always cooked and resemble chestnuts in flavor and texture (see p. 13 and 22).

It is the opinion of Dr. Emory that the breadfruits with seeds are hardier and will grow on coral atolls where the seedless types will not thrive. He states further that "the seeded breadfruit is a more valuable timber tree since it attains a far greater height," with a straight trunk.

When de Quiros, who accompanied Mendaña on his explorations in the South Pacific, visited the Marquesas Islands in 1595 he found the people using a fruit which grew on trees as their principal food. Though he did not name it, he gave a good description of the fruit, the tree, and preserved breadfruit (53).

The general local term for the fruit varies in different island groups. Those for Polynesia sound similar; for example, in Hawaii and Samoa it is *ulu*; in Kapingamarangi
and Rarotonga it is *kuru*; in Tahiti and the Marquesas it is *uru*. Likewise, in Micronesia, it is called *ma* in the Marshall Islands, *mei* in the Caroline Islands, and *mai* in the Gilbert Islands. It seems unfortunate that some form of the Polynesian or Micronesian terms should not have been adopted by Westerners instead of "breadfruit," which so far as we can learn was first used by William Dampier (13). He saw the fruit in Guam in 1686 and writes in the account of his voyage around the world, "The breadfruit (as we call it) grows on a large tree, as big and high as our largest apple trees. . . . There is neither seed nor stone in the inside, but all is of a pure substance like bread." Like de Quiros, almost a hundred years previously, he too, writes enthusiastically of its excellent qualities as a food, yet it was another hundred years before Cook's voyages stimulated the fateful trip of the *Bounty* in 1787, which was to have taken the breadfruit to the West Indies.

Use

All the seedless varieties of breadfruit are eaten only in the cooked state. Some varieties with large seeds may be eaten raw or cooked. The Pacific island people use almost all of their breadfruit in the mature but firm, starchy state because they prefer the bland flavor to the distinctly sweet taste of the ripe fruit. However, there are a few dishes described below which are made from the ripe breadfruit.

Since the Pacific island people had no cooking vessels in pre-European times, the breadfruit was cooked in the "earth oven" by means of heated stones, or was grilled or roasted over hot coals or stones. Both methods are still used in the Marshall and Caroline Islands, Kapingamarangi, and Samoa, but the breadfruit is also often boiled in water on a kerosene stove or over a fire.

The length of the breadfruit season is influenced by a number of factors; namely, the location and latitude of the island, the type of island (volcanic or coral atoll), the part of the island, the varieties of breadfruit grown, and the climatic conditions which may vary from year to year.

In Samoa in olden times, breadfruit is reported to have been the principal food for about six months of the year (61).
For Arno Atoll in the Marshall Islands, Stone (58) reports that "the peak of the breadfruit season is from May to July but the trees continue to bear in decreasing amounts until December." He thinks individual trees vary in duration of yield but that there is little varietal difference. Kramer (35) states that ripening begins in the northern islands in July and lasts until September, but that in the south, breadfruit is available throughout the whole year. This is confirmed by our Marshallese informant (Milne, 75) who tells us that on Ebon breadfruit are available almost the year round. On Moen, Caroline Islands, some kind of breadfruit can also be had all year round.

The Marshall Islands breadfruits which we analyzed were collected from Majuro Island in May and June before the height of the season.

Bascom (4) reports, for Ponape in the Caroline Islands, that breadfruit is associated with the rainy and humid seasons and is most plentiful about July and August, but that by planting both the early and late maturing varieties and by using the wild breadfruit from the hills, breadfruit may be available all year round. Hall and Pelzer (24) observed that in the Truk area varying quantities of breadfruit are
available for at least six months in the year and that the
main harvest season is from July to September. The
breadfruits from the Truk area in the Caroline Islands, for
which analyses are reported in this bulletin, were collected
in August and September at the height of the breadfruit
season.

Considering the economic importance and the nutritive
value of breadfruit for the people of the tropical islands in
the South Pacific, the problem of varieties and seasons
merits careful study, followed by selection and propagation
of early and late maturing varieties of high quality for all
the islands.

When "store foods" are not available, taro or other
starchy aroids, and/or pandanus are eaten between the
breadfruit seasons. The people of the Marshall and Car­
oline Islands prefer breadfruit to taro or other starchy
root crops.

Brief statements on appearance, use, and place in the
diet are given below for samples of breadfruit from the
Marshall and Caroline Islands and American Samoa which
were analyzed for this study.

**Batakdak.** Very smooth rind; flesh, creamy yellow and
smooth; oval shape, averaging about 10 inches long and 5
inches in diameter; average weight, 1200 grams or about
2\frac{1}{2} pounds.\(^1\) Baked, roasted, and boiled, mostly in the
mature green stage, but used also when ripe. The Marshall­
ese consider this their finest variety and call it "King" of
the breadfruits. In olden days, it was reserved for the
high chiefs.

**Bukdrol.** Rough rind (Fig. 4); flesh, white and less
smooth and tender than Batakdak; round in shape, averag­
ing about 6 inches long and 4 inches in diameter; average
weight, 820 grams. Baked, boiled, roasted, and preserved,
usually in the mature, green, starchy stage. The most
common variety in the Marshall Islands.

**Mijiwan.** Pale green, slightly rough rind (Fig. 4); the
white to cream-colored flesh is in small proportion to the
total weight (about 40 percent) because of the large number
of seeds (10–30 percent of total weight). Irregular in shape,
sometimes round and smooth, more often comma-shaped,

1. Average weights given in this section, unless otherwise specified, are
rounded means of three fruits weighed in the field.
like a cashew nut. Average weight, 680 grams. The only breadfruit analyzed that may be eaten raw. It is also baked, boiled, and preserved.

*Seeds of Mijiwan.* The seeds which are called "colè," vary in number, size, and shape. We found 10 to 15 seeds according to the size of the breadfruit. They tend to be irregular and unsymmetrical in shape and may be round or oval. Those we measured were from 2.5 x 1.4 x 2.0 cm. to 2.0 x 1.4 x 1.8 cm. The thin, dark brown skin or shell, about 0.5 mm. thick, is inedible. The seeds, which are unpalatable in the raw state, may be cooked with the intact breadfruit, or if the flesh is eaten raw, the seeds must be baked or boiled.

The texture and flavor of the seeds are often compared with chestnuts. They are firm, close-textured, and have a pleasant, sweet taste. Those from at least one variety are somewhat astringent and are not usually eaten. Sometimes the seeds are not cooked until they sprout.

*Atchapar.* Very rough rind; flesh, cream-colored, smooth and tender; ovoid in shape, approximately 9 x 4 inches; average weight, 1300 grams (second largest in Truk district). Boiled, baked, roasted, steamed, and preserved in mature green stage. Common breadfruit on Nomwin Island, uncommon elsewhere.

*Meichon.* Smooth rind (Fig. 5); flesh, pale yellow, very smooth and tender; round or slightly elongated, averaging 7 inches long by 5 inches in diameter; average weight, 1200 grams, about 2 1/2 pounds. It is good when cooked by any method and is regarded by the Trukese as their most superior breadfruit.

*Neisosoo.* Rind, rough and uneven (Fig. 5); flesh, light yellow and fibrous; elliptical, 10 inches by 5 inches; average weight, about 2300 grams or 5 pounds; largest variety in the Truk district. Boiled, baked, roasted, and

![Bukdrol.](image1.png)  
![Mijiwan.](image2.png)  

*Fig. 4. Two varieties of breadfruit from the Marshall Islands.*
Neisoso. Meichon.

Sawan. Smooth green rind (Fig. 5); flesh, tough and fibrous near the rind, smooth but spongy nearer the core; elliptical, 8 x 3$^\frac{1}{2}$ inches; average weight, about 900 grams or 2 pounds. Boiled, baked, or preserved.

Meikoch. Rind, rough and uneven; flesh, cream-colored and tender; slightly oblong, about 6$^\frac{1}{2}$ inches long by 4$^\frac{1}{2}$ inches in diameter; average weight, about 1200 grams or 2$^\frac{1}{2}$ pounds. Boiled, baked, roasted, and preserved. Fruit matures in October after the main harvest of other varieties.

Napar. Rind, rough (Fig. 5); flesh, white and tough; slightly oval, about 6$^\frac{1}{2}$ inches long by 4$^\frac{1}{2}$ inches in diameter; average weight, about 1000 grams or 1.8 pounds. May be used for any method of cooking but not as popular as Meichon variety because it is less palatable.

Puou. Rind, rough; flesh, cream-colored, tender; round in shape, averaging about 6 inches long and 5 inches in diameter; average weight, 1$\frac{1}{4}$ to 2 pounds.$^2$ May be baked or boiled. Two crops per year, the best between December and March and a second in June to August in American Samoa.

Maafala. Rind, smooth; flesh, tender; elliptical in shape, 7 or 8 inches by 4 inches; average weight, 1 to 1$\frac{1}{2}$ pounds.$^2$

$^2$ Dimensions and weights estimated by Dr. F. Losee, who furnished the samples.
Favorite variety in American Samoa. May be baked or boiled. Two crops per year, the largest usually from December to March.

Methods of preparing breadfruit and combinations of breadfruit with other foods which were observed in the Marshall and Caroline Islands are classified and listed below. Products analyzed are indicated by an asterisk (*). Products marked with a dagger (†) were described to one of the authors (M.M.) by native informants.

A. Cooked mature green breadfruit

1. *Ainbat* (Marshall and Caroline Islands). (The term "ainbat" has probably evolved from the two words "iron pot.")
   a. Boiled whole in rind for about 1 hour.
   b. The green rind is removed with a shell scraper or with a knife. The breadfruit is cut into halves, quarters, or eighths, and boiled in water for about 1 hour.

2. *Konjin* or *kwonjin* (Marshall Islands). *Notsuopos* (Caroline Islands). The rind is left on and the breadfruit is roasted over hot coals for about 2 hours. The black charred portion is removed with a shell scraper or knife.

3. *Kobjar* (Marshall Islands). *Mei um* (Caroline Islands). To cook in the earth oven, the whole green or half-ripe breadfruit with rinds are placed on the hot stones, covered with Cyrtosperma or taro leaves, and with an old mat or banana leaves. The mound is then covered with 3 or 4 inches of sand and left for about 1½ hours.

4. *Kon* (Caroline Islands). After removal of the rinds with a shell scraper, the mature green breadfruit are cut in quarters and the cores discarded. The sections are then steamed in an earth oven or in a large iron pot. If the earth oven is used, stripped sheaths of banana tree trunks are laid on top of the heated rocks before adding the breadfruit sections, which are piled systematically one on top of the other, and covered with taro or Cyrtosperma leaves. A small opening is left through which water is poured to create steam.
The hole is closed with more leaves and the whole covered with wet hemp sacks. After about 2 hours the breadfruit are removed and are ready for pounding.

The other method of cooking observed was as follows: A large iron pot (about 3 feet in diameter) over an open fire was filled with breadfruit sections, and a small amount of water added. Leaves from some starchy aroid and banana leaves were used to cover the breadfruit which was allowed to cook until soft, about 3 hours.

The steamed breadfruit is then pounded and made into kon by the men, who use a hand pounder made of coral rock (see sketch) and a pounding board.

When a small amount has been pounded to a dough-like consistency, another batch of steamed breadfruit is added. This continues until there is enough kon to make a loaf weighing 8 to 10 pounds. The loaves are made into neat bundles by wrapping them in taro, banana, or breadfruit leaves. Kon may be eaten the day it is made or it may be stored. By the fifth or sixth day, it begins to ferment. Although kon is preferred in the unfermented stages, it may be eaten after it becomes sour.

During the breadfruit season, kon is the staple and most important food of the Trukese. Men and women carry bundles of kon on their heads as they walk along the roads and they also take the leaf-wrapped packages on the native boats. Since there are no restaurants, and food is not given to travellers unless they are members of the same clan, one must carry his own food wherever he goes. As needed, the bundles of kon are opened and eaten with the fingers, along with some dried or canned fish.

B. Breadfruit combined with other foods

1. After removing the rind and core, the breadfruit may be stewed with fish or fowl.

2. Jokkob (Marshall Islands). Breadfruit porridge. The rind and core are removed, the breadfruit is cut into quarters or eighths, and boiled. When soft, the fruit is mashed, mixed with coconut cream, and salted to taste.
*3. Ror (Caroline Islands). Mature green breadfruit of the Meichon variety are roasted whole over hot coals for about an hour. The black charred portions are removed with a shell scraper. The remaining edible portion is usually pounded with a coral pounder, but it may be cut in large slices. Coconut cream is combined with the breadfruit, the mixture is wrapped in banana leaves, and put in an earth oven to bake for approximately 30 minutes.

*4. Emesefich (Caroline Islands). Breadfruit is cooked and pounded as for kon (see p. 15), then coconut oil is added and thoroughly mixed. The product is yellow, smooth in texture, and rich and sweet-tasting. The coconut oil is prepared by the method described on page 43, in the section on coconut.

†5. Arung (Caroline Islands). Breadfruit is roasted, and the rind and core removed. The edible portion is pounded in a manner similar to that used for kon but faster pounding movements are necessary to keep the breadfruit in a sticky, coherent condition. Small pieces are pinched off and rolled into dumplings to which coconut cream is added.

In Samoa, a similar product made for special occasions is called tafolo.

*6. Muatin (Caroline Islands). A mixture of kon (see p. 15) and coconut cream. The kon is put into a large bowl in one mass or it may be rolled into small pieces. Sufficient coconut cream is thoroughly mixed with the kon to produce a smooth, yellow, sweet-tasting product, the consistency of a very soft dough.

C. Ripe breadfruit

†1. Boljej (Marshall Islands). Mature green breadfruit is stored until it ripens. Rind and core are removed and the hole left by the core is filled with coconut cream. The top is plugged with a piece of the core and the whole wrapped in green breadfruit leaves, tied with a piece of pandanus root, and baked for about \( \frac{1}{2} \) hour.

†2. Ammach (Caroline Islands). Breadfruit is allowed to become thoroughly soft and ripe by storing it as long
as 10 days. It is then baked whole, the rind is removed, the flesh is cut or pulled into small pieces and mixed with coconut cream.

D. Preserved breadfruit

†1. *Bwiru* (Marshall Islands). The preparation of bwiru has been described by a number of people. Among the earlier ones are Hernsheim, 1884 (26), and Finsch, 1893 (19). The following description is condensed from field notes taken in 1950 by Dr. Leonard E. Mason, Professor of Anthropology, University of Hawaii (73).

Uncooked mature green breadfruit are used (usually about 50 to 100, but may be more). The rinds are removed with a shell scraper, the fruits are cut in two lengthwise, and the cores are removed and discarded. Batches of the cut fruit are placed in bags of sennit net and immersed in salt water of the lagoon or the ocean side. The bags are anchored with a piece of coral so as to keep them submerged but not touching bottom, and left for a day and a night. The fruit are taken from the water, piled on the ground, and covered with palm fronds. There they remain for 2 days and 2 nights, after which they become very soft and strong smelling. The breadfruit is squeezed between the hands and fin-

Fig. 6. *Breadfruit for bwiru is removed from lagoon and left covered with palm fronds overnight.* Photo by Gerald Wade.
fers to make a doughy mass. This mass is sprinkled with fresh water and stirred once a day for 3 consecutive days. It is now called bwiru.

The bwiru is placed in a pit lined with dried breadfruit leaves, covered with more breadfruit leaves and palm fronds, and left for about 2 weeks before using. By changing the breadfruit leaves, at first daily and later every week, the bwiru may be kept for as long as 1 or 2 years. The family removes bwiru from the pit as needed but it is always washed and cooked before using. It is also used to prepare manakajen (Fig. 9), ieok, chubwe, and bitro, described on page 21.

2. Apot (Caroline Islands). Preserved breadfruit. The
mature green breadfruit are scraped and cored, and left on the ground overnight covered with banana leaves.

A pit 3 to 5 feet by 2 feet deep is dug in the earth and lined with three or four layers of banana leaves. Breadfruits to the number of 200 to 500 are placed in one pit and covered with four layers of banana leaves which are weighed down with large rocks.

When the pit is opened, 2 or 3 months later, the breadfruit is a homogeneous, fermented mixture with a characteristic odor. The product is now ready for use, but it may be left in the pit for as long as a year, portions being removed as needed.

E. Dishes or preparations made from preserved breadfruit

†1. Manakajen (Marshall Islands). The preserved breadfruit is taken from the pit and compressed into slabs in "coconut cloth" (the fibrous, meshlike stipule of the coconut tree) and left in the sun to dry until it becomes very hard (about 1 week). See Figure 9. In this form the product will keep almost indefinitely. It is packed in bundles and covered with plaited pandanus to prevent insect attack and to keep it dry and clean. It thus forms an important emergency food.

To prepare the dried breadfruit for eating, it is broken into small pieces and soaked overnight in cold water. It is washed in several changes of water to clean it thoroughly and drained in a cloth bag. Then it is kneaded on a board until it becomes a sticky mass, and is used in the dishes described below.

Fig. 8. Marshallese man and wife kneading bwiru preparatory to cooking. Photo by Leonard Mason.
†2. Ieok (Marshall Islands). The washed and kneaded breadfruit (either bwiru or manakajen) is mixed with coconut cream and jekamai (coconut syrup), wrapped in fresh breadfruit leaves, and put in the earth oven to bake for 2 hours.

†3. Chubre (Marshall Islands). The preserved breadfruit prepared as described under bwiru or manakajen is mixed with coconut cream, wrapped in coconut leaves, and roasted on an open fire or hot coals.

†4. Bitro (Marshall Islands). Water with a little sugar is brought to a boil and small pieces of the preserved breadfruit, as described under bwiru or manakajen, are dropped in and boiled for 2 hours. The finished product resembles dumplings.

†*5. Apot mei mon (Caroline Islands). Preserved breadfruit (p. 20) is taken from the pit, kneaded by hand, put in a cloth bag, placed in the ocean or lagoon, and washed several times. The bag with the breadfruit is taken out and kneaded by hand or by foot to express the water containing the soluble materials resulting from the fermentation process and the salt water. Then sufficient fresh water is added to make the product the consistency of soft dough. Loaf-sized pieces are wrapped in breadfruit leaves and baked in the earth oven or steamed over boiling water.

†*6. Apot mei pupe (Caroline Islands). Preserved breadfruit taken from the pit is washed and kneaded as described for apot mei mon. Sufficient coconut cream is stirred in by hand to make a smooth, well-blended mixture which is made into bundles or loaves that are wrapped in breadfruit leaves and steamed in the earth oven for about an hour and a half. The finished product is light brown, has a strong coconut odor and flavor, but a sour taste from the fermented breadfruit despite the washing process to which it is subjected. It is oily and has a slightly rubber-like consistency.

Methods of preparing the seeded breadfruit

*Mijiwan (Marshall Islands). This variety may be eaten raw or cooked. The flesh is faintly yellow or white.
and has a sweet taste much like a banana. The common method of cooking is to boil, bake, or roast the breadfruit whole.

*Colé, or seeds, of the Mijiwan variety are always cooked before eating. The seeds resemble the chestnut in texture and flavor and are generally described as good tasting.

**Matete.** The Marshallese distinguish this as another variety of seeded breadfruit by the shape and size of leaves, but state that most people cannot distinguish between the fruits of this variety and Mijiwan. The Mijiwan and Matete varieties may be propagated from seeds.

†**Mamwe.** A third seeded breadfruit which is much larger than the other two and which has only a few seeds. It is commonly eaten in the cooked state. This variety is not produced from seeds but from roots or rhizomes.

†**Jankwin** (Marshall Islands). This product is always made from the Mijiwan (seeded) breadfruit. The fruits are picked in the mature green stage and allowed to ripen. The seeds, core, and rind are removed and the fruits are placed in coconut leaf baskets. The baskets of fruit are put in the earth oven and cooked overnight. The cooked breadfruit is spread on leaves and allowed to dry in the sun. After the breadfruit is dried, it is rolled and pressed to make a compact mass, wrapped in pandanus leaves, and tied with sennit in a manner similar to that employed for dried pandanus paste (see p. 73).

*Paku kura* (Kapingamarangi). Preserved breadfruit or breadfruit paste. In his book, *Material Culture of Kapingamarangi* (7), Dr. Peter H. Buck gives an excellent detailed description of the preparation of preserved breadfruit paste, which has been abstracted as follows:

Breadfruit with edible seeds are used. A thin peeling of the soft, ripe breadfruit is removed with a knife. (In olden times, they removed the rind by gently biting it off, if it was too soft to scrape with a shell.) The
seeds and core are removed; then large lumps of the soft fruit are wrapped in breadfruit leaves and cooked in the earth oven for 2 or more hours. The cooked breadfruit is removed from the leaf packages (which may have been left overnight, if not convenient to finish the process in 1 day) and pounded with a wooden pounder in a wooden bowl to produce a thick yellow paste.

The breadfruit paste is spread thinly on leaves placed on coconut-leaf mats and is left to dry in the sun. The paste is turned to dry on the other side and the strips are reversed as many times as needed to dry the paste to the required consistency.

The thin, oblong sheets of dried paste are rolled tightly to make a firm roll, trimmed at the ends, and covered with pandanus strips kept in place with sennit binding. Buck reports the completed roll, the preparation of which he describes in great detail, to have been 19 inches long and 3.8 inches in diameter. Prepared and wrapped in this way the paste has good keeping qualities and may be used for emergency and for long sea voyages.

Buck also reports that the paste, left in the stage of dried flat cakes, may be used at once to add variety to the diet.

Composition and Nutritive Value

The breadfruit products analyzed were: 17 samples of raw and cooked breadfruit, 2 samples of breadfruit seeds, 5 samples of breadfruit preserved and/or combined with some other ingredients, and 1 sample of breadfruit paste. Two samples of cooked breadfruit were from American Samoa and the breadfruit paste was from Kapingamarangi; all other samples were collected in the Marshall and Caroline Islands.

For methods of collection, storage of samples, and their preparation for analyses, see Appendix, pages 105 to 116. For analytical methods used, see pages 4 to 6.

The data on composition are summarized in Table 1.

*Breadfruit—fresh, whole*

The amount of waste and edible flesh of breadfruit var-
<table>
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<tr>
<th>Sample</th>
<th>Local name and method of preparation</th>
<th>Source</th>
<th>Water %</th>
<th>Food Energy</th>
<th>Protein</th>
<th>Carbohydrate</th>
<th>Fat</th>
<th>Total Fiber</th>
<th>Ash</th>
<th>Calcium</th>
<th>Phosphorus mg</th>
<th>Thiamine mg</th>
<th>Riboflavin mg</th>
<th>Niacin mg</th>
<th>Ascorbic acid mg</th>
<th>pH</th>
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<td>Marshall Islands</td>
<td>68.2</td>
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<td>1.82</td>
<td>0.52</td>
<td>28.51</td>
<td>1.55</td>
<td>0.95</td>
<td>28.8</td>
<td>61.6</td>
<td>1.02</td>
<td>0.101</td>
<td>0.084</td>
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<td>0.29</td>
<td>29.77</td>
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<td>0.93</td>
<td>20.9</td>
<td>62.5</td>
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<td>0.094</td>
<td>0.093</td>
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<td>52.9</td>
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<td>33.28</td>
<td>1.37</td>
<td>1.09</td>
<td>26.3</td>
<td>42.7</td>
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<td>0.070</td>
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<td>Protein</td>
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<td>2.28</td>
<td>0.129</td>
<td>0.083</td>
<td>1.34</td>
<td>19 Mijiwan, cooked 61.9</td>
</tr>
<tr>
<td>20</td>
<td>Breadfruit products</td>
<td>Caroline Islands</td>
<td>67.7</td>
<td>130</td>
<td>1.40</td>
<td>0.85</td>
<td>29.42</td>
<td>2.42</td>
<td>0.63</td>
<td>18.8</td>
<td>30.6</td>
<td>0.56</td>
<td>0.019</td>
<td>0.081</td>
<td>0.91</td>
<td>3.2</td>
</tr>
<tr>
<td>21</td>
<td>Apot mei mon, preserved breadfruit, baked†</td>
<td></td>
<td>54.2</td>
<td>270</td>
<td>2.74</td>
<td>18.89</td>
<td>23.65</td>
<td>2.24</td>
<td>0.52</td>
<td>20.7</td>
<td>61.4</td>
<td>2.10</td>
<td>0.019</td>
<td>0.026</td>
<td>0.36</td>
<td>3.2†</td>
</tr>
<tr>
<td>22</td>
<td>Emesefich, steamed pounded breadfruit with coconut oil†</td>
<td></td>
<td>69.7</td>
<td>129</td>
<td>0.85</td>
<td>2.37</td>
<td>26.33</td>
<td>0.87</td>
<td>0.75</td>
<td>12.2</td>
<td>32.7</td>
<td>0.46</td>
<td>0.052</td>
<td>0.043</td>
<td>0.78</td>
<td>6.5†</td>
</tr>
<tr>
<td>23</td>
<td>Muatin, steamed, pounded breadfruit with coconut cream†</td>
<td></td>
<td>68.4</td>
<td>125</td>
<td>1.05</td>
<td>0.46</td>
<td>29.42</td>
<td>1.26</td>
<td>0.67</td>
<td>20.3</td>
<td>32.5</td>
<td>0.33</td>
<td>0.078</td>
<td>0.042</td>
<td>0.66</td>
<td>1.6†</td>
</tr>
<tr>
<td>24</td>
<td>Ror, roasted breadfruit, baked with coconut cream†</td>
<td></td>
<td>61.8</td>
<td>191</td>
<td>1.58</td>
<td>8.78</td>
<td>27.00</td>
<td>0.93</td>
<td>0.84</td>
<td>16.1</td>
<td>50.2</td>
<td>0.61</td>
<td>0.074</td>
<td>0.046</td>
<td>0.68</td>
<td>3.2†</td>
</tr>
<tr>
<td>25</td>
<td>Breadfruit paste Kapingamarangi</td>
<td></td>
<td>20.8</td>
<td>283</td>
<td>6.34</td>
<td>2.16</td>
<td>67.72</td>
<td>5.14</td>
<td>2.98</td>
<td>134</td>
<td>164</td>
<td>0.83</td>
<td>0.140</td>
<td>0.116</td>
<td>7.42</td>
<td>* Actual figures obtained on frozen samples varied from a trace to 3 mgs. See page 28 for discussion. A† ascorbic acid assays made in the field by Mary Murai. T Made from the Meichon variety.</td>
</tr>
</tbody>
</table>
ies with the variety and size of the fruit. The percentage of waste for eight of the seedless types which were analyzed raw varied from 16 to 28 percent with an average of 23 percent. Thus the edible portion always exceeds 70 percent (pp. 105 to 116). In the Mijiwan variety, the total edible portion, including both flesh and seeds, varies from 46 to 60 percent. If one considers only the flesh, less than half the weight of the fruit, or approximately 43 percent, is edible.

**Breadfruit—edible portion, raw and cooked**

Breadfruit usually contains less than 0.5 percent fat (ether extract) and 0.7 to 2 percent of protein. Its carbohydrate content varies in the fresh state from about 22 to 30 percent with an average of 27 percent for the samples which we analyzed. When boiled, the moisture and carbohydrate remain about the same as in the fresh, but if it loses much moisture when roasted on hot coals or baked in the earth oven, the carbohydrate content may be proportionally increased.

Cooked breadfruit contains more carbohydrate than white potatoes, about the same amount as cooked sweet potatoes, about half as much as bread, and somewhat less than rice cooked by the Oriental method.

The relatively low crude fiber should not interfere with the absorption of other nutrients. Most of the values are a little more than 1 percent with several, especially the preserved products, containing more than 2 percent. (It seems likely that for Sample 7, some of the rind was not removed, otherwise the crude fiber would not have been so great.) White potatoes have less crude fiber (0.3 to 0.4 percent) but sweet potatoes are reported to have 1.0 percent for both the raw and boiled products (62) and about the same moisture content as the breadfruits which we analyzed.

There are no striking differences in the calcium content of the breadfruit from the low islands (Marshalls) and from the high islands (Carolines), but there appears to be considerable variation between varieties from both areas. The phosphorus and iron values for three varieties of breadfruit from the Marshalls are definitely higher than the six varieties from the Carolines.

The Maafala variety of breadfruit from American Samoa has twice as much calcium as the Puou variety and
almost twice as much phosphorus, but one was baked and
one boiled, and the dry matter differs considerably. Addi­
tional analyses would be required to learn if the Maafala,
which is the favorite variety in American Samoa, is truly
superior in this respect.

Breadfruit is at least twice as good a source of calcium
as white potatoes but not so good as sweetpotatoes. Bread­
fruit has about one-third as much calcium as white bread
made with 2 percent skim milk powder, but when compared
on the calorie basis, bread is only slightly superior to
breadfruit, and if made without skim milk powder it is less
good. Breadfruit has more than 10 times as much calcium
as cooked white polished rice.

Breadfruit has little yellow pigment and is usually
nearly white in the mature starchy stage; consequently it
would contribute little to the body's vitamin A needs. Car­
otene determinations were made on only the two breadfruit
samples from Samoa. Calculated to an average moisture
content of 68 percent, they contained 8 and 13 micrograms
of biologically active carotenoid pigments, or a vitamin A
value of approximately 10 International Units per 100
grams. As may be noted on page 112, these samples which
had been stored in the frozen state for some months before
analyses may have lost some carotene. Assays of cooked
samples of two varieties of breadfruit grown in Hawaii
gave values of 0 and 24 micrograms of carotene per 100
grams (47). It seems safe to conclude that, even when
eaten in large quantities, breadfruit can make only a neg­
ligible contribution of provitamin A to the diet.

The figures for thiamine of fresh breadfruit in Table 1
indicate a range of values from 0.070 to 0.122 milligrams
per 100 grams. How much of this variation is varietal and
how much the result of loss of thiamine because of the long
period of transportation and storage before the assays were
made is unknown. From an evaluation of figures obtained
on fresh samples grown in Hawaii, and the decrease in
thiamine values of foods during storage, even at 0° F. (37),
it is believed that a number of the values for thiamine in
Table 1 may be from 70 to 80 percent of the true values for
fresh breadfruit.

(Ten samples of fresh breadfruit grown on the Univer­
sity campus were analyzed in the mature but green starchy
stage for moisture and thiamine. When the moisture con­
tents varied from 65 to 69 percent [or were recalculated to an equivalent basis] the samples contained from 0.103 to 0.146 milligram of thiamine per 100 grams and averaged 0.124 milligram per 100 grams.)

Judging from the results on Samples 1 and 2, if the breadfruit is cooked whole without scraping or paring, there is little or no loss of riboflavin and niacin but about 10 percent loss of thiamine. Some of the figures in Table 1 indicate greater losses, but when cooked under controlled conditions in our laboratory (baked 1½ hours without peeling, or wrapped in aluminum foil, at 350° F.) the losses of thiamine were 10 percent or less.

Compared on the calorie basis, breadfruit, potatoes, and sweetpotatoes are about on a par if the thiamine is not leached out by long immersion in water when the foods are pared and cut in small pieces, or cooked in a large amount of water and the water discarded. Breadfruit is much superior to unenriched white bread if compared on a calorie basis (47).

Although not a rich source of thiamine, breadfruit supplies more than is needed for the metabolism of the carbohydrate it contains, judging from the recommended allowance of 0.5 milligram of thiamine for each 1000 calories (22).

Breadfruit compares favorably with potatoes and sweetpotatoes as a source of riboflavin and is superior to white bread and white rice. Breadfruit has about the same amount of niacin as white potatoes and about twice as much as sweetpotatoes. Again, breadfruit is superior to both bread and rice as a source of this vitamin.

By the time the samples of breadfruit sent from the South Pacific were assayed for ascorbic acid much of the vitamin had been lost, as the values varied from a trace to 3 milligrams per 100 grams. Although we have included some of these values in Table 1, they may not represent a true picture of breadfruit as a source of ascorbic acid as it is usually prepared and eaten. Values that were determined for some of the samples in the field have also been included in Table 1. These show that the ascorbic acid values for the fresh breadfruit (19 to 34 milligrams per 100 grams, Samples 1, 4, and 5) are similar to those found in Hawaii (47). Most of the field figures for the cooked product are 3 milligrams per 100 grams or less. Different
varieties of breadfruit grown in Hawaii assayed the same day or the day after they were harvested contained 15 to 35 milligrams per 100 grams for the raw samples. After baking at 400° F. for 1 1/2 to 2 hours the breadfruits lost 27 to 57 percent of their vitamin C and contained from 6 to 27 milligrams of ascorbic acid per 100 grams.

As with other fruits, there are no doubt varietal differences in ascorbic acid content, and environmental conditions may influence the quantity of the vitamin. In addition, the manner of cooking, the length of time, and the temperature would affect the amount remaining in the cooked product. Some unpublished data from this laboratory suggest that the ascorbic acid is less stable in the mature green samples than in the riper breadfruit. The conservative value of 4 milligrams per 100 grams has been used for calculating the amount of ascorbic acid furnished by different quantities of cooked breadfruit (Table 2), but it may often be more.

Although the pH of all the breadfruit samples was not determined, the figures in Table 1 indicate that when the fruit is in the green, mature, starchy stage the pH is usually around 6.0, which is probably not sufficiently acid to aid in retaining the ascorbic acid or thiamine. The preserved, fermented product, however, is quite acid with a pH of 3.2 (Sample 20). Addition of coconut cream has the effect of decreasing the acidity (Sample 21). During the pounding and mixing of kon (Sample 11), some fermentation must start at once as the pH changes from 5.5 to 4.3.

The 7-day dietary study in the Marshall Islands (49) included 324 people 1 year of age and over; of this number, 297 ate breadfruit, a few on 1 day only, but the majority for 6 or 7 days out of the week. The quantity consumed daily varied from about 125 grams to a little more than 1000 grams.

In the Carolines, the dietary study (49) indicated that of 290 people over 1 year of age for whom records were made, 286 ate breadfruit daily mostly in the form of kon. The daily consumption varied from about 100 grams to 3250 grams of kon and, in addition, some people ate smaller amounts of such preparations as ror, emesefich, and muatin (see p. 17).

To give a better picture of the amount of the nutrients furnished by different quantities of breadfruit, Table 2 has
**Table 2. Nutritive value of various quantities of breadfruit**

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>100 g.</th>
<th>E.P. of (\frac{1}{2}) med. or 1 small, 250 g.</th>
<th>E.P. of 1 med. or (\frac{1}{2}) large, 500 g.</th>
<th>E.P. of 2 med. or 1 large, 1000 g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>128</td>
<td>320</td>
<td>640</td>
<td>1280</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>1.4</td>
<td>4</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>21</td>
<td>52</td>
<td>105</td>
<td>210</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>52</td>
<td>130</td>
<td>260</td>
<td>520</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>0.8</td>
<td>2.0</td>
<td>4.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Vitamin A, I. U.</td>
<td>10</td>
<td>25</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.08</td>
<td>0.2</td>
<td>0.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>0.08</td>
<td>0.2</td>
<td>0.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>1.21</td>
<td>3</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Ascorbic acid, mg.</td>
<td>4.0*</td>
<td>10</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

* See discussion, page 29.

been prepared based on the average figures of seven cooked fruits given in Table 1 except for vitamin A (see p. 27) and for ascorbic acid (see p. 29). A medium breadfruit is given as 500 grams for ease in estimating quantities eaten, but actually the weights taken would indicate that most breadfruit considered of "medium size" would have between 400 and 500 grams of edible portion.

When trade goods are scarce or not available, breadfruit, when in season, may supply much if not all of the calories. If we estimate that the caloric needs of a moderately active Marshall or Caroline Islander are about 2700 (small stature and warm environment, see 21), the contribution of 1000 grams of breadfruit daily (approximately two medium or one large) would supply the following proportions of the recommended allowances: about one-half of the calories, one-fifth of the protein, one-fourth of the calcium, almost all the phosphorus, more than half the iron, negligible quantities of provitamin A, one-half to two-thirds of the thiamine, about one-half of the riboflavin, three-fourths of the niacin, and more than half of the ascorbic acid. If as much as 2000 grams are eaten, all the calories, the three B vitamins, and all the ascorbic acid would be supplied. Fish and coconut would be needed to supply the protein and fat. Some source of provitamin A would be important if
fish or shellfish did not supply it and no pandanus was in season as a source of provitamin A.

**Breadfruit--preserved**

When one considers the soaking, washing, and pounding to which the preserved breadfruit is likely to be subjected before it is eaten, it is surprising that it contains as much of the water-soluble vitamins as the analyses in Table 1 indicate. Thiamine is greatly reduced in both Samples 20 and 21. Sample 21, which was subjected to a relatively long period of soaking in water, has less riboflavin and much less niacin than the other samples. If yeasts are involved in the fermentation process, there is the possibility of an increase in thiamine. (This would be an interesting problem to investigate.)

The composition of the baked preserved breadfruit (Sample 20) is otherwise not much different from the fresh or freshly cooked samples, but Sample 21, apot mei pupu, had sufficient coconut cream added to bring the fat content up to nearly 19 percent. No doubt the quantity of coconut cream added varies from time to time so that we cannot state unequivocally that this dish always contains such a large amount of fat.

Emesefich (Sample 22), made of freshly pounded breadfruit, has only a little more than 2 percent fat, even though coconut oil was added. Here again the quantity of fat in the finished product may well vary with the mood of the maker.

Muatin (Sample 23) with added coconut cream might be expected to contain considerable fat, but it is no greater than some of the raw and cooked breadfruits. We have no satisfactory explanation of the different amounts of fat in Samples 21 to 24, all of which contain coconut cream or coconut oil, expect that the fat must be in proportion to the amount of oil or cream added. The fat tends to rise to the top of coconut cream if it is allowed to stand, in the same manner as cow's milk, and the quantity of fat obtained will depend upon whether the top or the bottom portion is added to a dish or whether the "cream" is well mixed before using.

**Breadfruit--dried preserved (manakajen)**

Manakajen made as described on page 20 and shown in Figure 9 resembles pieces of clay. It is greyed, creamy
white, and the rough surface results from the impressions made by the "coconut cloth" used to compress the moist material into shape. The pieces shown, typical of those prepared for household storage, are 1 x 9 x 14 centimeters (\(\frac{3}{8} \times 3\frac{1}{2} \times 5\frac{1}{2}\) inches), each weighing 130 to 135 grams. Microscopic examination of scrapings from a slab showed masses of starch grains with occasional small shreds of fiber. It is likely that when soaked and kneaded into an edible condition its composition would be similar to that of apot mei mon, except one would expect the vitamin and mineral content to be much reduced.

Fig. 9. Manakajen. Dried, preserved breadfruit.

The food nutrients of manakajen were not determined but the moisture content was found to be 12.34 percent and the dry matter would be about 87 percent. Assuming that the dry ingredients are in the same proportions as in fresh breadfruit or in apot mei mon, each slab would represent approximately 450 calories.

After more than three years storage in the laboratory with only a loose wrapping of wax paper about the slabs, there was no sign of deterioration. The natives long ago devised this excellent method of preserving breadfruit in a form which can be taken on long voyages and stored for emergency. It is the belief of the writer (C.D.M.) that this product might well be studied further by those interested in the welfare of the natives with the idea of promoting its preparation from surplus breadfruit, storage, and use.

**Breadfruit paste**

Since we have no analyses of the fresh seeded breadfruit from which the paste was made, it is not possible to make an accurate evaluation of the retention or the loss of nutrients, but comparing it with the figures for cooked Mijiwan (the seeded variety from the Marshall Islands) in Table 1, it would appear that the niacin is remarkably well retained in the dried product, while about half the thiamine and riboflavin have been lost as a result of the drying
process. If dried in the sun, this is not surprising since riboflavin is destroyed by light. The quantity of niacin, which is greater than might be expected when calculated to the fresh basis, is probably related to the variety of the breadfruit.

This type of preserved breadfruit, like pandanus paste (p. 80), resembles dried figs and dates as a source of carbohydrate and some of the other nutrients, but both pandanus and breadfruit pastes contain much more niacin than dried figs and dates.

The breadfruit paste has almost four times as much thiamine as the pandanus paste, about two times as much riboflavin, and more than three times as much niacin. The calcium and phosphorus are similar but the sample of pandanus paste had a much higher iron content.

Breadfruit seeds

As noted on pages 9 and 26, there are in general two kinds of breadfruit. There are many cultivated varieties without seeds, but the island people also recognize two or three varieties that have seeds.

We analyzed the seeds from the Mijiwan, which is the most important seeded variety in the Marshalls. Seeded breadfruit also grow in the Carolines but no samples were obtained from the Truk district.

The analyses of the seeds given in Table 1 show that both the fresh and cooked samples have about 8 percent protein. Breadfruit seeds are relatively low in fat (3 to 5 percent) whereas nuts, such as almonds, walnuts, and peanuts, contain 40 to 60 percent of fat (62). The crude fiber content of 1.29 percent is less than that of most nuts which have more than 2 percent, but when calculated to the moisture basis of most nuts (3 to 4 percent) the crude fiber is similar.

These complete analyses confirm preliminary ones for several nutrients made on a sample of seeds preserved in alcohol that Dr. Kenneth Emory brought from Kapingamarangi (unpublished data). Calculated to the same moisture basis, the seeds from Kapingamarangi contain almost the same amount of protein, calcium, phosphorus, and iron as those collected in the Marshalls.

On a similar moisture basis, the breadfruit seeds contain more protein and less fat and carbohydrate than chest-
nuts (62) and much more calcium, phosphorus, and iron, similar amounts of thiamine, less riboflavin, and about four times as much niacin. Neither contains any pro-vitamin A. The cooked breadfruit seeds are a poor source of ascorbic acid.

According to Dr. Emory, in Kapingamarangi, one person would eat about 20 seeds per day which we calculate to contain about 50 grams of edible portion. As the figures for the various nutrients in Table 1 are on the basis of 100 grams, it would mean that only half these quantities would be obtained daily from 20 nuts thus making a rather small contribution to the diet. Probably the variety in flavor and texture which they would add to a monotonous diet would be their most valuable contribution.

Summary and Conclusions

Breadfruit is one of the basic foods of the natives of many tropical Pacific islands. In some instances, for example in the Marshall and in the Caroline Islands, it is much preferred to starchy aroids such as taro and the Cyrtospermas. It has played such a major place in their lives that all ethnic groups have accounts of the creation of breadfruit in their folklore. Breadfruit was observed and described by the early western explorers in the Pacific from the late fourteenth to the nineteenth centuries.

Like other plants which have been cultivated for many centuries, numerous horticultural varieties have developed, each with a local name. That the size, appearance, and quality of these varieties are markedly different is attested to by European observers and by the data presented in this bulletin. Most of the varieties used are seedless or almost so and are usually eaten only in the cooked state. However, there are varieties with seeds as large as hazelnuts or pecans which are eaten in both the raw and cooked state. The seeds are always eaten after cooking. Because of its bland quality, the natives prefer the breadfruit in the fully mature but starchy stage, but occasionally eat it when it becomes ripe and sweet.

Eleven varieties of breadfruit, mostly from the Marshall and Caroline Islands, are described. The breadfruit seasons vary in all the tropical Pacific islands, but in most, breadfruit is to be had at least six months in the
year—sometimes spread over two or three bearing seasons. In order to utilize the surplus breadfruit and save it for periods when no breadfruit is available, various methods were devised for its preservation, the most common being to treat the raw breadfruit by soaking in salt water, after removal of rind and seeds, and then placing it in pits lined with breadfruit leaves and allowing it to ferment. Breadfruit paste which is made from ripe breadfruit, usually a variety with seeds, resembles dates.

The breadfruit products analyzed were 17 samples of raw and cooked breadfruit, 2 samples of breadfruit seeds, 5 samples of breadfruit preserved and/or combined with some other ingredients, and 1 sample of breadfruit paste.

The carbohydrate contents of the raw and cooked breadfruits range from 22 to 37 percent with a like variation in moisture content. Since the average crude fiber is a little more than 1 percent, breadfruit supplies a rather readily digested form of carbohydrate. Breadfruit is not a particularly good source of calcium and phosphorus; but when consumed in large quantities to satisfy the caloric needs it furnishes a large proportion of the needed minerals, especially phosphorus and iron. Breadfruit is a poor source of provitamin A as it has little or no yellow pigment. The thiamine, riboflavin, niacin, and ascorbic acid values on a weight basis appear to be rather small; but again when breadfruit is eaten in large quantities it supplies all or a large part of the recommended allowances for the three B vitamins and a somewhat smaller quota of the ascorbic acid. The breadfruit seeds have much more protein and fat than does the breadfruit itself, but about the same amount of carbohydrate. They have more calcium, phosphorus, and iron, and more thiamine, but less riboflavin and niacin than the flesh of the fruit. When the breadfruit products are subjected to fermentation followed by thorough washing, the water-soluble vitamins are greatly reduced.

From the nutritional standpoint, breadfruit is a food to be highly recommended. Encouragement should be given to the selection and propagation of the choice varieties in order to continue the production of this vital food, rather than replace it with introduced foods such as rice and flour.
COCONUT

Tall coconut palms with their tufts of long fronds and clusters of nuts have become almost a symbol of the South Pacific. They grow along the shores of both the high and the low tropical Pacific islands and must have provided an important source of food and drink ever since the islands were inhabited.

Although coconuts vary greatly in shape and size, and thickness of mature meat, and some have different colored husks in the young stages, they all belong to one species, *Cocos nucifera* L., according to St. John (76).

The island people recognize and have given local names to many different kinds of coconuts which might be considered horticultural varieties resulting from centuries of selection and propagation. They have also given specific names to the nut in all stages of development and utilize the nuts in different ways.

The Pacific islanders have long had many ways of obtaining nourishing food and drink from the coconut tree, some of which are fully described under Use. Westerners are likely to think of coconut only in terms of the mature shredded coconut, used in cakes and confections, or of an oil, used for making soap and other products. Actually, it is only since about 1860 that coconuts in the form of copra became an export crop from the Pacific, valuable as a commercial source of oil (59, 63). Prior to that, the oil was extracted and constituted an important commodity for traders by 1840. Coconut oil is even mentioned by Dampier (13) as an article of trade in Sumatra (Achin) as early as 1688.

Not only are the meat and liquid within the coconut shell at all stages of development and the sap obtained from the
inflorescence used as food and drink, but the sweet husks of some varieties are eaten in the young stages. Buck (5) reports that "the green husk of a particular kind of coconut is chewed for its sweet taste." And Luomala states, "In a sweet coconut (te bunia) the husk is edible except for its strings," and is "eaten with small fish from the reef" (40). St. John has also verified these observations. We were not informed in either the Marshall or Caroline Islands that they use the husk of any variety of coconut. No analyses of coconut husks of any kind were made by us.

Botanists (14) usually state that the coconut is indigenous to Asia and was carried to the Pacific islands by man or ocean currents.

European explorers, in their early contacts with the people of the tropical Pacific islands, always seemed impressed with the use of coconuts by the natives and soon learned to welcome them as gifts or obtained them by barter (8, 10, 13, 68).

De Quiros was probably describing coconuts in 1595 when he wrote "... and some nuts with a very hard shell, which were very oily, and many of them were eaten; some suspect that they brought on looseness ..." (53).

The most complete descriptions by the early explorers in the Pacific area are from Captain Dampier. He describes the trees, the coconuts, and the various stages in which they are used, the coconut sap or toddy, and the sprouted coconuts (13). His observations made in 1686 include the following:

The outer rind is near two Inches thick, before you come to the Shell; the Shell it self is black, thick, and very hard. The Kernel in some Nuts is near an Inch thick, sticking to the inside of the Shell clear round, leaving a hollow in the middle of it, which contains about a Pint, more or less, according to the bigness of the Nut, for some are much bigger than others.

This cavity is full of sweet, delicate, wholesome and refreshing Water. While the Nut is growing, all the inside is full of this Water, without any Kernel at all; but as the Nut grows towards its Maturity, the Kernel begins to gather and settle round on the inside of the Shell, and is soft like Cream; and as the Nut ripens, it increaseth in substance and becomes hard. The ripe Kernel is sweet enough, but very hard to digest, therefore seldom eaten, unless by Strangers, who know not the effects of it; but while it is young and soft like Pap, some Men will eat it, scraping it out with a Spoon, after they have drunk the Water that was within it. I like the Water best when the Nut is almost ripe, for it is then sweetest and briskest.

The Kernel is much used in making Broath. When the Nut is dry, they take off the Husk, and giving two good Blows on the middle of the Nut, it breaks in two equal parts, letting the Water fall on the Ground; then with a
small Iron Rasp made for the purpose, the Kernel or Nut is rasped out clean, which being put into a little fresh Water, makes it become white as Milk.

He also described the way in which the inflorescence is cut and the coconut sap or toddy collected, and states, "It is sweet and very pleasant. . . ." but recommends that it should be drunk within 24 hours after it is drawn or it will grow sour.

In this same account, Dampier tells of the sprouted coconut and describes it as "a small spungy, round knob growing inside, which we call an apple."

Use

Immature or drinking coconuts

The liquid within the "drinking coconuts" is used as a beverage until the meat begins to harden, but the natives recognize and have named the various stages and usually have a preference for a certain stage which they consider the most desirable for drinking purposes.

Grimble (23) and Luomala (40) have described these stages in the development of the coconut in some detail for the Gilbert Islands and have given the native names. Buck (7) has described them for Kapingamarangi, the Marshallese Dictionary (69) for the Marshall Islands, and Hall and Pelzer (24) for the Caroline Islands (Truk).

In general, the liquid constitutes an important and ever-available safe water supply, especially on atolls where fresh water is not always available.

The flesh of the drinking nuts may vary from a soft thin film to a firm jellylike (albeit slightly rubbery) layer, a fourth of an inch thick, all of which are today commonly referred to as "spoon meat" by everyone except the native islanders, who have more specific names for the various stages. Sometimes it is discarded but more often it is consumed. The soft jellylike meat is fed to babies at an early age—"as soon as they have enough teeth to chew" according to Luomala (40) and to "babies in arms" according to Grimble (23).

Luomala (40) states that in the third stage of the coconut, called te ubu by the Gilbertese, when it is very young and half the size of the ripe nut, the flesh is scraped to soften it and it is fed to children who have one to three
teeth. And that at the next stage, te moimoto, the soft flesh is given to babies after the mother has chewed it to soften it.

Fig. 10. Marshallese mother feeds baby soft coconut.

Sometimes the soft meat is broken up in the coconut water to make a product the consistency of a puree which is used for sick adults and for infant feeding. This product, called "vaisalo," has been briefly described by Buck (5). The preparation of vaisalo was demonstrated for one of the authors (C.D.M.) in American Samoa in 1935 as follows: The soft coconut meat from two drinking coconuts was combined with the water from within. A piece of coconut leaf frond was made into fine strips about one-fourth inch wide and formed into a circle about 6 inches in diameter. This was then used to mash the soft coconut, rubbing it between both hands and against the sides of the pan, to form a sort of puree with the coconut water. The coarse particles were strained out by using cheese cloth and the puree was brought almost to the boiling point by heating it on a ker-
osene stove. (In olden days they used a piece of coconut fiber to strain it and a hot stone to heat it.) According to our Samoan informants, this mixture may be used for babies 2 to 3 weeks old. For older babies, 5 months to a year old, arrowroot starch is added. The coconut cream puree is brought to a boil and the starch sprinkled in with the fingers. When vaisalo is used for older children or adults, it is sometimes flavored with lime leaves. Three clean lime leaves may be added to the mixture, allowed to steep for a minute or two, and then removed.

*Mature coconut*

The coconut is considered mature when the yellow or green husk begins to turn brown or is fully brown and the white meat has attained its maximum thickness and firmness, at which time it usually drops from the tree. There is still water within the cavity, which is usually discarded,

*Fig. 11.* Grating coconut on Polynesian grater without removing it from the shell. American Samoa. Photo by C.D. Miller.
but sometimes it is combined with the grated meat to prepare coconut cream.

It was observed that in the Marshall and Caroline Islands, the mature meat is often eaten without any preparation. The water from within the mature nut is discarded and the flesh including the adhering brown skin is eaten with fish or without accompaniments.

The grated coconut is used in a great many ways and in various combinations as listed on pages 46 and 47.

The Samoans are reported to use but little of the mature coconut "as is," but their favorite method of utilizing it is to prepare coconut cream which they use in a great variety of dishes (5, 33).

The inhabitants of the Marshall and Caroline Islands also make good use of the coconut cream (49) but perhaps do not use it quite so extensively as do the Samoans.

Oil is also made from the mature nut, which is used not only in foods but as a toilet preparation for the skin and hair.

Coconut "cream"

The term coconut "cream," rather than coconut milk, is used in this publication for the milk-white liquid extracted from grated coconut, because it contains such a large amount of fat. Throughout the tropical Pacific islands where coconuts are abundant, the coconut cream is prepared in a manner similar to that described below.

After the husks are removed from mature coconuts, they are cracked horizontally to divide them in about two equal sections. Without removing the meat from the shell, it is grated on a crude but efficient grater made of metal, sea shell, or notched coconut shell. The grater is attached to the end of a piece of wood which forms a part of the seat on which the operator sits while rubbing the inside of the coconut against the teeth of the grater (Fig. 11). The fineness of the grated coconut can be controlled by the pressure applied during grating, according to Buck (7). Water may or may not be added to the grated coconut before extracting the cream. Buck (7) reports that some fluid from the coconuts may be added. The quantity of water added depends upon the dilution desired and the dishes in which the coconut cream is to be used. The mixture of grated coconut and
water is kneaded by hand, put in a "strainer," and the milk wrung out (Fig. 12). In the Marshall and Caroline Islands they use "coconut cloth," the fibrous, meshlike stipule of the coconut tree which is widely used as a strainer in the tropical Pacific islands. In Kapingamarangi, Buck reports that strainers are made of three materials: hau bast, coconut husk of the drinking coconut, and the coconut leaf stipule just described. Each island group has different names for the "cream" according to the amount of water that is
added to the grated coconut and the use to which it may be put.

Coconut oil

Coconut oil is prepared for cooking purposes as well as for anointing the body and hair. The method of preparing oil for culinary use observed by one of the authors (M.M.) in the Truk area, Caroline Islands, was as follows:

Mature coconuts were grated and left exposed to the sun from 1 to 3 days. After sufficient exposure, fresh green leaves broken into small pieces were added, mixed, and kneaded with the grated coconut. The mixture was placed in a "coconut cloth" (p.42) about 12 by 15 inches and tied with sennit. The oil was extracted by a crude press made from two branches of a tree, using one limb as a lever to compress the "coconut cloth" bag.

The oil, which is not clear but white to light grey in color, is added to food without dilution (Table 3, p. 53).

Coconut embryo

So far as could be learned, no special effort is ever made to sprout coconuts. The ripe nuts simply drop to the ground, often concealed by grass or weeds, and are allowed to remain there until someone wants a coconut embryo and locates one at the desired stage, which is 3 to 4 months after the mature coconut falls from the tree. According to our Marshallese informant (75) it is most desirable 4 months after it drops to the ground. After the 5th month it is still edible but by 6 months it is overgrown and no longer tasty.

According to this same Marshallese man (75), the people would rather eat coconut embryo than the mature coco-
nut meat because they prefer the flavor of the former. He states it is usually eaten between breadfruit seasons and before the pandanus season has begun, especially in the areas where there is no taro or Cyrtosperma.

In the Marshall Islands, the dietary studies (49) showed that two embryos per person per day is quite common. It is not only eaten raw, but prepared in a number of ways as described on page 49.

Buck thought the sprouted nuts in Kapingamarangi were sweeter and juicier than those he had eaten in Tongareva (7). He states that too much raw coconut embryo acts as a purgative "but cooking removes the purgative properties and one can eat several helpings with impunity."

Luomala states that the Gilbertese daily diet includes about one and a half embryos (te riki) per person (40).

Coconut sap

Coconut sap, often referred to as coconut toddy, especially after various degrees of fermentation, is collected from the coconut blossom or inflorescence by a special process which Grimble believes is an ancient practice (23). Details of the method of collecting the sap have been described by many people, from Dampier in 1686 (13) to the present time (38). The reports of Leong, a chemist, in 1953 (38) and Grimble, an anthropologist, in 1933-1934 (23) are especially recommended.

Each area, in fact each individual, may use a slightly different technique, but essentially it consists of tightly binding the spathe before the blossoms open, bending the spathe so that it extends horizontally from the tree, cutting off the tip, which causes the sap to drip from the cut surface, and collecting the sap in a coconut shell or bottle which is emptied 2 or 3 times a day. Each time the sap is collected, a thin transverse section of the inflorescence is cut off to keep the sap flowing for 2 to 3 weeks. A study in the Philippines on a large number of trees indicated that an average of 0.65 liter per tree per day was collected (48).

According to our Marshallese informants, a flower stalk
is produced about every month (Moore, 48, reports every 26 days) and usually three flower stalks are tapped at the same time. Each family customarily uses three trees at a time all year round. After collection, the sap is normally boiled for a few minutes to prevent it from quickly fermenting. The coconut sap may be used full strength or diluted with water. It may also be concentrated to form a very thin syrup (jekajeje) (Sample 14).

In the Gilbert Islands the coconut sap is made into syrups of different concentrations according to the amount of boiling to which it may be subjected. Grimble (23) gives an excellent account of the manner in which this process is carried out using coconut shells as containers over embers to make the concentrated syrup called kamaimai (Sample 16, p. 122), a drink of which he states "forms the normal breakfast of the Gilbertese man or woman before setting out for the early morning labours." It is also much used in preparing other dishes (23).

The ways in which coconut and coconut products are used in the Marshall and Caroline Islands are summarized below. Most of these were observed by one of the authors (M.M.), others were described in detail by native informants. The products analyzed are marked with an asterisk (*).

---

**Fig. 16. Collection of coconut sap.**

a. Cut end of unopened inflorescence still wrapped in spathe (near man's right hand).  
b. The decapitated spathe is massaged to soften it, then tightly wound with sennit, bent downward, and tied.
Marshall Islands

Use of grated coconut prepared from mature nuts.

1. **Mokanrul.** Pulp of baked or boiled pandanus fruit (obtained by scraping keys on beka) mixed with grated coconuts and baked.

2. **Amedama.** Coconut candy made from a mixture of jekamai and grated coconuts.

3. **Jukjuk in iaraj.** Mashed Cyrtosperma with grated coconut meat.

4. **Benben in mokmok.** Arrowroot flour, jekara, and grated coconut meat.

5. **Jamkok.** Arrowroot flour mixed with grated coconut meat from semiripe coconuts and baked.

6. **Bere banke.** Grated coconut and sugar are added to boiled mashed pumpkin and the mixture is baked.

7. **Jukjuk in kābrān.** Bananas, boiled in the skins, are mashed and mixed with grated coconut meat. Sugar or jekara is added for flavoring.

9. *Jabjen*. Patties made with arrowroot flour are rolled in grated coconut.

10. *Mijeo*. Batak dak and bukdrol breadfruits are preferred but other varieties may be used. After roasting, rind and core are removed; and the flesh is pounded with a coral pounder until very thick. The doughlike mass is rolled out flat and sprinkled with finely grated coconut, or coconut cream is placed in the center, after which it is rolled up like a jelly roll.

**Use of coconut cream, el**

1. *Boljej*. Green breadfruit is stored until ripe. Both core and rind are removed. Hole is filled with coconut cream and covered with part of core; then breadfruit is wrapped with green breadfruit leaves, tied with pandanus roots, and baked about half an hour.

2. *Jokkob* (breadfruit porridge). Both core and rind are removed. Breadfruit is cut into pieces, boiled, mashed, and mixed with coconut cream. Salt added to taste.

3. *Ainbat ben*. Core and rind are removed, and breadfruit is cut into pieces and boiled. After it is done, it is again boiled with coconut cream.

4. *Ieok* (a method of using manakajen). Manakajen, after proper preparation (p. 20, Breadfruit), can be mixed with coconut cream and jekamai (coconut syrup), wrapped in fresh breadfruit leaves, and put in the earth oven to bake for 2 hours.

5. *Chubwe* (a method of using manakajen). After kneading preserved breadfruit until it becomes sticky, it is mixed with coconut cream, wrapped in coconut leaves, and roasted on an open fire.


Use of coconut sap, jekara

*1. Jekajeje.* Jekara boiled for half an hour.

*2. Jekamaï (coconut syrup).* Jekara boiled for 4 hours or more until it becomes a syrup.

3. *Amedama.* Refer to description under grated coconuts.

4. *Lukor.* Coconut embryo and jekara made into a pudding.

5. *Jukjuk in kābrān.* Refer to description under grated coconut meat.


7. *Benben in mokmok.* Description under grated coconut meat.


9. *Ieok.* Description under coconut cream.

10. *Jebuator.* Raw iaraj (*Cyrtosperma*), grated on a grater, is mixed with coconut cream and coconut syrup then wrapped in leaves, and put in earth oven to bake.

*11. Jaibo* (Sample 17). The ingredients of this dish are combined in the following proportions: 6 parts coconut sap, 3 parts flour, and 1 part coconut cream. It is a thick, cream-colored puree, used both in schools and by the people at large, especially when imported foods are scarce and locally grown starchy food crops, such as breadfruit, *Cyrtosperma*, and taro, are not obtainable or are out of season.

*12. Chokop* (Sample 18) (soft rice). The ingredients of this dish are combined in the following approximate proportions: 1 part raw rice, 3 parts water, 2 parts jekara, and 2 parts coconut cream. Rice is cooked until soft, then jekara and coconut cream are added just before serving.

The Marshallese have acquired a great liking for
polished rice, but often it is not obtainable or they cannot afford to buy it. Their idea of combining the rice with coconut sap and coconut cream is to make the rice last longer and to satisfy their desire for rice.

Use of embryo, iu

1. *Lukor*. Description under jekara.

2. *Iutir*. Baked embryo.

3. *Jup in mokmok*. Description under coconut cream (p. 48).

Caroline Islands

Use of coconut cream, arung

*1. Ror or opou* (Sample 24, breadfruit). Breadfruit is first roasted on the open fire. The charred rind is removed, the remaining edible portion is pounded or sliced, and coconut cream is added. Proportion of ingredients: for each breadfruit, one coconut is used; about one-third cup of water (either plain water or water from within the coconut) is added to the grated coconut to prepare the coconut cream.

2. *Ammach*. A very ripe Meichon breadfruit, which has been kept about 10 days until soft, is used. It is then baked and coconut cream added.

3. *Arung*. Breadfruit is roasted and rind removed. Edible portion is pounded. Faster pounding movements are used than for kon. This is necessary to keep breadfruit sticky. Small pieces are made into dumplings, and coconut cream is added.

*4. Apot mei pupu* (Sample 21, breadfruit). Preserved breadfruit is removed from the pit, cleaned, and kneaded. Coconut cream made without the addition of water is added and mixture is steamed or baked. Proportion of ingredients: for preserved breadfruit equivalent to one fresh breadfruit, one coconut is used to prepare the coconut cream, which is made without the addition of water.

*5. Muatin* (Sample 23, breadfruit). Breadfruit is steam-
ed and pounded, and coconut cream is added. Proportion of ingredients: same as for No. 1 above.

Use of coconut oil

*1. Emesefich (Sample 22, breadfruit). Steamed breadfruit is pounded and coconut oil added.

**Composition and Nutritive Value**

The coconut products analyzed were: two samples of liquid from drinking nuts, two samples of flesh from drinking nuts, one sample of liquid from mature nuts, two samples of flesh from mature nuts, two samples of coconut cream, two samples of coconut embryo, four samples of coconut sap, one of concentrated sap, one sample of coconut oil, and two products containing coconut sap, coconut cream, and other foodstuffs.

For methods of collection, storage of samples, and their preparation for analyses, see Appendix, pages 116 to 123. For analytical methods used, see pages 4 to 6.

Descriptive and local names of the coconut products and data on composition are summarized in Table 3. Discussions of the nutritive values for each type of product follow.

**Immature (drinking) coconuts**

Immature coconuts are probably most important to the island people in supplying an ever-available source of safe drinking water. If only the liquid is drunk, the amounts of the various nutrients obtained are small. When the soft flesh is eaten in addition, one may obtain more than 300 calories from two nuts, but the quantities of the other nutrients would not make a very significant contribution to the day's needs for an adult (Table 4).

Though the amount of calcium in the liquid is not great enough to be of much nutritional importance, the difference in the calcium content of the liquid of the drinking coconuts from the low and the high islands is quite striking (whereas the phosphorus and iron contents are similar). Additional analyses would be necessary to determine if this is always characteristic of the nuts from high and low islands or if it is related to the stage of development. The phosphorus content of the flesh is about 6 to 10 times greater than that of the water.
Both the liquid and the flesh from drinking nuts are slightly acid in reaction, but the small and variable quantities of ascorbic acid shown in Table 3 suggest that they are unreliable sources of this vitamin compared with coconut sap (p. 52-53).

According to our Marshallese informant (75), more drinking nuts than water are normally used. He estimated that the average consumption of drinking nuts per day for adults was about five and for children one or two smaller nuts. The records made during the dietary study, however, do not bear out these estimates.

During the Marshall Islands dietary study of 324 people, 1 year of age and over, for a period of 1 week, 724 drinking nuts were used by 177 persons (49). Most often one coconut per day was used (353 times), but two coconuts per day were recorded 131 times, and three coconuts per day 31 times. In only one case did one person in one day consume four drinking coconuts. The others had only a part of a coconut per day, because one coconut was shared by two or more people.

The records for the dietary study in the Marshall Islands showed that fewer people (60) ate the soft meat than consumed the liquid (177) from the drinking coconuts. Perhaps this is because very immature nuts, satisfactory for drinking, may have little or no meat to be eaten. The quantity of soft meat consumed at one time or during one day was usually between 100 and 200 grams, though in a few cases approximately 300 to 400 grams were taken in one day. When the soft meat is scraped from the shell the thin skin adheres to the shell.

In the Caroline Islands study of 290 people for a period of 1 week, 260 individuals used the drinking nuts from 1 to 7 days per week, the quantity per day ranging from one-quarter to five nuts. For the same group of people, only 39 consumed the soft meat from 1 to 7 days out of the week. The quantity eaten in one day varied from one-fourth of a nut to three nuts.

In American Samoa in 1935, two drinking nuts per person per day was estimated as the average quantity consumed (74).

In Table 5 we have compared the nutrients that could be obtained from the liquid and flesh of two and of three drink-
Table 3. Proximate composition, energy value, minerals, and vitamins of coconuts and coconut products
(per 100 grams edible portion)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Descriptive terms and local names</th>
<th>Source</th>
<th>Water %</th>
<th>Food Energy calor.</th>
<th>Protein g.</th>
<th>Fat g.</th>
<th>Carbohydrate Total g.</th>
<th>Fiber g.</th>
<th>Ash g.</th>
<th>Calcium mg.</th>
<th>Phosphorus mg.</th>
<th>Iron mg.</th>
<th>Thiamine mg.</th>
<th>Riboflavin mg.</th>
<th>Niacin mg.</th>
<th>Ascorbic acid mg.</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Liquid from drinking nuts, ni</td>
<td>Marshall Islands</td>
<td>96.9</td>
<td>11</td>
<td>0.21</td>
<td>0.05</td>
<td>2.57</td>
<td>0.27</td>
<td>12.5</td>
<td>5.4</td>
<td>0.07</td>
<td>0.010</td>
<td>0.24</td>
<td>trace</td>
<td>5.86</td>
<td>trace</td>
<td></td>
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<td>2</td>
<td>Liquid from drinking nuts, nu</td>
<td>Caroline Islands</td>
<td>98.6</td>
<td>0</td>
<td>0.12</td>
<td>1.8</td>
<td>3.4</td>
<td>0.6</td>
<td>5.6</td>
<td>51.8</td>
<td>0.78</td>
<td>0.025</td>
<td>0.027</td>
<td>0.55</td>
<td>5.96</td>
<td>trace</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Flesh from drinking nuts, mere</td>
<td>Marshall Islands</td>
<td>83.6</td>
<td>102</td>
<td>1.53</td>
<td>8.93</td>
<td>5.28</td>
<td>0.60</td>
<td>5.6</td>
<td>51.8</td>
<td>0.78</td>
<td>0.025</td>
<td>0.027</td>
<td>0.55</td>
<td>5.96</td>
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<td>Flesh from drinking nuts, apun</td>
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<td>110</td>
<td>1.31</td>
<td>9.36</td>
<td>6.58</td>
<td>0.76</td>
<td>7.3</td>
<td>30.6</td>
<td>1.00</td>
<td>0.004</td>
<td>0.024</td>
<td>0.30</td>
<td>trace</td>
<td>5.88</td>
<td></td>
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<tr>
<td>5</td>
<td>Flesh from mature nuts, waini†</td>
<td>Marshall Islands</td>
<td>38.8</td>
<td>421</td>
<td>3.60</td>
<td>41.54</td>
<td>14.99</td>
<td>3.47</td>
<td>17.1</td>
<td>95.4</td>
<td>1.95</td>
<td>0.058</td>
<td>0.013</td>
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<td>3.8</td>
<td>trace</td>
<td></td>
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<td>6</td>
<td>Flesh from mature nuts, taka†</td>
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<td>39.6</td>
<td>408</td>
<td>4.40</td>
<td>39.19</td>
<td>15.89</td>
<td>4.61</td>
<td>10.3</td>
<td>105.8</td>
<td>2.44</td>
<td>0.025</td>
<td>0.016</td>
<td>0.61</td>
<td>6.22</td>
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<td>7</td>
<td>Liquid from mature nuts</td>
<td>&quot;</td>
<td>97.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>trace</td>
<td></td>
</tr>
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<td>8</td>
<td>Coconut cream No. 1 (without water)</td>
<td>Honolulu T. H.</td>
<td>53.9</td>
<td>346</td>
<td>4.28</td>
<td>34.68</td>
<td>5.99</td>
<td>1.15</td>
<td>10.7</td>
<td>122.1</td>
<td>2.28</td>
<td>0.030</td>
<td>0.008</td>
<td>0.89</td>
<td>2.8</td>
<td>6.00</td>
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<td>9</td>
<td>Coconut cream No. 2 (with water)</td>
<td>&quot;</td>
<td>65.7</td>
<td>252</td>
<td>3.21</td>
<td>24.68</td>
<td>5.18</td>
<td>1.03</td>
<td>16.3</td>
<td>100.0</td>
<td>1.64</td>
<td>0.026</td>
<td>0.003</td>
<td>0.76</td>
<td>2.8</td>
<td>5.95</td>
<td></td>
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<td>Embryo from sprouted nuts, ju</td>
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<td>78</td>
<td>1.30</td>
<td>3.60</td>
<td>10.59</td>
<td>1.10</td>
<td>0.91</td>
<td>18.6</td>
<td>77.4</td>
<td>0.015</td>
<td>0.027</td>
<td>0.84</td>
<td>6.6*</td>
<td>5.62</td>
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<td>Sample</td>
<td>Descriptive terms and local names</td>
<td>Source</td>
<td>Water %</td>
<td>Food Energy calor.</td>
<td>Protein g.</td>
<td>Fat g.</td>
<td>Carbohydrate g.</td>
<td>Total Fiber g.</td>
<td>Ash mg.</td>
<td>Calcium mg.</td>
<td>Phosphorus mg.</td>
<td>Iron mg.</td>
<td>Thiamine mg.</td>
<td>Riboflavin mg.</td>
<td>Niacin mg.</td>
<td>Ascorbic acid mg.</td>
<td>pH</td>
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<td>11</td>
<td>Embryo from sprouted nuts, chofar</td>
<td>Caroline Islands</td>
<td>83.2</td>
<td>83</td>
<td>1.29</td>
<td>4.56</td>
<td>9.97</td>
<td>1.93</td>
<td>0.98</td>
<td>19.8</td>
<td>54.8</td>
<td>0.54</td>
<td>0.014</td>
<td>0.036</td>
<td>0.88</td>
<td>5.0*</td>
<td>5.80</td>
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<td>45</td>
<td>0.10</td>
<td>0.33</td>
<td>10.83</td>
<td>0.34</td>
<td>0.6</td>
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<td>11.97</td>
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<td></td>
</tr>
<tr>
<td>14</td>
<td>Boiled, jekajeje</td>
<td>&quot;</td>
<td>77.6</td>
<td>90</td>
<td>0.14</td>
<td>0.23</td>
<td>21.49</td>
<td>0.54</td>
<td>2.0</td>
<td>22.2</td>
<td>0.19</td>
<td>0.024</td>
<td>0.007</td>
<td>0.62</td>
<td>20.5</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Slightly fermented, kareve</td>
<td>Gilbert Islands</td>
<td>94.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.2</td>
</tr>
<tr>
<td>16</td>
<td>Concentrated sap or syrup, kamaimai</td>
<td>&quot;</td>
<td>28.4</td>
<td>272</td>
<td>0.77</td>
<td>0.14</td>
<td>69.34</td>
<td>1.35</td>
<td>4.9</td>
<td>47.0</td>
<td>1.32</td>
<td>0.024</td>
<td>0.012</td>
<td>2.02</td>
<td>50.8</td>
<td>4.57</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>A mixture of coconut sap, coconut cream, and white flour, cooked. Jaibo</td>
<td>Marshall Islands</td>
<td>61.8</td>
<td>76</td>
<td>0.36</td>
<td>0.44</td>
<td>17.21</td>
<td>0.01</td>
<td>0.19</td>
<td>5.6</td>
<td>29.4</td>
<td>0.50</td>
<td>0.061</td>
<td>0.037</td>
<td>0.88</td>
<td>trace</td>
<td>3.51</td>
</tr>
<tr>
<td>18</td>
<td>Coconut sap, coconut cream, and polished rice, boiled. Chokop</td>
<td>&quot;</td>
<td>84.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>trace</td>
</tr>
</tbody>
</table>

* Ascorbic acid assays made in the field by Mary Mural.  
+ Sample included brown skin. See Appendix, p. 117.
Table 4. Nutrients from various quantities of drinking coconuts

<table>
<thead>
<tr>
<th></th>
<th>100 g.</th>
<th>1 nut 230 g.</th>
<th>2 nuts 460 g.</th>
<th>3 nuts 690 g.</th>
<th>4 nuts 920 g.</th>
<th>5 nuts 1150 g.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Liquid</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water, g.</td>
<td>98.0</td>
<td>225.4</td>
<td>451</td>
<td>676</td>
<td>902</td>
<td>1127</td>
</tr>
<tr>
<td>Calories</td>
<td>11</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>100</td>
<td>125</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>0.2</td>
<td>0.46</td>
<td>0.9</td>
<td>1.4</td>
<td>1.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Fat, g.</td>
<td>0.05</td>
<td>0.12</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Carbohydrate, g.</td>
<td>2.6</td>
<td>5.98</td>
<td>12.0</td>
<td>17.9</td>
<td>23.9</td>
<td>29.9</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>12.5</td>
<td>28.8</td>
<td>58</td>
<td>86</td>
<td>115</td>
<td>144</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>5.4</td>
<td>12.4</td>
<td>25</td>
<td>37</td>
<td>50</td>
<td>62</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>0.07</td>
<td>0.16</td>
<td>0.3</td>
<td>0.5</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.002</td>
<td>0.005</td>
<td>0.010</td>
<td>0.015</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>0.008</td>
<td>0.018</td>
<td>0.036</td>
<td>0.054</td>
<td>0.072</td>
<td>0.090</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>0.16</td>
<td>0.37</td>
<td>0.7</td>
<td>1.1</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Ascorbic acid, mg.</td>
<td>2.0</td>
<td>4.6</td>
<td>9</td>
<td>14</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td><strong>Flesh</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water, g.</td>
<td>83.0</td>
<td>107.9</td>
<td>216</td>
<td>324</td>
<td>432</td>
<td>540</td>
</tr>
<tr>
<td>Calories</td>
<td>105.0</td>
<td>136</td>
<td>272</td>
<td>408</td>
<td>544</td>
<td>680</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>1.4</td>
<td>1.82</td>
<td>3.6</td>
<td>5.5</td>
<td>7.3</td>
<td>9.1</td>
</tr>
<tr>
<td>Fat, g.</td>
<td>9.1</td>
<td>11.83</td>
<td>23.7</td>
<td>35.5</td>
<td>47.3</td>
<td>59.2</td>
</tr>
<tr>
<td>Carbohydrate, g.</td>
<td>6.0</td>
<td>7.80</td>
<td>15.6</td>
<td>23.4</td>
<td>31.2</td>
<td>39.0</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>6.4</td>
<td>8.3</td>
<td>17</td>
<td>25</td>
<td>33</td>
<td>42</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>41.2</td>
<td>53.5</td>
<td>107</td>
<td>160</td>
<td>214</td>
<td>268</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>0.89</td>
<td>1.16</td>
<td>2.3</td>
<td>3.5</td>
<td>4.6</td>
<td>5.8</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.020</td>
<td>0.026</td>
<td>0.052</td>
<td>0.078</td>
<td>0.104</td>
<td>0.130</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>0.025</td>
<td>0.032</td>
<td>0.064</td>
<td>0.096</td>
<td>0.128</td>
<td>0.160</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>0.50</td>
<td>0.65</td>
<td>1.3</td>
<td>2.0</td>
<td>2.6</td>
<td>3.2</td>
</tr>
<tr>
<td>Ascorbic acid, mg.</td>
<td>2.0</td>
<td>2.6</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>
Table 4 (continued)

<table>
<thead>
<tr>
<th>Liquid and flesh combined</th>
<th>1 nut</th>
<th>2 nuts</th>
<th>3 nuts</th>
<th>4 nuts</th>
<th>5 nuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water, g.</td>
<td>333.3</td>
<td>667</td>
<td>1000</td>
<td>1333</td>
<td>1666</td>
</tr>
<tr>
<td>Calories</td>
<td>161</td>
<td>322</td>
<td>483</td>
<td>644</td>
<td>805</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>2.28</td>
<td>4.5</td>
<td>6.8</td>
<td>9.1</td>
<td>11.4</td>
</tr>
<tr>
<td>Fat, g.</td>
<td>11.95</td>
<td>23.9</td>
<td>35.8</td>
<td>47.8</td>
<td>59.8</td>
</tr>
<tr>
<td>Carbohydrate, g.</td>
<td>13.78</td>
<td>27.6</td>
<td>41.3</td>
<td>55.1</td>
<td>68.9</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>37.1</td>
<td>74</td>
<td>111</td>
<td>148</td>
<td>186</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>5.9</td>
<td>132</td>
<td>198</td>
<td>264</td>
<td>330</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>1.32</td>
<td>2.6</td>
<td>4.0</td>
<td>5.1</td>
<td>6.6</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.031</td>
<td>0.062</td>
<td>0.093</td>
<td>0.124</td>
<td>0.155</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>0.050</td>
<td>0.100</td>
<td>0.150</td>
<td>0.200</td>
<td>0.250</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>1.02</td>
<td>2.0</td>
<td>3.1</td>
<td>4.1</td>
<td>5.1</td>
</tr>
<tr>
<td>Ascorbic acid, mg.</td>
<td>7.2</td>
<td>14</td>
<td>22</td>
<td>29</td>
<td>36</td>
</tr>
</tbody>
</table>

Nutrients from various quantities of mature coconuts
(firm flesh with adhering brown skin)

<table>
<thead>
<tr>
<th></th>
<th>100 g.</th>
<th>200 g.</th>
<th>300 g.*</th>
<th>400 g. *</th>
<th>500 g. *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>414</td>
<td>828</td>
<td>1242</td>
<td>1656</td>
<td>2070</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>4.0</td>
<td>8.0</td>
<td>12.0</td>
<td>16.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Fat, g.</td>
<td>40.4</td>
<td>80.8</td>
<td>121.2</td>
<td>161.6</td>
<td>202.0</td>
</tr>
<tr>
<td>Carbohydrate, g.</td>
<td>15.4</td>
<td>30.8</td>
<td>46.2</td>
<td>61.6</td>
<td>77.0</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>14</td>
<td>28</td>
<td>42</td>
<td>56</td>
<td>70</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>101</td>
<td>202</td>
<td>303</td>
<td>404</td>
<td>505</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>2.2</td>
<td>4.4</td>
<td>6.6</td>
<td>8.8</td>
<td>11.0</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>.040</td>
<td>.080</td>
<td>.120</td>
<td>.160</td>
<td>.200</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>.014</td>
<td>.028</td>
<td>.042</td>
<td>.056</td>
<td>.070</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>.613</td>
<td>1.226</td>
<td>1.839</td>
<td>2.452</td>
<td>3.065</td>
</tr>
</tbody>
</table>

* The meat from one mature nut usually weighs between 300 and 400 grams.
Table 5. Nutrients furnished by immature coconuts (liquid and soft meat) compared with human milk and with cow's milk (quantities approximating those for a 3-month-old baby)

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>2 coconuts</th>
<th>3 coconuts</th>
<th>Human Milk 700 ml.</th>
<th>Cow's Milk 660 ml.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water, g. or ml.</td>
<td>667</td>
<td>1000</td>
<td>616</td>
<td>574</td>
</tr>
<tr>
<td>Calories</td>
<td>322</td>
<td>483</td>
<td>497</td>
<td>455 from milk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>655 milk + sugar</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>4.5</td>
<td>6.8</td>
<td>8.4</td>
<td>22</td>
</tr>
<tr>
<td>Fat, g.</td>
<td>23.9</td>
<td>35.8</td>
<td>26.6</td>
<td>25</td>
</tr>
<tr>
<td>Carbohydrate, g.</td>
<td>27.6</td>
<td>41.3</td>
<td>49</td>
<td>32</td>
</tr>
<tr>
<td>Cane sugar, g.</td>
<td>74</td>
<td>111</td>
<td>238</td>
<td>832</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>132</td>
<td>198</td>
<td>112</td>
<td>653</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>2.6</td>
<td>4.0</td>
<td>1.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>0.062</td>
<td>0.093</td>
<td>0.105</td>
<td>0.277</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.100</td>
<td>0.150</td>
<td>0.329</td>
<td>1.043</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>2.0</td>
<td>3.1</td>
<td>1.204</td>
<td>0.561</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>14</td>
<td>22</td>
<td>31</td>
<td>6</td>
</tr>
<tr>
<td>Ascorbic acid, mg.</td>
<td>602 I.U.</td>
<td>502 I.U.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A + carotenoids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To be diluted with one-half the volume of water to make approximately 990 ml.

ing coconuts, assuming that they would be prepared as vaisalo, a sort of puree described on page 39, with 700 milliliters of mother's milk and with a typical cow's milk formula for a 3-month-old baby. The most striking deficiencies of the coconut preparations are for protein, calcium, vitamin A, and riboflavin. Vaisalo is certainly not a satisfactory substitute for mother's milk, but might be useful for tiding a baby over an emergency period of a day or two or as a supplement to mother's milk. If used for more than a few days, it would be essential to have a good protein that would also supply riboflavin and vitamin A. Such proteins are available to the island people in the soft parts of some shell fish like opihi (the Hawaiian limpet) which was fed with poi at an early age to babies in ancient Hawaii (44). Unless unsafe from the bacteriological standpoint, there is no reason why they might not be so used today.
Table 6. Weights of edible portion of flesh and liquid in drinking coconuts, the thick flesh in mature coconuts, and the embryo in sprouted nuts

<table>
<thead>
<tr>
<th>Drinking coconut</th>
<th>Weight of coconut with shell*</th>
<th>Weight of coconut water</th>
<th>Weight of soft spoon meat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g.</td>
<td>g.</td>
<td>g.</td>
</tr>
<tr>
<td>1</td>
<td>492</td>
<td>144</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>440</td>
<td>120</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>770</td>
<td>372</td>
<td>168</td>
</tr>
<tr>
<td>4</td>
<td>388</td>
<td>120</td>
<td>64</td>
</tr>
<tr>
<td>5</td>
<td>668</td>
<td>320</td>
<td>192</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
<td>272</td>
<td>160</td>
</tr>
<tr>
<td>7</td>
<td>-</td>
<td>156</td>
<td>156</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>244</td>
<td>140</td>
</tr>
<tr>
<td>9</td>
<td>-</td>
<td>280</td>
<td>144</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>260</td>
<td>136</td>
</tr>
<tr>
<td>Average</td>
<td>552</td>
<td>229</td>
<td>128</td>
</tr>
<tr>
<td>Average of 4 coconuts†</td>
<td>Marshall Islands</td>
<td>125</td>
<td>66</td>
</tr>
<tr>
<td>Average of 5 coconuts†</td>
<td>Caroline Islands</td>
<td>270</td>
<td>115</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mature coconut</th>
<th>Weight of coconut with shell*</th>
<th>Weight of mature meat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g.</td>
<td>g.</td>
</tr>
<tr>
<td>1</td>
<td>616</td>
<td>350</td>
</tr>
<tr>
<td>2</td>
<td>613</td>
<td>344</td>
</tr>
<tr>
<td>3</td>
<td>620</td>
<td>352</td>
</tr>
<tr>
<td>Average</td>
<td>616</td>
<td>349</td>
</tr>
<tr>
<td>Average of 4 coconuts†</td>
<td>Marshall Islands</td>
<td>337</td>
</tr>
<tr>
<td>Average of 6 coconuts†</td>
<td>Caroline Islands</td>
<td>354</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avg. 348</td>
</tr>
</tbody>
</table>

* Without husk.
† Edible portions of the coconuts were pooled, and individual weights were not taken.

Mature coconut meat

Samples 5 and 6, Table 3, show the nutrients in 100 grams of mature coconut from which the thin, closely adhering brown skin was not removed. The fat is high, about 40 percent, the protein low, about 4 percent, and the carbohydrate approximately 15 percent. The minerals and vitamins are relatively low except for iron. The larger part of the iron may reside in the brown skin adhering to the white
Table 6A. Weights of coconut embryo

<table>
<thead>
<tr>
<th>Embryo of sprouted coconut</th>
<th>Weight of coconut with shell* (g.)</th>
<th>Waste (g.)</th>
<th>Weight of embryo (g.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>510</td>
<td>408</td>
<td>102</td>
</tr>
<tr>
<td>2</td>
<td>369</td>
<td>273</td>
<td>96</td>
</tr>
<tr>
<td>3</td>
<td>385</td>
<td>243</td>
<td>142</td>
</tr>
<tr>
<td>4</td>
<td>333</td>
<td>233</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>353</td>
<td>253</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>373</td>
<td>248</td>
<td>125</td>
</tr>
<tr>
<td>Average</td>
<td>387</td>
<td>276</td>
<td>111</td>
</tr>
<tr>
<td>Average of 4 coconuts†</td>
<td></td>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average of 5 coconuts‡</td>
<td></td>
<td></td>
<td>102</td>
</tr>
<tr>
<td>Caroline Islands</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Without husk.

† Edible portions of the coconuts were pooled, and individual weights were not taken.

meat rather than in the white portion itself, though this was not determined.

Since the fiber is roughly 3.5 to 4.5 percent, it can be expected that it would interfere with the digestion and absorption of the other nutrients, but people accustomed to foods high in crude fiber such as coconuts and pandanus flour may utilize the nutrients more efficiently than people who have a relatively smooth diet.

Records made by one of the authors (M.M.) during the dietary study in the Marshall Islands on 324 persons indicated that mature coconut was eaten out of hand with or without other foods by 89 people from one to six times per week; 34 ate coconut only once during the week the dietary study was made; 22 had coconut two times; 20, three times; 10, four times; 2, five times; and 1, six times.

The quantity eaten in 1 day also varied, with the majority using between 175 and 350 grams daily. One person ate as little as 10 grams and another as much as 700 grams of mature coconut in 1 day. The weight of the mature white meat with the adhering brown skin of large coconuts averaged about 350 grams, smaller nuts averaged about 335 grams (Table 6). It was not at all unusual for an individual to eat one-half to one large nut per day.

In the Caroline Islands, perhaps because it was the
height of the breadfruit season, smaller quantities of the mature flesh were utilized during the week-long dietary study as their consumption was recorded for only 96 out of 290 people. The mature flesh was eaten from 1 to 5 days per week in quantities representing as little as one-fifth of one coconut to one whole coconut.

The daily consumption of as much as 400 grams of mature coconut (a very large nut, on the basis of our calculations in Table 6) would make a large contribution to the energy needs, and would furnish about 25 percent of the protein, about 70 percent of the iron, and about 30 percent of the niacin listed in the recommended dietary allowances (Table 4). Assuming a standard of 1.32 grams of phosphorus per day, about one-third of the phosphorus would be supplied. The amounts of calcium, thiamine, and riboflavin furnished by this quantity of coconut would be small, only one-tenth or less of the daily recommended allowances.

Whether or not these calculated quantities could actually be obtained is questionable in view of the high fiber content of the mature coconut and the difficulty of chewing such a firm, tough substance to a very fine consistency.

Considerable use is made of grated coconut combined with other foods (pp. 46 and 47) and it seems reasonable to assume that the utilization of all the nutrients would be increased because its finer consistency would permit better contact with the digestive juices.

The quantities of the essential amino acids found in coconut globulin (27), the principal protein of coconuts, compare favorably with some animal proteins except for tryptophane and suggest that it should have a relatively high biological value. Work planned by the South Pacific Commission should yield definitive information on this aspect of the nutritive value of the coconut.

Coconut cream

The preparation of coconut cream from mature coconuts is a simple way to obtain the most important nutrients and eliminate the fiber. Samples 8 and 9 in Table 3 show the composition of coconut cream prepared in two ways. Sample 8 was made without the addition of water to the grated coconut and Sample 9 with the addition of water (see Appendix, pp. 118-119, Coconut, for details of the method of preparation).

Coconut Cream No. 1, made without the addition of wa-
ter to the grated coconut, has less water than Coconut Cream No. 2, but all other nutrients except calcium are greater (Table 3) and ascorbic acid is the same. It was thought that the water-soluble vitamins in Coconut Cream No. 2 might be as great or greater than in the more concentrated cream, but such did not prove to be the case except for ascorbic acid, which is low in both. The higher calcium content of Coconut Cream No. 2 probably resulted from the addition of the water within the coconut to the grated meat before pressing out the cream.

No accurate comparison of the nutrients in coconut cream with those in the mature coconut can be made from the figures in Table 3, as we did not analyze the mature coconut from which the cream was made, nor the residue remaining after the cream was expressed, so that we do not know the percent of nutrients extracted. However, per unit of weight, the cream is about as good a source of protein, phosphorus, iron, niacin, and ascorbic acid as the mature coconut, but has smaller quantities of fat, carbohydrate, and riboflavin, and about the same amount of thiamine.

The authors have no data on the quantities of coconut cream used by the native peoples, but it is believed that when utilized, it is likely to be between 100 and 200 grams daily.

**Embryo of sprouted coconuts**

Perhaps one reason many people like the embryo is that it has about one-third the fiber content of mature coconut with about the same carbohydrate content. The fat is only about one-tenth and the protein one-third to one-half that of the mature nut. The figures in Table 3 indicate that compared to the mature coconut meat the calcium and phosphorus contents are similar and the iron much less in the embryo. The thiamine content of the embryo is less than the mature nut, the riboflavin two or three times as great, and the niacin similar. The amounts of most of these nutrients are such that they would make but a small contribution to the day's needs unless the embryos are eaten in large quantities (see below).

Six embryos weighed in the Marshall Islands ranged from 96 to 142 grams, an average of 111 grams each (Table 6). Four embryos used for analyses (Sample 10) from
the Marshalls averaged 90 grams each and 5 embryos from the Caroline Islands (Sample 11) averaged 102 grams each. Therefore 100 ± 10 grams may be considered a typical weight for the embryo of the sprouted coconut. Judging from the figures in Table 6, the size and weight of the embryo are not proportional to the weight and size of the original nut.

The records made by one of the authors (M.M.) in the Marshall Islands showed that 70 people out of the 324 taking part in the week-long dietary study ate the coconut embryo 99 times. Forty-five of them ate it once a week and the remainder two or three times a week. The quantity eaten at one time varied from 100 to 500 grams. In 42 out of the 99 times, the quantity eaten daily was between 100 and 200 grams; 17 times, the amount eaten was 200 to 300 grams; 12 times, 300 to 400 grams; and 28 times, the amount eaten was approximately 500 grams, which would be four and perhaps five embryos in 1 day. The approximate quantities of the various nutrients furnished by one to five embryos (assuming 100 grams as an average weight for one embryo) are shown in Table 7. With a water content of 83.4 percent, the embryos are somewhat comparable to apricots and oranges in their proximate composition except that the coconut embryos have more fat. The mineral and vitamin contents are relatively low.

When as much as four or five coconut embryos are eaten, the following approximate amounts of the various nutrients in relation to the recommended daily allowances would be furnished: protein, $\frac{1}{10}$; calories, $\frac{1}{10}$; calcium, $\frac{1}{10}$; phosphorus, $\frac{1}{5}$; iron, $\frac{1}{4}$ to $\frac{1}{3}$; thiamine, less than $\frac{1}{10}$; riboflavin, $\frac{1}{10}$ or less; niacin, $\frac{1}{5}$ to $\frac{1}{4}$; and ascorbic acid, $\frac{1}{3}$, according to our figures. The crude fiber content, comparable to such vegetables as green lima beans, string beans, and carrots, should permit relatively good utilization of the nutrients, especially the carbohydrate and fat. To our knowledge, no data are available on the biological value of the protein or the individual amino acids of the embryo as compared with the mature meat.

**Coconut sap**

The most striking thing about the coconut sap and the more concentrated syrup made from it is the relatively high ascorbic acid value. The figures for this nutrient for
the samples in Table 3 show a range of values from 15 to 24 milligrams per 100 grams on the sap that has not been concentrated. It should be noted that these values were determined after some months of transportation and storage (pp. 121-122, Coconut). The fact that the saps are distinctly acid, as shown by the pH values in Table 3, no doubt helped to preserve the vitamin. Whether or not freshly drawn sap would show even higher values remains to be determined.

Even when the sap is concentrated to a syrup, and the moisture content reduced from about 95 percent to 28 percent (p. 45), the product retained sufficient ascorbic acid to give it a value of 50 milligrams per 100 grams.

The sap is to be highly recommended as a local source of ascorbic acid, especially for infants and children. In addition, its thiamine content is as good or better than mother's milk and the niacin value more than twice that of mother's milk. The riboflavin, usually associated with protein, is only one-fourth to one-tenth the amount found in mother's milk. The amounts of calcium and phosphorus are not significant but the iron content is relatively good.

The protein and fat, as might be expected, are low, but the carbohydrate content of 10 to 12 percent for the fresh sap makes it a good natural source of sugars. In fact, the fresh sap has about the same carbohydrate content as fresh orange juice, but about half the ascorbic acid content.

In the Marshall Islands dietary study of 1 week on 324 persons 1 year and older, 50 of them used jekara anywhere from one to six times per week, the majority being once or twice a week, and nine drank it five or six times a week. The quantity used per day varied; the majority having from a little more than 100 to 450 milliliters; about 225 milliliters was the most common quantity. Further study of the records showed that 90 times, 100 to 300 milliliters of jekara were consumed in 1 day; for 14 times the quantity per day was between 300 and 500 milliliters; 2 times it was more than 500 milliliters; and 1 day one person used 1000 milliliters of jekara.

Even small quantities of the sap (100 milliliters, about 1/2 cup) will make a significant contribution of ascorbic acid to the day's diet. Large quantities of sap (500 to 1000 milliliters) would add a good quota only of niacin, in addition to calories and ascorbic acid (Table 7).
### Table 7. Nutritive values of various quantities of coconut sap and of embryo from sprouted nuts

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>100 g.</th>
<th>200 g.</th>
<th>300 g.</th>
<th>500 g.</th>
<th>1000 g.</th>
<th>100 g.</th>
<th>200 g.</th>
<th>300 g.</th>
<th>400 g.</th>
<th>500 g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water, g.</td>
<td>87.5</td>
<td>175</td>
<td>262</td>
<td>438</td>
<td>875</td>
<td>83.4</td>
<td>167</td>
<td>250</td>
<td>334</td>
<td>417</td>
</tr>
<tr>
<td>Calories</td>
<td>48</td>
<td>96</td>
<td>144</td>
<td>240</td>
<td>480</td>
<td>80</td>
<td>160</td>
<td>240</td>
<td>320</td>
<td>400</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>0.22</td>
<td>0.4</td>
<td>0.7</td>
<td>1.1</td>
<td>2.2</td>
<td>1.30</td>
<td>2.6</td>
<td>3.9</td>
<td>5.2</td>
<td>6.5</td>
</tr>
<tr>
<td>Fat, g.</td>
<td>0.40</td>
<td>0.8</td>
<td>1.2</td>
<td>2.0</td>
<td>4.0</td>
<td>4.08</td>
<td>8.2</td>
<td>12.2</td>
<td>16.3</td>
<td>20.4</td>
</tr>
<tr>
<td>Carbohydrate, g.</td>
<td>11.40</td>
<td>22.8</td>
<td>34.2</td>
<td>57.0</td>
<td>114.0</td>
<td>10.28</td>
<td>20.6</td>
<td>30.8</td>
<td>41.1</td>
<td>51.4</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>0.4</td>
<td>0.8</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>19.2</td>
<td>38</td>
<td>58</td>
<td>77</td>
<td>96</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>20.0</td>
<td>40.0</td>
<td>60</td>
<td>100</td>
<td>200</td>
<td>66.1</td>
<td>132</td>
<td>198</td>
<td>264</td>
<td>330</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>0.18</td>
<td>0.36</td>
<td>0.54</td>
<td>0.90</td>
<td>1.8</td>
<td>0.69</td>
<td>1.38</td>
<td>2.07</td>
<td>2.76</td>
<td>3.45</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.016</td>
<td>0.032</td>
<td>0.048</td>
<td>0.08</td>
<td>0.16</td>
<td>0.015</td>
<td>0.030</td>
<td>0.045</td>
<td>0.060</td>
<td>0.075</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>0.006</td>
<td>0.012</td>
<td>0.018</td>
<td>0.03</td>
<td>0.06</td>
<td>0.032</td>
<td>0.064</td>
<td>0.096</td>
<td>0.128</td>
<td>0.160</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>0.48</td>
<td>0.96</td>
<td>1.44</td>
<td>2.4</td>
<td>4.8</td>
<td>0.86</td>
<td>1.72</td>
<td>2.58</td>
<td>3.44</td>
<td>4.30</td>
</tr>
<tr>
<td>Ascorbic acid, mg.</td>
<td>20.6</td>
<td>41</td>
<td>62</td>
<td>103</td>
<td>206</td>
<td>6.0</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>
Cereal gruels with coconut sap and coconut cream (jaibo and chokoP)

The records of the week-long dietary study on 324 people showed that 68 persons ate jaibo, a sort of gruel made of white flour, coconut sap, and coconut cream. Forty-eight ate it four times per week with the quantities per day amounting to 400 to 600 grams daily.

The quantities of coconut sap and coconut cream added do not markedly improve the nutritive value of a white flour gruel though they doubtless improve the flavor and make it a more acceptable dish. The total carbohydrate content is comparable to that of a cooked cereal like rolled wheat (17 percent) and more than a granular cereal like cooked farina (9 percent), though the quantity of water used in preparing the cereal might change these figures.

There was not a sufficiently large sample to determine the proximate composition and the calcium, phosphorus, and iron content of chokoP (Sample 18), which is a similar mixture of white polished rice, coconut sap, and coconut cream. But judging from the vitamin values, the same general conclusions drawn on nutritive value for jaibo above, are applicable to chokoP.

Summary and Conclusions

Observations on the use of coconut by the early explorers in the Pacific are noted. The different forms and stages of the coconut used as food, as well as products such as grated coconut, coconut cream, and coconut sap, are described. Nineteen samples of coconut or products containing some form of coconut were analyzed as follows: two samples of liquid from the drinking nuts, two samples from the flesh of drinking nuts, one sample of liquid from mature nuts, two samples of flesh from mature nuts, two samples of coconut cream, two samples of embryo from sprouted nuts, five samples of coconut sap (fresh and concentrated), two dishes containing sap and coconut cream, and one sample of coconut oil. The results are summarized in table form, followed by discussion of the nutritive values. Most of the samples were obtained in the Marshall and Caroline Islands. Information is given on the quantity of the coconut products used in the Majuro and
Truk districts of the Marshall and Caroline Islands where dietary surveys were made in 1951.

The quantity of edible portion obtained from drinking nuts, mature coconuts, and sprouted coconuts are recorded. The quantity of nutrients that may be obtained from one to five drinking coconuts and from various quantities of mature coconut, embryo or sprouted nuts, and coconut sap are given in table form. Because the immature coconuts are sometimes used to supplement, or replace, mothers' milk for babies and little children, the nutrients furnished by a combination of the liquid and soft meat from immature coconuts are compared with the nutrients in human's and cow's milk.

The liquid from immature or drinking coconuts is most valuable to the island people because it supplies an ever-available source of safe drinking water. But even when as many as five nuts are used, the amount of various nutrients provided is very small. The flesh of the immature nuts furnishes more calories and more of the various nutrients than does the water from the drinking coconut except for calcium and ascorbic acid. Naturally, when both the flesh and the liquid of drinking nuts are consumed, the maximum nutritive value is obtained.

The flesh of the mature coconuts has more of all of the various nutrients than the immature nuts. The fat especially increases to approximately 40 percent and the carbohydrate to approximately 50 percent. Since mature coconut contains 3 to 4 percent of fiber, just how well the various nutrients are utilized is not known. By preparing coconut cream from the mature coconuts, the native people can obtain as much protein per unit of weight as from the mature nut, approximately half the quantity of carbohydrate, and two-thirds the amount of fat. Since the mature coconut used for the preparation of the coconut cream was not analyzed as such, accurate statements regarding the percentage of the nutrients obtainable in the cream as compared with the mature nuts cannot be made; but judging from the separate analyses presented in table form, it would appear that the quantities of calcium, phosphorus, iron, thiamine, niacin, and ascorbic acid are just as great per unit of weight, but the riboflavin is less.

The embryos of the sprouted nuts, which are much liked by the natives, contain less protein, about two-thirds the
amount of carbohydrate, and much less fat and fiber than do the mature coconuts. The amount of calcium is similar but the quantities of phosphorus and iron are less than in the mature nut. The amount of thiamine is less, but the amounts of riboflavin, niacin, and ascorbic acid are greater in the embryo than in the mature nut.

Fresh coconut sap contains 10 to 12 percent of sugars and small amounts of all other nutrients tested except ascorbic acid, which we find to be between 17 and 25 milligrams per 100 milliliters. Even when concentrated by boiling so that the carbohydrate is increased from 12 to 70 percent, much of the ascorbic acid is retained. Since many of the foods used by the island people are low in ascorbic acid, coconut sap when freshly drawn and heated to prevent fermentation may serve as an important and valuable, though not rich, source of vitamin C for the feeding of infants and young children.

Coconut oil made by the native method was found to contain 98.80 percent of fat with only small traces of other nutrients.

There is no doubt that the coconut in its many forms has constituted an important and vital source of food for the people of tropical Pacific islands and should continue to be used in all forms. Those concerned with the health of the people should urge that adequate coconut plantings be made for local use rather than putting all the emphasis on the production of copra as a commercial cash crop.
PANDANUS

Description and Geographical Distribution

The pandanus, sometimes called "screw pine," is widely distributed in Southeast Asia and all the tropical Pacific islands, but according to St. John (76), it is only in Kapingamarangi, and in the Marshall, Gilbert, and Ellice Islands that one finds the varieties with choice edible fruit. On the small and relatively dry, low islands or atolls, pandanus and coconuts are the principal and sometimes the only vegetable foods.

Almost all parts of the pandanus plant are used by the inhabitants of these islands; the leaves provide material for clothing and shelter, and for household use such as baskets and mats. The chief edible part is the fruit, especially the fleshy base of the keys.

There are two distinct sexes of trees for all varieties, male (staminate) and female (pistillate). The pistillate trees bear fruits of different sizes, varying from the inedible ones 3 or 4 inches in diameter, which weigh a pound or less, to the very large edible fruits weighing 20 to 30 pounds (see Fig. 18). A 30-pound fruit has approximately 50 keys and a core and stem weighing about 2 pounds.

Each fruit is made up of many small sections called keys (botanically, a phalange), because though irregular in shape they fit closely together to form a solid fruit. In a large fruit the keys are 3 to 4 inches long; at the outer end they are $1\frac{1}{2}$ to 2 inches in diameter and at the inner end near the core $\frac{3}{4}$ to 1 inch (see Fig. 19). The rough outer surface may be green or yellow when ripe, but the inner edible end is always yellow-orange in color. The inedible varieties have fruits, which, though smaller, look just like
the edible types, but they are extremely astringent and bitter.

The chemical analyses and studies of the nutritive values of pandanus fruit reported in this bulletin were made on fruits from Micronesia: Majuro and Mille Atolls of the Marshall Islands and Kapingamarangi of the Caroline Islands.

**Use as Food**

The earliest account of the edible pandanus fruit and its use by the natives of the Marshall Islands is by Kotzebue
(32) who, early in 1816 when he first touched at the Radak Island chain, observed "they had nothing with them except a few grains of pandanus, which they constantly chewed."

Kotzebue (32) and Chamisso (9), the naturalist who accompanied the expedition, tell of being served "pandanus juice" which was pressed from the keys after they were bruised with a stone and which Kotzebue states, "had a sweet and spicy taste."

Discussing the abundant pandanus, Chamisso stated, "It is also diligently cultivated; numerous varieties, with improved fruits, which are to be ascribed to cultivation, are propagated by layers" (9).

Kotzebue (32) opined that "the pandanus contains very little nourishment," but noted that the natives "enjoy extraordinary health, and attain to an advanced and cheerful old age." His picture of the teeth, however, is quite in contrast to that of some of the early voyagers who remarked on the fine teeth of the Polynesians (11, 17). Kotzebue states, "All the islanders are great lovers of sweet things; and their chief food, which they draw from the sweet pandanus fruit, is probably the reason, that even children of 10 years old have not good teeth, and that they have generally lost them all in the prime of life" (32).

Chamisso (9) gives a rather detailed account of the making of pandanus paste (mōkan), which is essentially the same method used today. He also observed that the paste

Fig. 19 a. Roll of pandanus paste in lauhala wrappings, collected at Mille Atoll by Dr. Kenneth P. Emory.

Fig. 19 b. A single key from a large Lojekerer, side and end views. Sketch by M. Higa.
was "carefully preserved as a valuable stock for long voyages."

Pandanus has apparently always been an important food in the Marshall as well as the Gilbert Islands as it figures prominently in their folklore and is commonly considered to have come with their creation (23, 75).

Selection and propagation must have been practiced by these isolated people for many years in order to have developed the fine edible varieties which are limited in their distribution.

No edible pandanus was in evidence when the dietary study was made in the Caroline Islands (49), but it was thought that it might have been out of season. Chamisso (9) states that at the time of their visit (1817), although the pandanus grew on all the islands, "the fruit is neither eaten, nor ever used for an ornament. None of the improved kinds are found there."

In the Marshall Islands, each household owns some pandanus trees which may be near the house or at some distance from the dwelling. When ripe and ready for use, the large fruits are cut from the tree with a bush knife and the keys broken apart to be eaten raw or cooked.

Pandanus was in season in the Marshall Islands from January to the end of May, 1951, and at the time the dietary study was made in April both pandanus and breadfruit were being used (49). On the low islands, pandanus is one of the important foods between breadfruit seasons; when breadfruit is abundant, pandanus may or may not be used.

The most common method of eating pandanus is to gnaw at the soft inner ends, leaving the long tough fibers attached to the keys. Children and adults seem to chew the keys almost continuously during their waking hours. People eat them much as Westerners might eat nuts or candy or smoke cigarettes. Chewing pandanus keys, talking and gossiping are an important part of their social life. Records of the amounts eaten and the nutrients furnished are given in the section on composition and nutritive value, pp. 77-78.

The hard portion of the keys is used as firewood. The inedible ends also contain the seeds, which can be removed only with great difficulty because they are enclosed in an unusually tough woody case and people rarely bother to extract them, although they are sometimes eaten.

In the raw state, the edible portion of the pandanus is
merely a juice pressed from the cells embedded in coarse fibers. It is not a pulp but a liquid which when extracted in the laboratory has a small portion of solid material that settles to the bottom of a beaker. The juice is sweet and subacid with a pungent aromatic flavor. When cooked, the starch causes the juice to thicken and the edible portion becomes a soft pulp, resembling mashed sweet potatoes both in color and in texture. The flavor is similar to the raw juice.

If a good supply of other foods is available, the pandanus keys are more likely to be eaten in the raw state because people simply do not bother to cook them. But when the pandanus constitutes a large proportion of the diet (such as was observed in February, 1951, at Mejit Island, Mejit Atoll; Utirik Island, Utirik Atoll; and Ailuk Island, Ailuk Atoll; in the drier northern Marshall Islands), it is eaten cooked as well as raw, probably to add variety. It is also combined with other foods as listed below.
The names and descriptions of edible pandanus fruit and products made from the fruit which were observed by one of the authors (M.M.) in the Marshall Islands in 1951 are as follows:

**Bop**, the pandanus tree or the whole fruit made up of many keys.

**Kôbeo**, raw pandanus fruit.

**Erourm**, boiled or baked pandanus.

**Joanrung**, pandanus juice.

**Môkan** (see below for preparation), cooked and preserved pandanus pulp.

**Beru**, soft pulp from boiled pandanus cooked with arrowroot flour to produce a sweet dessert.

**Môkanrul**, pulp of cooked pandanus fruit mixed with grated coconut and baked.

**Jakaka**, shredded fresh (uncooked) pandanus which is dried for almost one week and used as a confection.

The native people in most of the islands still make all the products from pandanus which their ancestors made. But where Western influence is strong, or where more favorable conditions permit growing a greater variety of foods, they no longer preserve the pandanus, though they continue to enjoy it in the raw or freshly cooked state. Two products which we analyzed, that can be stored and used for emergency or as wanted, pandanus paste and flour, are described below.

**Pandanus paste** (Marshallese name, **Môkan**)

Wherever the pandanus constituted an important native food in the fresh and cooked state, pandanus paste was also made, and is still made in some areas.

Many reports of scientists in the nineteenth and twentieth centuries tell of the preparation of pandanus paste which they also refer to as pandanus conserve or preserve (9, 19, 34, 36, 64).

Details of the process may vary slightly in different localities but, in general, the paste is made as follows: The separated pandanus keys are cooked in a deep earth oven with alternating layers of fruit and leaves for as long as 2 days, though one report states for 12 hours (64). The soft ends of the keys are rubbed against a scraper
and the orange-colored pulp is collected and dried on leaves. When it becomes a sticky mass, it is dried further over hot stones until it is thick and rather firm. The flat cakes are then rolled or pressed into a firm mass, wrapped in plaited pandanus leaves, and firmly tied with coconut cord as shown in Figure 19a.

These rolls are reported to have been of enormous size formerly—6 feet long and more than 1 foot in diameter (19, 36, 64). Today they are more likely to be 12 to 15 inches long and 3 or 4 inches in diameter (Fig. 21). The "model" shown in Figure 21 is only 8 inches long.

One account of the preparation of pandanus paste (64) calls attention to the unsanitary methods employed in making it, but probably they were no less sanitary than the handling of other foods.

The product is brown in color and tastes much like date or fig paste. It will keep a year or more and was formerly an important manner of preparing food for use on voyages and for storage in case of famine as well as for a regular food supply when pandanus was not in season (see p. 69).

_Pandanus flour_

Though the accounts of anthropologists (7, 23) vary somewhat as to the method of making the dried product, referred to as "pandanus flour," they agree on the essential points which are here summarized.

The soft ends of the keys are cut off, placed in some type of coconut basket, and cooked, usually by steaming in an earth oven until tender, about 1 hour. The cooked fruits are pounded to a paste, which is made into large thick flat cakes about 14 inches in diameter, then dried (7). In some places they are dried in the sun and finished over a grill of hot stones, and in other places they are dried over the hot stones first and then placed in the sun. The sun-drying may take several days. They are usually given a final drying over hot stones and then the large crisp cakes are broken and pounded to a coarse flourlike consistency.

The product is dull yellow with a pleasant pungent odor. It can be stored in tubular containers made of plaited pandanus leaves and will keep for several years.

Grimble (23) reports that formerly pandanus flour and water were often the only food and drink taken on long
voyages. The powder was simply mixed with water and drunk.

Luomala (72), who made observations in the Gilbert Islands in the latter half of 1948, especially on the Island of Tabiteuea, says that she saw both pandanus flour and pandanus paste being made.

To our knowledge the pandanus is not made into a flour in the Marshall Islands as it is in the Gilbert Islands and in Kapingamarangi.

**Pandanus varieties**

The number of edible varieties of pandanus in the Marshalls is uncertain, but St. John (76) states that he has collected several score.

One of the authors (M.M.) collected what were believed to be two native varieties of edible pandanus for chemical analyses, but St. John, who has examined the keys, believes them to be the same botanical species.

Lojekerer (local name), *Pandanus pulposus* Martelli: This variety is the most common and widely distributed in the Radak chain. Four fruits on Majuro Island in April and May, 1951, had the following weights: 23, 32, 25, and 30 pounds. The keys are large, 3 to 4 inches long, 1 1/2 to 2 inches in diameter, and weigh from about 3 to 7 ounces (100 to 200 grams). They are eaten both raw and cooked.

According to our informants this variety usually fruits but once a year. Our samples were obtained toward the end of the fruiting season.

Joibeb (local name), *Pandanus pulposus* Martelli: This variety, which according to our informants, is also widely distributed, was thought to have originated on Jaluit of the Ralik chain. Four fruits on Majuro Island in April and May, 1951, had the following weights: 24, 30, 20, and 25 pounds. These fruits also had large keys.

We were informed that on Jaluit and Ebon, this variety usually fruits twice a year.

For clarity, we refer below to the fresh pandanus by the two local names as if they were two horticultural varieties.

**Composition and Nutritive Value**

The pandanus products analyzed were: two varieties of fresh and cooked pandanus from the Marshall Islands (Ma-
juro) collected in 1951; one sample of pandanus seeds; one sample of pandanus paste collected in 1949 by Dr. Kenneth P. Emory (70), ethnologist of the Bernice P. Bishop Museum, at Mille Atoll, Marshall Islands; and one sample of pandanus flour from Kapingamarangi, also collected by Dr. Emory in 1947. Sufficient material was not available to make analyses for all nutrients in one sample of cooked pandanus and for the pandanus seeds. The data on composition are summarized in Table 8.

**Fresh, raw, and cooked pandanus fruit**

The fresh fruit contains but small amounts of protein and fat (less than 0.5 percent), consequently its greatest food value may be ascribed to its carbohydrate, mineral, and vitamin contents.

The carbohydrate content (14 to 18 percent) of the edible portion of the fresh pandanus is a little less than raw potatoes, somewhat greater than fresh fruits such as apricots and peaches, and about the same as apples and pears (62). The moisture content of 80 to 84 percent is also similar to these fruits.

The edible portion of the fresh, raw pandanus fruit is juicy, whereas the cooked product has much the consistency of a moist, cooked, mashed sweetpotato. The fresh samples of Lojekerer and Joibeb were examined and found to contain starch granules which were ruptured in the cooked product and which were easily stained blue with iodine. The starch granules of both varieties were round and relatively small, averaging 9 microns for the Lojekerer variety and 6 microns for Joibeb. The raw juice of the Joibeb which we examined obviously contained more starch than the Lojekerer and it also thickened to a greater degree when small samples of the extracted juice were cooked in the laboratory. Whether or not this difference may be explained on the basis of ripeness of the two samples or as a true varietal characteristic can be determined only by additional tests.

The thickening which takes place on cooking can be explained by the presence of the starch grains, but pectins, for which no tests were made, may also be present.

Pandanus fruit contains more calcium than do such temperate climate fruits as apples and peaches, and one sample had as much calcium as fresh apricots and almost
<table>
<thead>
<tr>
<th>Sample</th>
<th>Local name and method of preparation</th>
<th>Source</th>
<th>Water</th>
<th>Energy</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
<th>Total Fiber</th>
<th>Ash</th>
<th>Calcium</th>
<th>Phosphorus</th>
<th>Iron</th>
<th>Carotene*</th>
<th>Thiamine</th>
<th>Riboflavin</th>
<th>Niacin</th>
<th>Ascorbic acid</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lojekerer, fresh</td>
<td>Marshall Islands</td>
<td>80.2</td>
<td>71</td>
<td>0.37</td>
<td>0.27</td>
<td>18.63</td>
<td>0.28</td>
<td>0.53</td>
<td>9.6</td>
<td>25.9</td>
<td>0.89</td>
<td>1242</td>
<td>0.031</td>
<td>0.038</td>
<td>0.88</td>
<td>2.3</td>
<td>5.2</td>
</tr>
<tr>
<td>2</td>
<td>Lojekerer, boiled</td>
<td>&quot;</td>
<td>83.8</td>
<td>56</td>
<td>0.22</td>
<td>0.20</td>
<td>15.42</td>
<td>0.08</td>
<td>0.42</td>
<td>13.3</td>
<td>19.6</td>
<td>0.39</td>
<td>847</td>
<td>0.024</td>
<td>0.034</td>
<td>0.71</td>
<td>8.9</td>
<td>5.1</td>
</tr>
<tr>
<td>3</td>
<td>Joibeb, fresh</td>
<td>&quot;</td>
<td>84.2</td>
<td>56</td>
<td>0.38</td>
<td>0.27</td>
<td>14.55</td>
<td>0.30</td>
<td>0.63</td>
<td>16.4</td>
<td>33.0</td>
<td>0.58</td>
<td>164</td>
<td>0.052</td>
<td>0.025</td>
<td>0.95</td>
<td>2.6</td>
<td>4.9</td>
</tr>
<tr>
<td>4</td>
<td>Joibeb, boiled</td>
<td>&quot;</td>
<td>80.6</td>
<td>236</td>
<td>2.23</td>
<td>1.38</td>
<td>76.14</td>
<td>3.28</td>
<td>2.42</td>
<td>134.4</td>
<td>108.2</td>
<td>5.74</td>
<td>291</td>
<td>0.069</td>
<td>0.042</td>
<td>0.73</td>
<td>(1.5)</td>
<td>5.6</td>
</tr>
<tr>
<td>5</td>
<td>Mōkan, pandanus paste</td>
<td>&quot;</td>
<td>17.8</td>
<td>293</td>
<td>2.94</td>
<td>1.25</td>
<td>80.71</td>
<td>14.95</td>
<td>4.30</td>
<td>797.0</td>
<td>114.0</td>
<td>1.73</td>
<td>1200 I.U.</td>
<td>0.062</td>
<td>0.156</td>
<td>2.25</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Paku harahara, pandanus flour</td>
<td>Kapinga-marangi</td>
<td>10.8</td>
<td>196</td>
<td>2.94</td>
<td>1.25</td>
<td>80.71</td>
<td>14.95</td>
<td>4.30</td>
<td>797.0</td>
<td>114.0</td>
<td>1.73</td>
<td>1200 I.U.</td>
<td>0.062</td>
<td>0.156</td>
<td>2.25</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pandanus seeds†</td>
<td>Marshall Islands</td>
<td>47.2</td>
<td>10.00</td>
<td>24.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Total carotenes, chromatographic method.

† Biological determination of vitamin A value with rats.

†† See p. 82.
as much as orange juice. Our fresh samples of pandanus were equal to or better than white potatoes as a source of calcium but they contained only about half as much calcium as average sweetpotatoes. No determinations for oxalates were made and only digestion studies would determine whether or not the calcium is well utilized.

The phosphorus content of pandanus is about the same as that of the fresh fruits listed above but is much less than that of potatoes and sweetpotatoes.

The iron content of our fresh samples varied but compares favorably with the fresh, temperate-climate fruits already mentioned and with potatoes and sweetpotatoes.

Pandanus is a good source of provitamin A, the Lojekker variety being superior to yellow peaches, but not as good as apricots or yellow sweetpotatoes. Since the Mar­shallese, as well as some other island people (49, 57, 40), consume little if any green and yellow fruits and vegetables, pandanus may constitute the most valuable source of provitamin A in their diet.

Pandanus is at least as good a source of thiamine, riboflavin, and niacin as are apples, peaches, apricots, and pears. It is a less good source of thiamine and riboflavin than potatoes and sweetpotatoes. However, there may have been some loss during the periods of transportation and storage prior to analyses. Pandanus contains less niacin than white potatoes but more than sweetpotatoes, apples, and pears and about the same amount as apricots and peaches.

Both samples of the Joibeb contained approximately twice as much thiamine as the Lojekker, but the differences in riboflavin and niacin content of the two varieties were small and not consistent for the samples analyzed.

The ascorbic acid content of the boiled sample of pandanus is about four times as great as that of the two fresh samples (Table 8). Possibly inactivation of the enzymes in the cooked sample prior to the long period of transportation and storage may account for this. Obviously, additional studies are needed to determine the range of and typical ascorbic acid values for this fruit.

To determine what proportion of the pandanus keys are usually eaten, 50 children at the Marshall Christian Training School at Ronron co-operated in a simple experiment. A single raw key was given to each student and his name
and the weight of the key were recorded. They were asked to eat the pandanus in the usual way and the remaining inedible portion was again weighed.

The weights of single keys ranged from 130 to 200 grams, with an average of 156 grams. The weight of the edible portion ranged from 40 to 102 grams (mostly 60 to 90 grams), with an average of 75 grams. This figure for the weight of the edible portion of a single key has been used for all calculations in Table 9.

While this little study indicated that almost 50 percent of the keys is edible, when the keys were prepared for analyses in the laboratory, the waste was much greater and the edible portion was found to range from 25 to 40 percent. The edible portion of the cooked product was somewhat greater than the raw. It is probably easier to suck or gnaw out the sweet juice or pulp than to obtain it by mechanical means, and the size and ripeness of the fruit, as well as variety, may influence the proportion of waste.

The dietary study in the Marshall Islands (49) included weekly records of 324 people 1 year of age and over; of this number, 138 ate pandanus, some for only 1 day, others for 6 days out of 7, making a total of 293 days on which pandanus was recorded. The number of large keys consumed ranged from 1 to 25 for all ages. Many ate at least 10 keys and several ate 20, the highest recorded was 25. Children 1 year old ate as many as 10. Records for 18

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Table 9. Nutritive value of the edible portion of various quantities of large pandanus keys

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>1 key 75 g.</th>
<th>5 keys 375 g.</th>
<th>10 keys 750 g.</th>
<th>20 keys 1500 g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>53</td>
<td>265</td>
<td>530</td>
<td>1060</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>0.28</td>
<td>1.4</td>
<td>2.8</td>
<td>5.6</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>7.2</td>
<td>36</td>
<td>72</td>
<td>144</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>19.4</td>
<td>97</td>
<td>194</td>
<td>388</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>0.7</td>
<td>3.5</td>
<td>7.0</td>
<td>14</td>
</tr>
<tr>
<td>Carotene, mcg.</td>
<td>932</td>
<td>4660</td>
<td>9320</td>
<td>18640</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.02</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>0.03</td>
<td>0.15</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>0.7</td>
<td>3.5</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Ascorbic acid, mg.</td>
<td>2</td>
<td>10</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

---

78
different days for 9 children, 2 and 3 years old, showed that they ate 2 to 10 keys with an average of 5 keys per day.

The nutrients obtainable from various quantities of large pandanus keys have been calculated on the basis of our figures for raw Lojekerer and are summarized in Table 9. The conservative value of 3 milligrams of ascorbic acid per 100 grams of edible portion has been used for the calculations in this table though it is highly probable that the value is greater when the pandanus is eaten fresh.

An estimate of the nutritive value of the fresh pandanus may be made by evaluating the contributions to the diet made by 20 large keys, which is not at all an unusual quantity, even when a variety of other foods are available. Twenty keys would supply about half the calories needed per day by a small and not very active person. In addition, twenty keys would supply all of the provitamin A, niacin, and iron, about one-third the thiamine, almost half the riboflavin, and more than half the ascorbic acid, as judged by the National Research Council's Recommended Dietary Allowances (22). Twenty keys would provide little protein, calcium, or fat but would make a good contribution toward the phosphorus needs.

On the basis of our analyses, it is obvious that the greatest contributions of pandanus fruit to the diet are calories, provitamin A, and ascorbic acid. When large amounts are eaten, the quantities of the three minerals (Ca, P, and Fe) obtained are not inconsiderable, but the variety (or varieties) which we analyzed indicate that the edible portion is not an important source of calcium and phosphorus.

It should be emphasized that the groups studied on Uliga Island and Majuro Island, Majuro Atoll, had a rather varied diet and a number of other foods, but in the isolated islets where pandanus, coconut, and fish are often all that is available, half or more of the caloric needs are probably satisfied by pandanus. Coconuts would supply the fat needed and fish and shellfish would furnish not only protein but calcium and phosphorus, especially when small fish are eaten whole.

If the value of about 8 milligrams of ascorbic acid obtained for the cooked sample should prove to be typical of all fresh pandanus, then the fruit would constitute an important source of this vitamin. Even if the pandanus usually has only
half this amount the quantity of ascorbic acid obtained when large amounts are eaten, would satisfy the daily needs.

**Pandanus paste**

The composition of the pandanus paste may be compared with dried dates, which it resembles. The pandanus paste has a little less moisture and therefore a greater energy value (325 calories per 100 grams). The total carbohydrate content is almost identical with dates and the crude fiber content about 1 percent higher. The reducing sugars of pandanus paste were determined by the Munson-Walker method (2:506) and found to be 50.0 percent (calculated as glucose), which would indicate that about two-thirds of the carbohydrate is in the form of sugars and the remainder includes starch.

The protein and fat contents of pandanus paste and dates are low and of little significance.

The calcium content of the paste is almost twice that of dates and the phosphorus and iron contents exceed those of dates, though it may well be that some of the iron in the paste is the result of contamination during preparation and drying.

The pandanus paste has almost 20 times the vitamin A value of dates, about the same amount of niacin, and less thiamine and riboflavin. The period of storage prior to the determination of vitamin A was longer than that for the other vitamins as has been indicated. Doubtless all the vitamins were reduced as a result of storage, but since this is a preserved product used for emergencies, the figures which we obtained are probably typical for pandanus paste.

Although by the dye titration method pandanus paste had about 1.5 milligrams of ascorbic acid per 100 grams, it may be due to reducing substances other than vitamin C. More work on the paste would be desirable to learn if other samples appear to contain ascorbic acid.

**Pandanus flour**

The sample of pandanus flour from Kapingamarangi which was analyzed is probably typical of the dried products made in other islands judging from the description of its preparation given by Grimble (23) for the Gilbert Islands.

Because the entire soft end is cut off and dried as described earlier, no fibers are removed and the resulting
"flour," which resembles fine sawdust, is high in crude fiber (15.0 percent) and low in moisture (10.8 percent). (The low moisture content is necessary to insure its good keeping quality.) If the crude fiber is calculated to a product containing 80 percent of water (comparable to the fresh product), the crude fiber would be reduced to approximately 3.3 percent, which is much greater than that of even our coarsest vegetables such as cabbage. This is in contrast to the pandanus paste which when recalculated to a fresh basis has less crude fiber than the fresh fruit from the Marshalls (Table 8).

Grimble (23), discussing pandanus flour, states that "the gently purgative qualities of the food are also recognized and valued by the islander, who uses it freely as an aperient for his children."

It is to be expected that a food with such a high fiber content would tend to absorb water and form gas, thus lending bulk to the fecal residues and giving it laxative properties. Just how seriously the fiber would interfere with the absorption of food nutrients is difficult to predict. Digestion experiments upon people accustomed to such a coarse diet would be necessary to determine this point. When the pandanus flour is eaten either with water or with concentrated coconut sap as described by Grimble (23), a much greater percentage of crude fiber would probably be ingested than when the fresh raw or freshly cooked pandanus is nibbled and the fibers are rejected or left clinging to the woody end of the keys.

The calcium content of 797 milligrams per 100 grams seems to be remarkably high and when calculated to 80 percent moisture would still appear high (180 milligrams per 100 grams). Perhaps much of the calcium is in the fibrous portion, but there is also the possibility that a few grains of coral sand, blown into the pandanus flour in the process of making or drying, could raise the calcium to this high value. Additional analyses are desirable to check this figure. The phosphorus and iron contents when calculated to the fresh basis fall within the range for fresh fruit.

The vitamin A value for pandanus flour was determined in 1948 by rat feeding methods employed in our laboratory with standard vitamin-A acetate fed to the controls (46). Either the variety from which this sample was made is low
in biologically active carotenoid pigments or as a result of oxidation and desiccation the vitamin A value is greatly reduced.

The flour retained its riboflavin content remarkably well and appears to have twice as much of this vitamin as does the paste, on a comparable moisture basis. Riboflavin is sensitive to light and it would be expected that losses would be great when a food is dried in the sun. Again the original variety of pandanus used in making the flour no doubt influenced the final product.

The niacin, being more stable, appears to have been relatively well retained in the pandanus flour as in the paste.

Pandanus seeds

By use of a hammer and chisel, a sufficient quantity of pandanus seeds were removed from their woody cases to permit determination of only the moisture, protein, and fat contents, which were 47.2 percent, 10.0 percent, and 24.7 percent, respectively. (These were obtained in Honolulu from keys of the edible varieties shipped from the Marshalls.) Since all the seeds extracted weighed less than half a gram, and the keys available to us had no more than three or four seeds, usually only one or two, and sometimes none, more energy is required to extract the seeds than could be obtained from eating them.

Summary and Conclusions

In some Pacific islands, especially Kapingamarangi and the Marshall, Gilbert, and Ellice Islands, the pandanus fruit is an important seasonal food.

The soft ends of the keys which form the fruits contain a sweet spicy juice or pulp that is eaten in the raw or cooked state. The edible portion is also preserved in two ways—as a dried paste resembling dried dates and as a "flour."

The fresh raw or cooked pandanus contains 14 to 18 percent carbohydrate in the form of starch and sugars, but has negligible amounts of protein and fat.

The calcium, phosphorus, and iron contents are comparable to temperate climate fruits such as peaches and apricots.
The carotenoid pigments which give the pandanus a rich yellow-orange color may be the only source of provitamin A available to the people of these islands when there are few or no green or yellow vegetables in the diet.

Pandanus, like most fruits, is not a rich source of thiamine and riboflavin, though it makes a significant contribution of these factors in the diet when eaten in large amounts. This is especially true of riboflavin.

Pandanus is a poor source of ascorbic acid, if compared with fruits rich in vitamin C; but when eaten in relatively large amounts, it could meet the needs of the body for this vitamin.

The composition of pandanus paste and pandanus flour are discussed in relation to the fresh samples. Their special worth lies in their energy value as emergency rations or for long sea voyages.

Our work suggests that additional studies on different varieties, followed by selection and propagation by agriculturists, might be profitable. Planting and continued use of the varieties of highest nutritive value that suit particular areas could well be encouraged by all concerned with the health of the people living in the low, dry islands of the Pacific. It is especially important to stress that the edible pandanus should not fall into disuse as the result of introducing "store foods" of low nutritive value.

Fig. 22. Beka of traditional Marshallese type from Arno Atoll, Marshall Islands, collected in 1950 by L. Mason. Sketch by F. Pen.

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OTHER FRUITS

Description and Use

The resident of temperate climes is likely to think of the "natives" of the south Pacific islands as enjoying an abundance of tropical fruits, but fruits as the Westerner regards them have never formed an important part of the diet of the Polynesian or Micronesian peoples.

Bananas and pandanus are the only plants yielding a fruit in the culinary sense, as breadfruit is used almost entirely in the starchy stage as a staple food. The bananas are likely to be the varieties that are most palatable when cooked (this was true of all the Hawaiian varieties). The eating bananas that have been introduced by Europeans and Americans are often preferred in the green stage (as observed by C.D.M. in Samoa).

The introduced citrus fruits, except possibly limes, require more careful cultivation than the natives are likely to give them and the majority make no regular use of those citrus fruits which they have. Papayas, which can be grown in most of the tropical islands and which would furnish an excellent source of ascorbic acid and provitamin A, are regarded with much indifference and are likely to be reserved for gifts or sale to the foreigner, or they are eaten in the green or half-ripe stages. Education as to the nutritive value of the papaya through the schools should help overcome this indifference to such an excellent fruit.

Banana

The Utsutopvariety of banana from the Caroline Islands, which was analyzed both raw and cooked (Samples 2 and 3), is considered more palatable after cooking, but it is also eaten raw. It is used in large quantities when breadfruit
and some of the starchy aroids are not available. The common method of cooking is to boil it in the skins, but on festive occasions the bananas may be baked with grated coconuts.

The Samawa variety, Sample 1, is eaten raw, and is the most popular of all the bananas in the Truk district. At the time the dietary study was made (49) it was in plentiful supply.

**Apuch**

The fruit locally called apuch has been identified botanically as *Crataeva speciosa*, and according to Kanehira's check list (29) it is "very common in Yap; planted or growing spontaneously in Truk, Panape, and Palau." As no description of this fruit can be found for Guam, Java, and the Philippines, it appears to be limited to the area of the Carolines.

![Fig. 23. Apuch (Crataeva speciosa).](image)

The fruit is oblong in shape and has a light green skin with white spots scattered over the surface (see Fig. 23). The dimensions and weight for six fruits averaged 4 x 2 x 1\(\frac{3}{4}\) inches, and 150 grams, including waste. The flesh, in the immature stage, is white and spongy, but changes to an orange color when ripe and best for eating out of hand. The fruit has a very pungent odor much liked by the Trukese but repugnant to the uninitiated.

**Limes**

When one of the authors (M.M.) worked both at Majuro, Marshall Islands, and Truk, Caroline Islands, limes were plentiful but it was only in the Marshall Islands that they were included among the foods in the dietary study. However, it was observed that in the Truk district, lime juice was combined with sea water and used as a drink. In Majuro, where they are called "laim," they eat them just as we would eat oranges, by peeling off the skin and eating the fruit with the membranes. They were also seen sucking limes for juice.

Other ways in which the Marshallese utilize limes are as follows:
a. A combination of lime juice and coconut cream is used with raw fish.
b. Lime juice, salt, and coconut cream are combined as a sauce for breadfruit.
c. Lime juice and sugar are mixed with water and used as a drink.

Composition and Nutritive Value

The only fruits from the Trust Territory for which we made complete analyses were the three bananas and a fruit locally called apuch, *Crataeva speciosa*, all from the Caroline Islands. Ascorbic acid assays of two limes and an orange were made in the field. Analytical data are summarized in Table 10.

**Banana**

The composition of bananas shown in Table 10 indicates that the amounts of nutrients follow the usual pattern for this fruit. Bananas are a good source of calories and a readily digested carbohydrate (if ripe and properly cooked) with a low fiber content. They have negligible amounts of protein and fat.

The calcium and iron values are lower than the average values reported in AH 8 for both eating and cooking bananas, but the phosphorus values are higher (62).

The provitamin-A pigments were not determined, but the color of the flesh would not indicate that they are significant.

Like most fruits bananas are poor sources of thiamine, riboflavin, and niacin and those from the Caroline Islands were no exception. The values shown in Table 10 tend on the whole to be lower than the average values given in AH 8 (62), though the relatively long period of transportation and storage may have served to reduce them below their original content.

Only traces of ascorbic acid were found in the stored samples, but the figures for ascorbic acid marked with an asterisk (*) were carried out in the field and indicate that the bananas compare favorably with common commercial varieties in the United States (62) and with values for cooking bananas which we have studied in Hawaii.
Table 10. Proximate composition, energy value, minerals, and vitamins of some fruits

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fruit</th>
<th>Source</th>
<th>Water</th>
<th>Food Energy</th>
<th>Carbohydrate</th>
<th>Protein</th>
<th>Fat</th>
<th>Energy</th>
<th>Protein</th>
<th>Fat</th>
<th>Total</th>
<th>Fiber</th>
<th>Ash</th>
<th>Calcium</th>
<th>Phosphorus</th>
<th>Iron</th>
<th>Thiamine</th>
<th>Riboflavin</th>
<th>Niacin</th>
<th>Ascorbic acid</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Banana, eating Samawa Islands</td>
<td>Caroline Islands</td>
<td>71.8</td>
<td>99</td>
<td>1.22</td>
<td>0.29</td>
<td>25.80</td>
<td>0.39</td>
<td>0.89</td>
<td>7.9</td>
<td>31.5</td>
<td>0.23</td>
<td>0.026</td>
<td>0.124</td>
<td>0.61</td>
<td>11.6*</td>
<td>4.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Banana, fresh Utsutop</td>
<td>Utsutop</td>
<td>74.8</td>
<td>88</td>
<td>0.81</td>
<td>0.14</td>
<td>23.33</td>
<td>0.30</td>
<td>0.92</td>
<td>6.8</td>
<td>44.8</td>
<td>0.28</td>
<td>0.023</td>
<td>0.046</td>
<td>0.40</td>
<td>8.2*</td>
<td>4.63</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>Banana, boiled Utsutop</td>
<td>Utsutop</td>
<td>69.2</td>
<td>108</td>
<td>0.75</td>
<td>0.04</td>
<td>29.07</td>
<td>0.30</td>
<td>0.94</td>
<td>2.0</td>
<td>41.0</td>
<td>0.51</td>
<td>0.021</td>
<td>0.032</td>
<td>0.45</td>
<td>7.5*</td>
<td>5.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Apuch, fresh</td>
<td></td>
<td>82.6</td>
<td>58</td>
<td>1.76</td>
<td>0.09</td>
<td>14.34</td>
<td>1.50</td>
<td>1.21</td>
<td>11.3</td>
<td>58.7</td>
<td>0.50</td>
<td>0.028</td>
<td>0.038</td>
<td>0.50</td>
<td>45.3*</td>
<td>5.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Limes, with membrane Marshall Islands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6</td>
<td>Limes, with membrane Caroline Islands</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>Orange (juice)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* Ascorbic acid determined in the field by Mary Mural.
**Apuch**

Apuch has a carbohydrate content similar to fruits such as apples and apricots, with an equally low protein and fat content. It is superior to apples in its calcium, phosphorus, and iron contents. It is lower in calcium and iron than apricots, but has a considerably higher phosphorus content (see Table 10).

The three B vitamins in the apuch are low and similar to bananas but its ascorbic acid content of 45 milligrams per 100 grams compares favorably with oranges. It should, therefore, constitute an important source of this vitamin where it is eaten in relatively good amounts.

**Limes**

Complete analyses of the limes were not made, but the ascorbic acid of the juices determined in Majuro and Truk showed them to be relatively good sources of vitamin C (24 and 29 milligrams per 100 grams) that compare favorably with the average figure of 27 milligrams per 100 grams given in AH 8 (62). The ascorbic acid of a local orange is also included. The orange had an ascorbic acid value of 37 milligrams per 100 grams, which is lower than average oranges (62).

In the Marshall Island dietary study of 324 persons 1 year and older, for a period of one week, 60 of them used limes from one to seven times per week, the majority being one to five times during the week. The quantity used per day varied from one-half to three limes. Most people ate one to two limes per day; very few ate as many as three or four limes daily.

Six individual limes of different sizes were weighed in the field and the edible portion was found to range from 20 to 60 grams with an average of 40 grams. This would mean that when one lime is eaten daily it would supply only about 10 milligrams ascorbic acid but if as many as three were consumed daily approximately 30 milligrams of vitamin C would be furnished.

Judging from the number of people who ate limes and the quantity eaten per day, it would appear that most of the people would have insufficient vitamin C if they depended upon limes to furnish this important vitamin.
STARCHY AROIDS

Three species of plants, two of them often erroneously referred to as taro, have been grouped under the heading of "starchy aroids" upon the recommendation of St. John (76).

**Colocasia esculenta** (L.) Schott

The true taros are widely distributed in the tropical Pacific islands. Taro formed the principal food of the ancient Hawaiians and the Samoans. Buck (5) states that "talo is (1930) the staple vegetable food of Samoa. It takes easy precedence over the breadfruit, yam, and sweetpotato." However, in the Marshall and Caroline Islands none of the starchy aroids is as highly regarded by the islanders as breadfruit. No taro samples were collected from the Marshall Islands because but little taro grows there and only one sample was obtained from the Truk district in the Carolines. Three of the four samples of taro analyzed were from American Samoa.

There are, in general, two types of taro, one called wetland, which must be constantly submerged in water, and the upland types, sometimes called dryland taro because these varieties do not require submerged culture. The variety collected in the Truk district is said to grow partially submerged and also in moist uplands. The samples from American Samoa represented both wetland and upland varieties.

Like other plants that have been cultivated for centuries, many horticultural varieties have developed. According to a study made in Hawaii published in 1939 (65), the ancient Hawaiians recognized 150 to 175 distinguishable forms of taro.

It is the starchy corm (main root stock) and the cormels
which are commonly eaten wherever taro is grown. The young heart-shaped leaves, and sometimes the petioles, were also much used in ancient Samoa and Hawaii and are still used today. According to our observations, the natives of the Caroline Islands make no use of the leaves, and we have located no published report to the contrary. Stone, in his monograph on soils and agriculture of Arno (58) under the heading Colocasia, comments that, "In keeping with the Marshallese disinterest in leafy foods the edible leaves and stems are not utilized at all."

**Cyrtosperma Chamissonis** (Schott) Merr.

Cyrtosperma has different local names. In the Marshall Islands it is called *iaraj* (St. John spells it *iaratz*); in the Caroline Islands each island group has one or more local names which are different from the Marshallese name; in the Gilbert Islands, *babai*; and in Kapingamarangi, *puraka*.

Like taro, Cyrtosperma produces corms (76) though they are often referred to as tubers (7, 40). The corms may be harvested when young or may be allowed to grow to enormous size, each weighing 10 pounds or much more. The plants as well as the tubers grow to immense size (see Figs. 24 and 25). Most people consider it a coarser food than

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*Fig. 24. Cyrtosperma Chamissonis with Colocasia esculenta in foreground (both with arrow-shaped leaves) at Majuro, Marshall Islands. Photo by L. Mason.*
taro. It has a gritty feeling in the mouth, but does not have the same irritating quality that taro has when not thoroughly cooked.

St. John (76) states that he observed Cyrtosperma as a common cultivated plant on both high and low islands of Micronesia and judged it to be the most important starchy plant on some of the low coral islands of the Marshall and Caroline Islands. Where conditions permit, it is grown in large swampy fields. On Pingelap he saw one about 300 by 600 feet, within which each family controlled a plot. For this island he reports five varieties with vernacular names, and states it is "the most important food crop" (55).

Stone (58) states that at one time Cyrtosperma ranked with, or perhaps exceeded, breadfruit and pandanus, but when he made his observations in 1950 at Arno Atoll in the Marshall Islands, he reported that "less than one-tenth of the pits prepared for its culture are growing significant amounts...."

In Kapingamarangi, Buck points out that puraka is grown in the former taro pits, which he calls sunken gardens, and states that it "now (1947) forms the staple food of the atoll" (7).

Cyrtosperma is an important food in Yap according to the district agriculturist (30) and "is eaten three times a day and daily the year round."

Drews judged babai to be second to the coconut as a source of vegetable food (16) in the Gilbert Islands.

Both Buck (7) and Drews (16) describe in considerable detail the carefully prepared and tended "sunken gardens" in which the Cyrtosperma are grown in Kapingamarangi and in the Gilbert Islands. Whether the ones noted by recent observers in the Marshall Islands were once likewise so carefully cultivated, or whether they have gradually deteriorated as people came to depend partly on "store foods," cannot be stated with certainty.

In general, on the higher islands, Cyrtosperma is grown in naturally swampy areas, whereas on the low islands it is grown in excavated gardens or pits which Stone (58) thinks have probably been used for generations. His Marshallese informant recalled that one was dug on Arno Island in the early 1900's but Stone thinks this was among the last constructed on the atoll. He notes further that, "Certainly each
pit was an undertaking of considerable magnitude, involving the excavation of one- to several hundred tons of sand with crude tools and baskets."

Undoubtedly the raising of good-quality Cyrtosperma requires considerable labor, especially on the low islands, and the natives are likely to pursue its cultivation only when stimulated by lack of other foods or by local social and economic organization.

Alocasia macrorrhiza

Alocasia does not require the water culture of wetland
taro or such moist conditions as Cyrtosperma and is generally considered a hardier plant.

Though it is much less highly regarded than either taro or Cyrtosperma, Alocasia may be eaten by people who are short of other food supplies, especially between breadfruit seasons. The plant does not have corms or cormels, as do Colocasia and Cyrtosperma, but the portion eaten, is the thick, starchy stem or trunk which grows above ground and to the tip of which the petioles are attached (see Fig. 28).

Composition and Nutritive Value

Table 11 presents a summary of the analyses of 12 samples of three species of the starchy aroids just described—four of _Colocasia esculenta_, six of _Cyrtosperma Chamissonis_, and two of _Alocasia macrorrhiza_.

The quantities of the various nutrients furnished by different amounts of the first two starchy aroids are given in Table 12. The calculations are based on the average composition of the samples shown in Table 11.

**Colocasia esculenta**

The carbohydrate content of the four samples of taro varied from 29 to 47 percent with a relatively low fiber content 0.6 to 0.8 percent, making taro an excellent source of calories, even though the protein and fat contents are low—2 percent or less.

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*Fig. 26. Wot (Alocasia macrorrhiza) growing in yard. Jaluit, Marshall Islands. Photo by L. Mason.*
Table 11. Proximate composition, energy value, minerals, and vitamins of starchy aroids

<table>
<thead>
<tr>
<th>Sample</th>
<th>Food</th>
<th>Source</th>
<th>Water</th>
<th>Food Energy</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
<th>Ash</th>
<th>Calcium</th>
<th>Phosphorus</th>
<th>Iron</th>
<th>Thiamine</th>
<th>Riboflavin</th>
<th>Niacin</th>
<th>Ascorbic Acid</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Talo tai fur (wetland), baked</td>
<td>Anuva Islet, American Samoa</td>
<td>63.5</td>
<td>141</td>
<td>1.96</td>
<td>0.18</td>
<td>33.23</td>
<td>0.66</td>
<td>1.13</td>
<td>32.5</td>
<td>36.8</td>
<td>0.68</td>
<td>0.110</td>
<td>0.030</td>
<td>0.94</td>
<td>trace</td>
</tr>
<tr>
<td>2</td>
<td>Talo niue (upland), baked</td>
<td>Pavaiai, Tutuila, American Samoa</td>
<td>50.1</td>
<td>195</td>
<td>1.52</td>
<td>0.23</td>
<td>46.85</td>
<td>0.76</td>
<td>1.30</td>
<td>30.3</td>
<td>79.2</td>
<td>1.40</td>
<td>0.100</td>
<td>0.024</td>
<td>1.18</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>Talo niue (upland), boiled</td>
<td>Pavaiai, Tutuila, American Samoa</td>
<td>69.1</td>
<td>120</td>
<td>1.06</td>
<td>0.14</td>
<td>28.81</td>
<td>0.89</td>
<td>24.1</td>
<td>25.4</td>
<td>0.88</td>
<td>0.096</td>
<td>0.024</td>
<td>0.59</td>
<td>trace</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Oni, otsu (wetland and upland), roasted</td>
<td>Caroline Islands</td>
<td>60.1</td>
<td>156</td>
<td>0.96</td>
<td>0.09</td>
<td>37.99</td>
<td>0.56</td>
<td>0.86</td>
<td>18.7</td>
<td>64.4</td>
<td>0.95</td>
<td>0.062</td>
<td>0.040</td>
<td>0.70</td>
<td>trace</td>
</tr>
</tbody>
</table>

*Ascorbic acid assays made in the field by Mary Murai.*
Though the figures for calcium, phosphorus, and iron given in Table 11 do not indicate particularly high values for these nutrients, when taro is eaten in large amounts it becomes a good source of these minerals. Previously published experiments with rats and with humans in this laboratory have shown that the calcium and phosphorus are well utilized (51, 52) and experiments with anemic rats showed excellent utilization of the iron (45).

Likewise, the quantities of thiamine and niacin per 100 grams do not appear very large, but there is enough of both to meet the daily standards for these two vitamins when sufficient taro is eaten to supply a large amount of the caloric needs (Table 12). The Samoan taros averaged 0.10 milligram thiamine per 100 grams even after cooking, shipping, and frozen storage of several months. The one sample of taro from the Caroline Islands is about 40 percent less or 0.06 milligram per 100 grams. The niacin averaged about 0.9 milligram per 100 grams. When 1000 grams of these are eaten daily (which is not an unusual amount for those who eat taro), the day's need for thiamine and niacin would be largely met, and for a small person a large quota of the calories.

The carotene content of taro Samples 1, 2, and 3 from American Samoa were determined and found to be 12.3, 8.5, and 12.0 micrograms per 100 grams, respectively. Such
low values are of little importance nutritionally and indicate that taro would make but a small contribution to the day's needs for provitamin A, even when large amounts are consumed.

Since taro has little or no provitamin A, and but small amounts of ascorbic acid and riboflavin, other sources of these vitamins would be needed for an adequate diet.

Cyrtosperma Chamissonis

The Cyrtospermas appear to be as good sources of carbohydrate as the true taros but they have about twice as much crude fiber and are certainly coarser to eat. A truly satisfactory comparison of the caloric values of the starchy aroids on the fresh basis cannot be made since the moisture contents vary. However, calculated to the dry basis, they all have about the same carbohydrate content and, therefore, nearly the same caloric value.

Two of the Cyrtosperma samples from the Marshall Islands had remarkably high calcium contents (almost 600 milligrams per 100 grams), and it would seem that they should be very valuable as sources of this mineral in diets generally poor in calcium. However, determination of the oxalic acid content of buroro, Sample 1, showed it to contain 1.04 percent oxalic acid, more than sufficient to combine with all the calcium in the vegetable.

There is a marked difference in the calcium content of the Cyrtospermas from the low islands (Marshall Islands) and from the high islands (Caroline Islands). Because the calcium figure for puna was so much smaller than for the other samples, the analyses were repeated and the figure given in Table 11 was confirmed. The calcium contents (and possibly the oxalate content) of the Cyrtospermas from

Fig. 29. Puna (Cyrtosperma Chamissonis). (Long root was cut in sections for ease in transportation, reassembled for photo in Honolulu.)
the Marshalls are 3 to 15 times greater than those from the Carolines. Perhaps this difference is the result of environmental conditions (soil and water) but variety may also be a factor.

One of the authors (M. M.) was informed in the Marshalls that it is a common practice to remove and discard with the skin an outer layer of \( \frac{1}{2} \) inch or more of the Cyrtosperma because it is believed to make it more palatable (by removing some of the calcium oxalate). Such a layer was not removed from the samples prepared for analyses and there has been no opportunity to verify or contradict this idea by microscopic or chemical examination.

McCay and co-workers (39) have shown that at certain stages of growth, rats can accommodate their metabolism to the presence of oxalic acid in food and utilize calcium despite its presence. However, to our knowledge, no human calcium balance experiments using Cyrtosperma have ever been made and it would seem safer to assume that the calcium is probably not well utilized because it is largely, if not entirely, in the form of calcium oxalate.

The Cyrtospermas have less than half the thiamine content of the taros but about the same amount of riboflavin and niacin. They, too, have little or no provitamin A or ascorbic acid.

In the Marshall Islands 12 persons out of the 324 co-operating in the dietary study for a period of one week ate one variety of Cyrtosperma (boiled Kaliklik) and then only once in each case. The quantities eaten in one day varied from 50 to 500 grams. Another variety of Cyrtosperma, Wan, was eaten more often and by more people. Of the 324 persons co-operating, 133 ate Wan, one to five times per week, a total of 240 times. The quantities eaten per day were usually from 200 to 500 grams, but one individual ate as little as 50 and another as much as 1150 grams (2.5 lbs.) in one day.

During the dietary study of one week in the Truk district, Caroline Islands, none of the starchy aroids were recorded, probably because it was the height of the breadfruit season and the aroids and sweetpotatoes are saved for between breadfruit seasons.

If Cyrtosperma is not only more easily grown than taro, but also has a greater yield, and is quite as acceptable a food for the people of the tropical Pacific islands, it de-
serves more study to learn if variety and location influence the amount of calcium and oxalic acid before horticulturists recommend it highly as a plant to replace taro. Buck has stated that it is the staple food of Kapingamarangi and also observes, "The absence of rickets and malnutrition is proof enough that the people have a well-balanced diet which meets all the requirements of health and gives pleasure and satisfaction" (7). Do the people utilize the calcium despite its high oxalic acid content, or do they obtain sufficient calcium from other sources to prevent its interfering with the calcium metabolism? Further study would be required to elucidate these matters.

_Alocasia macrorrhiza_

The moisture content of the single Alocasia sample analyzed is higher and the thiamine values are as good or better than either the taros or Cyrtospermas. On the same moisture basis, the niacin content compares favorably with the other two starchy aroids. The riboflavin tends to be lower, but all three species are poor sources of this vitamin.

**Summary and Conclusions**

Analyses are presented to show that the two starchy aroids—_Colocasia esculenta_ (L.) Schott (taro), and _Cyrtosperma Chamissonis_ (Schott) Merr.—are comparable as sources of carbohydrate and calories though the taros have approximately half the crude fiber of the Cyrtospermas. Both are low in protein and fat.

The calcium contents of the Cyrtospermas from the Marshall Islands are extremely high in comparison with the taros and other vegetables of similar moisture content. Previously published data have shown the calcium and phosphorus of Hawaii-grown taro to be well utilized by human subjects, but similar data are not available for the calcium and phosphorus of Cyrtosperma. Analyses of one sample of Cyrtosperma showed the oxalic acid content to be great enough to unite with all of the calcium present in the corm and more.

Data are presented in table form to show that if relatively large amounts (1000 grams) of the two starchy aroids are eaten daily, a good quota of the needed calories would be supplied. The taro would supply more thiamine
than the other species but the Cyrtospermas would furnish more riboflavin than the taros. All varieties would make a good contribution toward the day's need for niacin. Both species are poor sources of provitamin A and ascorbic acid.

Additional studies of the nutritive value (especially calcium and oxalic acid) of different horticultural varieties of Cyrtosperma are needed before they are recommended to replace breadfruit and taro.

Because of its higher moisture content, Alocasia appears to be lower in nutritive value than the other two species of starchy aroids.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>100 g.</th>
<th>300 g.</th>
<th>500 g.</th>
<th>750 g.</th>
<th>1000 g.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taro</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calories</td>
<td>153</td>
<td>459</td>
<td>765</td>
<td>1148</td>
<td>1530</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Carbohydrate, g.</td>
<td>37</td>
<td>111</td>
<td>185</td>
<td>278</td>
<td>370</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>26</td>
<td>78</td>
<td>130</td>
<td>195</td>
<td>260</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>51</td>
<td>153</td>
<td>255</td>
<td>382</td>
<td>510</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>1.0</td>
<td>3.0</td>
<td>5.0</td>
<td>7.5</td>
<td>10.0</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.092</td>
<td>0.28</td>
<td>0.46</td>
<td>0.69</td>
<td>0.92</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>0.030</td>
<td>0.09</td>
<td>0.15</td>
<td>0.22</td>
<td>0.30</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>0.85</td>
<td>2.6</td>
<td>4.2</td>
<td>6.4</td>
<td>8.5</td>
</tr>
<tr>
<td><strong>Cyrtosperma</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calories</td>
<td>131</td>
<td>393</td>
<td>655</td>
<td>982</td>
<td>1310</td>
</tr>
<tr>
<td>Protein, g.</td>
<td>0.9</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Carbohydrate, g.</td>
<td>31</td>
<td>93</td>
<td>155</td>
<td>232</td>
<td>310</td>
</tr>
<tr>
<td>Calcium, mg.</td>
<td>(334)</td>
<td>(1002)</td>
<td>(1670)</td>
<td>(2505)</td>
<td>(3340)</td>
</tr>
<tr>
<td>Phosphorus, mg.</td>
<td>56</td>
<td>168</td>
<td>280</td>
<td>420</td>
<td>560</td>
</tr>
<tr>
<td>Iron, mg.</td>
<td>1.2</td>
<td>3.6</td>
<td>6.0</td>
<td>9.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Thiamine, mg.</td>
<td>0.045</td>
<td>0.14</td>
<td>0.22</td>
<td>0.34</td>
<td>0.45</td>
</tr>
<tr>
<td>Riboflavin, mg.</td>
<td>0.074</td>
<td>0.22</td>
<td>0.37</td>
<td>0.56</td>
<td>0.74</td>
</tr>
<tr>
<td>Niacin, mg.</td>
<td>0.88</td>
<td>2.6</td>
<td>4.4</td>
<td>6.6</td>
<td>8.8</td>
</tr>
</tbody>
</table>
OTHER STARCHY ROOTS

Arrowroot Flour

Arrowroot flour, called mokmok in the Marshalls, is made from the tubers of *Tacca leontopetaloides* (L.) Ktze. The term, mokmok, is applied both to the plant and to the starchy flour (Figs. 30 and 31). All parts of the plant have been fully described by Merrill (43) and by Degener (15). It has true tubers which grow at the end of roots in the same manner as the common white potato. They are usually shaped somewhat irregularly like flattened spheres, varying in diameter from 1 to 8 centimeters, with a thin brown skin and a white starchy interior. Though the tubers are generally described as being rather small, Taylor (60) reports finding some weighing 550 grams in the northern Marshalls.

Arrowroot has long been used in Micronesia as it is mentioned in the legends of the people according to Wendler (64), but apparently only in the northern Marshalls is it an important food, especially when other foods are in short supply. Published accounts and conversations with the Marshallese indicate that the flour is the only form in which arrowroot is used, although Stone (58) reports that . . . "it is possible to eat them [the tubers] baked. . . ." From personal experience, St. John believes the raw tubers to contain something of a poisonous nature (76). The irritating and perhaps poisonous substance in the raw tubers is being investigated (1955–1956) by Dr. Paul J. Scheuer of the University of Hawaii chemistry department (77).

Made into arrowroot flour, mokmok can be kept for years without deterioration. Wendler (64) gives a detailed description of the preparation of the flour as he observed it and states that in 1907 he saw a hand-driven grating machine which would lighten the labor of preparing the flour.

Preparation of mokmok as observed by one of the au-
Fig. 30. Arrowroot or mokmok (Tacca leontopetaloides). Leaves below and flower stalks and clusters above.

Fig. 31. Cake of mokmok flour after draining, ready to dry in the sun.
thors (M.M.) at Ailuk Atoll, Ailuk Island, in 1951 was as follows: After peeling, the tubers were ground in a pan with a stone. The ground material was put in a cloth, placed in a wooden frame strung with sennit over a large tub half-filled with salt water. (The sennit was crisscrossed at about two-inch intervals to form a coarse sieve.) The salt water was repeatedly dipped from the tub and poured over the crushed arrowroot while the mass was stirred until all the starch was washed out. The rough residue in the cloth was discarded. When the starch settled to the bottom of the tub, the salt water was decanted and the tub was half-filled with salt water for the second time. After thorough stirring, the starch was allowed to settle and the salt water was decanted. This washing process removes the bitter taste and produces a relatively pure starch. The wet starch was placed in a cloth and hung from the ceiling to drip. When the starch had hardened, it was spread outside to dry in the sun until powdery. The mokmok was scraped from the cloth and stored in a woven basket for use as needed.

Use

The most common way of using mokmok or arrowroot flour is to boil it in water, add coconut sap, make it into round balls or large patties, and roll them in grated coconut. The product is called jabjen. When a trip was made to the northern islands of the Marshalls by one of the authors (M.M.) in February, 1951, it was noted that arrowroot flour was used extensively where imported goods were not available because the breadfruit season had not begun and/or was not available.

Arrowroot flour was combined with a number of other foods as follows:

*Beru.* Soft pulp from ends of boiled pandanus combined with arrowroot flour, poured into a cone-shaped receptacle made of two fresh breadfruit leaves, and cooked.

*Likabola.* A mixture of arrowroot flour and coconut sap.

*Benben in mokmok.* Arrowroot flour, coconut sap, and grated coconut meat.
Jup in mokmok. Arrowroot flour, coconut embryo, fish, and coconut milk.

Kebjeltak. Arrowroot flour, crackers, and coconut sap.

Jamokok. Arrowroot flour mixed with grated coconut meat and baked.

Composition and Nutritive Value

The arrowroot flour more closely resembles corn-starch than cereal flours as it has about 86 percent carbohydrate, 12 percent moisture, and less than 0.2 percent protein. The particular sample analyzed had a fairly high ash content (1.89 percent) and more calcium (58 milligrams per 100 grams) than would be expected in a highly purified starch (Table 13). Whether or not this quantity of calcium would be found in all samples and whether it comes from contamination with a few bits of fine coral and/or partly from the sea water can only be determined by additional studies. It also contained small amounts of phosphorus and iron, and a trace of thiamine. It is well that the flour has little or no crude fiber since it is consumed with mature coconut and coconut products such as the embryo. Its chief value lies in the fact that it can contribute to the needed calories, especially when other sources of starch are not available. From the standpoint of good nutrition, arrowroot is not a starchy food to be highly recommended, though it is no doubt an important source of readily digested carbohydrate.

Sweetpotato

The sweetpotato was a principal article of diet of the Polynesians in New Zealand (6) and Hawaii (25). In other parts of Polynesia and Micronesia, it was or is not very highly regarded or extensively grown either in pre-Cook times or at present (6). The Samoans did not favor the sweetpotato as it was regarded as being too sweet (5).

No sweetpotatoes were observed in the Marshall Islands (M.M.) and they were grown to only a limited extent in the Carolines.
Use

No sweetpotatoes were noted in the Marshall Islands dietary study but they were used in the Truk area of the Caroline Islands where they are called "kamuti."

Nutritive Value

Only one sample of sweetpotato collected at Truk was analyzed. The figures which are given in Table 13 show that the proximate composition and mineral values for this sample compare favorably with the average figures for boiled sweetpotatoes given in AH 8 (62); the carbohydrate content is a little higher and the calcium, phosphorus, and iron are similar. The thiamine and the niacin are a little less and the riboflavin distinctly less than the average figures from the same source. Possibly these low vitamin values are the result partly of the long boiling period and consequent leaching, followed by the long period of transportation and storage. The provitamin-A pigments were not determined but they would probably be low since the flesh was cream-colored and not a deep yellow.

Table 13. Proximate composition, energy value, minerals, and vitamins of sweetpotato and arrowroot flour (per 100 grams edible portion)

<table>
<thead>
<tr>
<th>Sample Food</th>
<th>Source</th>
<th>Water (%)</th>
<th>Energy (calor.)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Carbohydrate (g)</th>
<th>Total (g)</th>
<th>Fiber (g)</th>
<th>Ash (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweetpotato, boiled</td>
<td>Caroline Islands</td>
<td>67.4</td>
<td>128</td>
<td>0.76</td>
<td>0.16</td>
<td>30.82</td>
<td>0.73</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>(Kamuti)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrowroot flour</td>
<td>Marshall Islands</td>
<td>12.1</td>
<td>346</td>
<td>0.18</td>
<td>0.05</td>
<td>85.74</td>
<td>0</td>
<td>1.89</td>
<td></td>
</tr>
<tr>
<td>(mokmok)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample Food</th>
<th>Source</th>
<th>Calcium (mg)</th>
<th>Phosphorus (mg)</th>
<th>Iron (mg)</th>
<th>Thiamine (mg)</th>
<th>Riboflavin (mg)</th>
<th>Niacin (mg)</th>
<th>Ascorbic Acid (mg)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweetpotato, boiled</td>
<td></td>
<td>30.6</td>
<td>60.7</td>
<td>0.58</td>
<td>0.080</td>
<td>0.019</td>
<td>0.45</td>
<td>trace</td>
<td>5.57</td>
</tr>
<tr>
<td>(Kamuti)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrowroot flour</td>
<td></td>
<td>58.0</td>
<td>7.2</td>
<td>0.55</td>
<td>0.002</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mokmok)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Sample 1. Breadfruit, fresh.

1. Marshallese name: Batakdak.

2. Date and place of collection: May 15, 1951. Uliga, Majuro Atoll, Majuro Island.

3. Date vitamin assays begun: June 19, 1951.3

4. Preparation of sample after collection: Three fruits were obtained at the beginning of the breadfruit season. Within a few hours after collection they were treated as follows: The breadfruits were weighed, and scraped with a shell scraper in the native manner; the cores were removed, the three fruits were cut into large chunks, and thoroughly mixed. A large portion was made into six small packages of 100 grams or less each, wrapped in heavy wax paper, and quick-frozen. From a smaller portion, a slurry was prepared as follows: 300 grams of breadfruit and 150 milliliters of 1 percent oxalic acid solution were combined in a Waring blender. Shortly before slurry was complete, 5 milliliters of chloroform and 3 drops of mixed tocopherols were added. The slurry was transferred to brown glass bottles, the plastic caps screwed down tight, and sealed with paraffin wax. Refuse (core and rind), 28 percent.

3. The date of the vitamin assays is indicated for each food sample. When proximate composition and minerals were determined at a later date, the tests for moisture were repeated to learn if there had been any change as a result of freezer-storage. When necessary, the figures for other nutrients were re-calculated to the same moisture basis as for the vitamins.
5. Transportation and storage.

Frozen samples: Stored at 0° F. for 13 days in Navy cold storage. Sent to Honolulu on a Navy vessel and kept at 12° F. for 9 days en route. Transferred to Foods and Nutrition Laboratory. Rewrapped in heavy aluminum foil and kept at 0° to -5° F. until analyzed.

Slurry: Bottles were kept at 36° F. at Uliga, Marshall Islands, until May 29, 1951. The bottles were packed in cartons and shipped by air without refrigeration. The flight took 2 hours to Kwajalein. Bottles were refrigerated at 36° F. at Kwajalein during a stop-over of 20 hours. The flight from Kwajalein to Honolulu took 9 hours. Samples were transferred to the Foods and Nutrition Laboratory and kept at 36° F. until analyzed.

6. Preparation for analyses: The frozen material was thawed at room temperature in the original wrappings, sliced, finely chopped, and thoroughly mixed before sampling. The slurry was brought to room temperature in the bottles and thoroughly mixed before sampling.

Frozen material used for moisture, vitamins, and protein; slurry used for fat, crude fiber, and minerals.

Sample 2. Batakidak breadfruit, roasted.

1, 2, 3, 5, and 6, same as Sample 1.

4. Preparation of sample after collection: Three mature, green breadfruit, each from a different tree, cooked whole for 2 hours on an open fire. Coconut and pandanus husks used as fuel. After cooking, charred black rind was removed with shell scraper. Remainder of preparation, same as Sample 1, except that 400 milliliters of 1 percent oxalic acid was used for 300 grams of roasted breadfruit. Weights taken before and after cooking and preparation. Refuse (rind and core), 38 percent.

Sample 3. Batakidak breadfruit, baked.

1, 2, 5, and 6, same as Sample 1.

3. Date vitamin assays begun: June 27, 1951.
4. Preparation of sample after collection: Three mature, green breadfruit were wrapped in dried breadfruit leaves. Cooked whole in earth oven of hot corals for $1\frac{1}{2}$ hours. Remainder of preparation same as Sample 1. Refuse (rind, core, and seeds), 29 percent.

Sample 4. Breadfruit, fresh.
1. Marshallese name: Bukdrol.
2. Date and place of collection: May 19, 1951. Uliga Atoll, Majuro Island.
3. Date vitamin assays begun: June 27, 1951.
4. Preparation of sample after collection: Same as Sample 1. Refuse, 23 percent.
5 and 6, same as Sample 1, but stored at 0°F. in Navy cold storage for 9 days.

Sample 5. Bukdrol breadfruit, roasted.
1, 2, 3, and 5, same as Sample 4.
4. Preparation of sample after collection: Same as Sample 2. Refuse, 30 percent.
6. Preparation for analyses: Same as Sample 1. Frozen material used for moisture and vitamins; slurry, for proximate composition and minerals.

Sample 6. Breadfruit, fresh.
1. Marshallese name: Mijiwan.
2. Date and place of collection: May 18, 1951. Uliga Atoll, Majuro Island.
3. Date vitamin assays begun: September 7, 1951.
4. Preparation of samples after collection: The flesh from two breadfruit, treated in the same manner as described for Sample 1, constituted the frozen sample. The flesh of one breadfruit was used for the slurry in the same manner and the same proportions as described for Sample 1. (For treatment of seeds, see Sample 18.)
5. Transportation and storage: Same as Sample 1, but frozen sample kept in Navy cold storage for 10 days before shipping. Slurry, same as Sample 1.

6. Preparation for analyses: Same as Sample 1. Frozen material from the two fruits used for moisture and vitamins. Slurry from one fruit used for proximate analyses and minerals.

Sample 7. Mijiwan breadfruit, roasted.

1, 2, and 3, same as Sample 6.

4. Preparation of sample after collection: Two mature, green breadfruit cooked whole for 2 hours on an open fire. Coconut and pandanus husks used for fuel. After cooking, charred black rind was removed by a shell scraper. Slurrying process (240 grams breadfruit), same as Sample 1 except for a larger volume of oxalic acid--220 milliliters. Slurry made from the flesh of two roasted breadfruit used for all analyses. Seeds removed and used for Sample 19. Refuse, burned portions of exterior surface.

5 and 6, same as Sample 1 for slurry.


1. Trukese name: Atchapar.

2. Date and place of collection: September 7, 1951. Dublon, Truk district.

3. Date vitamin assays begun: February 29, 1952.

4. Preparation of sample after collection: Three fruits, each from a different tree, were wrapped separately in aluminum foil and quick-frozen at 0° F.

5. Transportation and storage: Stored at 0° F. for 8 days in Trust Territory cold storage. Kept at 10° F. for 3 days from Truk, Caroline Islands to Guam, Marianas Islands, on a Trust Territory vessel. Kept at 10° F. in Navy cold storage awaiting transportation to Honolulu on a Navy vessel for 27 days. Kept at 20° F. en route to Honolulu from Guam for 7 days. Stored at Pearl Harbor, in Navy cold storage at 0° to 10° F. for
1 day (vessel arrived on Sunday). Stored at commercial cold storage at -5° F. until analyzed.

6. Preparation for analyses: The samples were thawed in the original wrappings at room temperature. A composite of the three fruits was made as follows: The breadfruit were cut lengthwise into quarters which included the core. One slice from each quarter was taken in such a way that it was not contiguous with the slice taken from the other quarters. The edible portions, chopped and mixed before sampling, were used for all analyses. Refuse (rind and core), 25 percent.


1. Trukese name: Meichon.
2. Date and place of collection: August 27, 1951. Moen Island, Truk district.
3. Date vitamin assays begun: February 29, 1952.
4. Preparation of sample after collection: One large fruit wrapped in aluminum foil and quick-frozen at 0° F.
5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 19 days instead of 8 days.
6. Preparation for analyses: The breadfruit was thawed at room temperature, pared, cored, finely chopped, and thoroughly mixed before sampling. Refuse (rind and core), 16 percent.


1. Trukese name: Meichon.
2. Date and place of collection: August 18, 1951. Moen, Truk district.
3. Date vitamin assays begun: February 8, 1952.
4. Preparation of sample after collection: Three fruits, each from a different tree, were boiled in an iron pot over a coconut charcoal fire until tender, about an hour. The fruits were cooled, each wrapped separately in aluminum foil and quick-frozen at 0° F.
5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 28 days.

6. Preparation for analyses: Same as Sample 8. Refuse (rind and core), 35 percent.


1. Trukese name: Kon.

2. Date and place of collection: August 18, 1951. Moen, Truk district.

3. Date vitamin assays begun: December 18, 1951.

4. Preparation of sample after collection: Analyses made on composite sample of three different samples from three different villages. Each sample was taken from a mixture of 30 or more breadfruits. These three samples were mixed together and divided into four smaller packages of 7 or 8 pounds. Each was wrapped in aluminum foil and quick-frozen. (See p. 15 for method of preparation of kon.)

5. Transportation and storage: Same as Sample 10.

6. Preparation for analyses: Packages were thawed at room temperature and the contents chopped before sampling.


1. Trukese name: Meikoch.

2. Date and place of collection: Same as Sample 9.

3. Date vitamin assays begun: April 29, 1952.

4. Preparation of sample after collection: Two breadfruits, each from a different tree, were wrapped in aluminum foil and quick-frozen at 0°F.

5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 19 days instead of 8 days.

6. Preparation for analyses: Same as Sample 8. Refuse (rind and core), 26 percent.

1. Trukese name: Napar.
4. Preparation of sample after collection: Analyses made on composite of three mature breadfruits picked from three different trees.
5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 17 days instead of 8 days.
6. Preparation for analyses: Same as Sample 8. Refuse (rind and core), 22 percent.


1. Trukese name: Neisoso.
2. Date and place of collection: Same as Sample 8.
3. Date vitamin assays begun: March 18, 1952.
4. Preparation of sample after collection: Two fruits, each from a different tree, were wrapped separately in aluminum foil and quick-frozen at 0° F.
5 and 6, same as Sample 8. Refuse (rind and core), 28 percent.

Sample 15. Breadfruit, raw.

1. Trukese name: Sawan.
2. Date and place of collection: Same as Sample 8.
3. Date vitamin assays begun: Same as Sample 14.
4. Preparation of sample after collection: Same as Sample 14.
5 and 6, same as Sample 8. Refuse (rind and core), 19 percent.

Sample 16. Breadfruit, baked.

1. Samoan name: Maafala.
2. Date and place of collection: June 24, 1951. Islet of Aunuu, American Samoa. Collected by Commander Fred L. Losee.

3. Date vitamin assays begun: August 6, 1951.

4. Preparation of sample after collection: Rind removed from two green breadfruit with coconut-shell scraper. Each fruit left whole and cooked in earth oven of hot stones covered with leaves and burlap bags for about 35 minutes.

5. Transportation and storage: Each fruit wrapped in heavy wax paper. Quick-frozen at -20° F. Sent to Honolulu in reefer of Navy vessel. Transferred to Foods and Nutrition Laboratory. Rewrapped in heavy aluminum foil and kept at 0° to -5° F. until analyzed.

6. Preparation for analyses: The two breadfruit were thawed in the refrigerator in the original wrappings. Burned portions of exterior surface and core were discarded. The remainder was finely chopped and thoroughly mixed before sampling.

Sample 17. Breadfruit, boiled.
1. Samoan name: Puou.
2 and 3, same as Sample 16, but from Utulei, Tutuila.
4. Preparation of sample after collection: Mature but green breadfruit scraped as for Sample 16, then boiled in water about 45 minutes.
5 and 6, same as Sample 16.

Sample 18. Breadfruit seeds, fresh.
1, 2, 3, 5, and 6, same as Sample 6.
4. Preparation of sample after collection: Seeds were removed from the three fresh fruits described under Sample 6. Refuse (skins around seeds), 25 percent.

1 and 2, same as Sample 6.
3. Date of analysis: September 7, 1951.
4. Preparation of sample after collection: Cooking process and preparation of slurry same as Sample 7. Analyses made on approximately 30 seeds (from two fruits) removed after the fruits were cooked. Refuse (skins around seeds), 26 percent.

5 and 6, same as Sample 6, slurry.

Sample 20. Breadfruit, preserved and cooked.

1. Trukese name: Apot mei mon.

2. Date and place of collection: August 18, 1951. Moen, Truk district.

3. Date vitamin assays begun: December 5, 1951.

4. Preparation of sample after collection: See page 21 for method of preparation. The preserved breadfruit was taken from the pit and kneaded on a board, sufficient water was added to make the consistency of soft dough. Loaf-sized pieces were wrapped in breadfruit leaves and baked in the earth oven for 1 hour. Prepared from breadfruit preserved from the 1950 crop.

5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 28 days instead of 8 days.

6. Preparation for analyses: Packages were thawed at room temperature and the contents chopped before sampling.


1. Trukese name: Apot mei pupu.

2 and 3, same as Sample 10.

4. Preparation of sample after collection: Analyses made on composite of three samples obtained from three different villages. Preserved (fermented) breadfruit is taken from a pit and is first kneaded by hand. Then the breadfruit is put in a cloth bag and placed in

4. Samples 21, 22, 23, and 24. In each case the lots from three sources were thoroughly mixed immediately after collection, then made into packages of 1 to 2 pounds, wrapped, and quick-frozen.
the ocean or lagoon and washed several times. Then the bag with breadfruit is taken out and kneaded by hand or by foot to express the water containing the soluble materials resulting from the fermentation process and the immersion in salt water. Coconut cream is added next. This mixture is wrapped in breadfruit leaves and steamed in an earth oven for about an hour and a half.

5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 28 days instead of 8 days.

6. Preparation for analyses: Packages were thawed at room temperature and the contents chopped before sampling.

Sample 22. Breadfruit, steamed, pounded, and coconut oil added.

1. Trukese name: Emesefich.

2. Date and place of collection: August 18, 1951. Moen, Truk district.

3. Date vitamin assays begun: January 22, 1952.

4. Preparation of sample after collection: Analyses made on three samples collected from three villages on Moen, Truk district. First step in preparing is similar to method used in making kon. Then coconut oil is added. Coconut oil is extracted from coconuts which had been grated the day before and left in the open overnight to dry.

5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 28 days instead of 8 days.

6. Preparation for analyses: Packages were thawed at room temperature and the contents chopped before sampling.

Sample 23. Breadfruit, steamed, pounded, and coconut cream added.

1. Trukese name: Muatin.
2. Date and place of collection: August 18, 1951. Moen, Truk district.

3. Date vitamin assays begun: January 22, 1952.

4. Preparation of sample after collection: See page 17 for preparation of muatin. Analyses made on three samples from three different villages. Small batches of about 3 pounds each were wrapped in aluminum foil and quick-frozen.

5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 28 days instead of 8 days.

6. Preparation for analyses: Packages were thawed at room temperature and the contents chopped before sampling.

Sample 24. Breadfruit, roasted, and baked in coconut cream.

1. Trukese name: Ror.

2. Date and place of collection: August 20, 1951. Moen, Truk district.

3. Date vitamin assays begun: December 18, 1951.

4. Preparation of sample after collection: See page 17 for preparation of ror. Analyses made on composite of samples from three different sources. Small batches of about 2 pounds were wrapped in aluminum foil and quick-frozen.

5. Transportation and storage: Same as Sample 8 except kept in Trust Territory cold storage for 26 days instead of 8 days.

6. Preparation for analyses: Packages were thawed at room temperature and the contents chopped before sampling.

Sample 25. Breadfruit paste.

1. Polynesian name: Paku kura (Kapingamarangi).

3. Date vitamin assays begun: July, 1948.

4. Preparation: Similar to method described on page 22.


6. Storage: Stored in tightly closed bottles in the refrigerator until analyzed.

Coconut


1. Marshallese name: Ni.

2. Date and place of collection: September 6, 1951. Uliga Island, Majuro Atoll, by Mr. Harry Uyehara.

3. Date vitamin assays begun: October 25, 1951.

4. Preparation of sample after collection: Four coconuts taken from trees, husked, wrapped in aluminum foil, and labeled.

5. Transportation and storage: Stored at 10° F. on a Navy vessel 13 days en route to Honolulu. Transferred to Foods and Nutrition Department, and placed in freezer-storage at 0° to -5° F. until analyses were made.

6. Preparation for analyses: The nuts were thawed at room temperature, the soft eyes punctured, and the liquid poured out to make a composite sample from four nuts.

Sample 2. Coconut, immature. Liquid.

1. Trukese name: Nu.

2. Date and place of collection: August 18, 1951. Moen, Truk district, Caroline Islands.

3. Date vitamin assays begun: April 8, 1952.

4. Preparation of sample after collection: Five coconuts from five different sources were husked, wrapped in aluminum foil, and labeled.
5. Transportation and storage: Frozen and kept at 0° F. in Trust Territory cold storage box for 28 days. Kept frozen at 10° F. for 3 days from Truk, Caroline Islands, to Guam, Marianas Islands, on a Trust Territory vessel. Kept frozen at 10° F. in Navy cold storage awaiting transportation to Honolulu on a Navy vessel for 27 days. Kept at 20° F. en route to Honolulu from Guam for 7 days. Stored at Pearl Harbor, in Navy cold storage at 0° to 10° F. for 1 day (vessel arrived on Sunday). Stored at commercial cold storage at 5° F. until analyzed.

6. Preparation for analyses: Same as Sample 1. Sample for analyses, composite from five nuts.


1. Marshallese name: Mere.

2, 3, 4, and 5, same as Sample 1.

6. Preparation for analyses: After the liquid was poured out (Sample 1), the shells were cracked through the center and the soft white meat was removed with a spoon, weighed, and blended in the Waring blender. Analyses on a composite from four coconuts.


1. Trukese name: Apun.

2, 3, 4, and 5, same as Sample 2.

6. Preparation for analyses: Same as Sample 3. Analyses on composite from five coconuts.


2, 3, 4, and 5, same as Sample 1.

6. Preparation for analyses: After the samples were thawed at room temperature, the shells of the nuts were cracked in the center, the liquid collected and measured. Meat was removed from shells and without removing brown skin it was chopped into very fine
pieces. Analyses made on composite of four nuts from different trees.


1. Trukese name: Taka.
2. Date and place of collection: August 20, 1951. Moen, Truk district.
3. Date vitamin assays begun: April 9, 1952.
4. Preparation of sample after collection: Same as Sample 1.
5. Transportation and storage: Same as Sample 2 except frozen and kept at 0° F. in Trust Territory cold storage box for 26 days instead of 28 days.
6. Preparation for analyses: Same as Sample 5. Analyses made on composite of six coconuts from six different trees.


2, 3, 4, and 5, same as Sample 6.
6. Preparation for analyses: The water drained from the eyes of six coconuts used for Sample 6 was combined before taking aliquots.

Sample 8. Coconut cream No. 1.

1. Polynesian and Micronesian names: Samoan, pe'pe'pe'e; Marshallese, el; Trukese, arung.
4. Preparation of sample: Coconuts gathered over a period of 4 weeks from two adjoining private gardens in Manoa Valley were husked and examined. From the lot of 40 coconuts, 21 heavy nuts were selected for grating. The water was drained out after piercing the eyes. The water and coconut were examined to be certain they were fresh and in good condition. The nuts were cracked in approximate halves and, without
removing the coconut from the shell, they were grated on a Polynesian grater within about 3 hours. The water and quantity of grated coconut from each coconut were measured and weighed. The entire lot of approximately 7500 grams of grated coconut was mixed and divided into two equal quantities from which were prepared Sample 8 and Sample 9.

Half of the large lot of grated coconut was very thoroughly mixed; small quantities (about 2 cups) were then placed in one thickness of cheesecloth in a 2-quart, screw-type household press and as much cream expressed as possible. No water was added. Yield 1200 milliliters. The small lots obtained after each pressing were thoroughly mixed and placed in dark bottles with bakelite tops.

5. Storage and analyses: Ascorbic acid was determined the same day the cream was prepared. The remainder was quick-frozen and held at 0° F. The following day, one bottle was brought to room temperature and thoroughly mixed by blending in a Waring blender for about 1½ minutes, after which aliquots were taken for moisture and the B vitamins. A second bottle of the cream was kept frozen until proximate composition and minerals were determined.

Sample 9. Coconut cream No. 2.

1, 2, and 3, same as Sample 8.

4. Preparation of sample: The grated coconut was prepared as described for Sample 8. To about half the total lot of grated coconut (approximately 3750 grams), 4½ cups of the mixed water from the 21 coconuts were added, and thoroughly mixed by kneading with the hands. The cream was then expressed in the same manner as for Sample 8, Coconut cream No. 1. Yield 2000 milliliters.

5. Storage and analyses: Same as Sample 8.

Sample 10. Coconut, embryo.

1. Marshallese name: Iu.

2. Date and place of collection: Same as Sample 1.
3. Date vitamin assays begun: October 25, 1951.

4. Preparation of sample after collection: Four coconuts collected from ground, husks removed, wrapped in aluminum foil, and labeled.

5. Transportation and storage: Same as Sample 1.

6. Preparation for analyses: Samples were thawed at room temperature. Shells were cracked open and embryos were removed. Size about 4 inches by 2 inches. Analyses made on composite of four embryos.

Sample 11. Coconut, embryo.

1. Trukese name: Chofar.

2 and 3, same as Sample 6.

4. Preparation of sample after collection: Husks removed from coconuts, wrapped in aluminum foil, and labeled.

5. Transportation and storage: Same as Sample 2 except stored for 26 days instead of 28 days in Trust Territory cold storage.

6. Preparation for analyses: Same as Sample 10. Analyses made on composite of five embryos.

Sample 12. Coconut sap, very slightly fermented.

1. Marshallese name: Jekara.

2. Date and place of collection: Same as Sample 1.

3. Date vitamin assays begun: September 25, 1951.

4. Preparation of sample after collection: Pooled sample from three different trees combined in a gallon glass jar.

5. Transportation and storage: Stored at 38°F. on a Navy vessel 13 days en route to Honolulu. Transferred to the University of Hawaii and stored at 36°F. until analyses were completed.

6. Preparation for analyses: Contents of bottle brought to room temperature before sampling.

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Sample 13. Coconut sap, slightly fermented.

1, 2, 3, 4, 5, and 6, same as Sample 12. Analyses made on a composite of three samples, each sample from a separate tree.


1. Marshallese name: Jekajeje.
3. Date vitamin assays begun: December 5, 1951.
4. Preparation of sample after collection: Composite of three samples from three different trees boiled for 20 minutes. Transferred to clean, dry, milk cartons with a tight cover. Collected and frozen the same day.
5. Transportation and storage: Frozen at 0° F. in field for 28 days in Navy cold storage. Kept frozen at 12° F. on a Navy vessel for 9 days en route to Honolulu. Transferred to Foods and Nutrition Department, and kept frozen at 0° to -5° F. until analyzed.
6. Preparation for analyses: Sap was brought to room temperature before sampling for analyses.

Sample 15. Coconut sap, slightly fermented.

1. Gilbertese name: Kareve.
2. Date and place of collection: August 27, 1951. Onotoa, Gilbert Islands, by a member of the Pacific Science Board expedition.
3. Date vitamin assays begun: September 25, 1951.
4. Preparation of sample after collection: Unknown except that it was collected in the manner described on page 44 and boiled longer than Sample 14.
5. Transportation and storage: Cold room at 38° F. on Coast Guard vessel 22 days until September 19, 1951. Transferred to the Foods and Nutrition Department, and stored at 36° F. for 6 days until analyzed.
6. Preparation for analyses: Sap was brought to room temperature before sampling.

1. Gilbertese name: Kamaimai.

2. Date and place of collection: August 28, 1951. Makin, Gilbert Islands, by a member of the Pacific Science Board expedition.

3. Date vitamin assays begun: September 25, 1951.

4. Preparation of sample after collection: Period of time of boiling uncertain but similar to that described on page 45. Collected in a clean bottle.

5. Transportation and storage: Same as Sample 15.

6. Preparation for analyses: Contents of bottle were mixed, syrup was brought to room temperature before sampling.

Sample 17. Gruel of white flour, coconut sap, and coconut cream.

1. Marshallese name: Jaibo.


3. Date vitamin assays begun: December 5, 1951.

4. Preparation of sample after collection: Sample was collected in clean, dry, milk cartons with a tight cover, which was taken from a large quantity prepared for the students at school given above. The mixture is made in the proportion of six parts of coconut sap, three parts of flour, and one part of coconut cream.

5. Transportation and storage: Frozen for 1 day in refrigerator freezing compartment on Ronron, Marshall Islands. Kept frozen in insulated container en route to Uliga from Ronron. Placed at 0° F. in Navy cold storage at Uliga for 27 days. Kept frozen at 12° F. on a Navy vessel for 9 days en route to Honolulu. Transferred to the Foods and Nutrition Department, and kept frozen at 0° to -5° F. until analyzed.

6. Preparation for analyses: Product brought to room temperature before sampling.
Sample 18. Gruel of white rice, coconut sap, and coconut cream.

1. Marshallese name: Chokop (see p. 48).
2. Date and place of collection: Same as Sample 17.
3. Date vitamin assays begun: December 5, 1951.
4, 5, and 6, same as Sample 17.

Sample 19. Coconut oil.

1. Marshallese name: Binep.
2. Date and place of collection: September, 1953, Majuro. Collected and sent by Sheila Malcolm, Nutritionist with the South Pacific Commission.
3. Date vitamin assays begun: October, 1953.
4. Preparation of sample after collection: Similar to that described on page 43.
5. Transportation and storage: Shipped by air mail from Majuro, Marshall Islands; about 1 week en route. Kept refrigerated until analyzed.
6. Preparation for analyses: Brought to room temperature before sampling. Determination of the fat by the Babcock test was unsatisfactory. A known quantity of the oil was absorbed on filter paper and then the fat extracted by the Soxhlet-type apparatus.

Sample 1. Pandanus, fresh.

2. Date and place of collection: May 20, 1951. Uliga Island, Majuro Atoll.
3. Date vitamin assays begun: October 11, 1951.
4. Preparation of sample after collection: Keys from three fruits, each from a different tree, were weighed, wrapped in groups of three in several thicknesses of...
wax paper, labeled, and placed in the freezer.

5. Transportation and storage: Frozen at 0° F. and held in Navy cold storage for 8 days. Kept frozen at 12° F. on a Navy vessel for 9 days en route to Honolulu. Transferred to Foods and Nutrition Department. The samples were examined and rewrapped in the same wax papers with an outer wrapping of aluminum foil. The keys were kept in freezer-storage at 0° to -5° F. until analyses were made.

6. Preparation for analyses: Samples were thawed in the refrigerator and then brought to room temperature. Total weights of keys and weights of edible portions were recorded. Edible portions were cut into small pieces and blended in the Waring blender without addition of liquid. The coarser fibers were removed by putting slurry through two thicknesses of cheesecloth to obtain a value more representative of the portion actually eaten. The juice so extracted was put into brown glass bottles filled with carbon dioxide, closed tightly with bakelite tops, labeled and held at 0° F. until all analyses had been made. Refuse, 59 percent.

Notes on analyses. Crude Fiber: To remove a large portion of the sugars from the pandanus samples to be analyzed for crude fiber, the samples were weighed, transferred quantitatively to filter paper in funnels, and extracted with distilled water in the refrigerator for almost 2 weeks. (Refrigeration was necessary to prevent the growth of molds.) The water-extracted residues were dried on the filter papers for 48 hours, below 70° C., and then extracted with ether in the usual manner. The ether-extracted residues and the attached filter paper were used for the crude fiber determinations. A blank of filter paper was run simultaneously with each of the triplicate determinations of fiber.

Sample 2. Pandanus, boiled.

1, 2, and 3, same as Sample 1.

4. Preparation of sample after collection: Keys from the same fruit as Sample 1 were boiled without a cover in a large glass beaker of plain water for 30 minutes. The water was drained off and the keys cooled. Keys
were weighed and labeled as stated for Sample 1.

5. Transportation and storage: Same as Sample 1.

6. Preparation for analyses: Same as Sample 1, except that in addition to cutting off the soft ends, any soft juicy pulp remaining in the fibers was scraped out with a dull knife and added to the soft ends before mixing in the Waring blender. Refuse, 65 percent.

Sample 3. Pandanus, fresh.


2. Date and place of collection: May 15, 1951. Majuro Island, Majuro Atoll.

3. Date vitamin assays begun: October 11, 1951. Other analyses same as Sample 1.

4. Preparation of sample after collection: Keys from three fruits from three different trees, prepared in the same manner as Sample 1.

5. Transportation and storage: Same as Sample 1, but product held in Navy cold storage for 13 days before shipping.

6. Preparation for analyses: Same as Sample 1. Refuse, 66 percent.

Sample 4. Pandanus, boiled.

1, 2, and 3, same as Sample 3.

4. Preparation of sample after collection: Keys from same three fruits as Sample 3 were boiled for 30 minutes in plain water in a large glass beaker without a cover. After cooling, the soft ends of the keys were scraped with a dull knife to remove the pulp that constitutes the edible portion. The following were mixed in a Waring blender: 164 grams of pulp, 90 milliliters of 1 percent oxalic acid, and shortly before slurry was completely blended, 5 milliliters of chloroform and 3 drops of mixed tocopherols were added. The samples were transferred to brown glass bottles, the plastic caps screwed down tightly and sealed with paraffin wax. Refuse, 75 percent.
5. Transportation and storage: Bottles were kept at $36^\circ$ F. at Uliga, Marshall Islands, until shipped by plane on May 29, 1951. The bottles were packed in cartons and shipped by air without refrigeration. The flight took 2 hours to Kwajalein, bottles were refrigerated at $36^\circ$ F. in a Navy reefer during a stopover of 20 hours at Kwajalein. The flight from Kwajalein to Honolulu took 9 hours during which time they were not refrigerated. Samples were transferred to the Foods and Nutrition Laboratory and kept at $36^\circ$ F. until analyzed.

Sample 5. Pandanus Paste.

1. Marshallese name: Mōkan.
3. Date vitamin assays begun: October 10, 1949, except carotene which was determined in January, 1951.
4. Preparation: Similar to method described on pages 72 and 73, but exact times of cooking and drying are not known. Thin slices were made into a roll approximately 3 inches in diameter and 14 inches long, covered with plaited pandanus, and tied securely with sennit (see Fig. 19a).
5. Transportation and storage: Transported by ship without refrigeration to Honolulu. Brought to the Foods and Nutrition Department in September, 1949. Kept at room temperature until analyses were begun, samples were removed from wrappings and thereafter kept refrigerated in tightly closed bottles.

Sample 6. Pandanus Flour.

1. Polynesian name: Paku harahara.
3. Date vitamin assays begun: Vitamin-A feeding tests, July, 1948; other vitamins, August, 1948.

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4. Preparation: Similar to method described on page 73.


6. Storage: Stored in tightly closed bottles in the refrigerator until analyzed.

Other Fruits

Sample 1. Banana, eating, fresh.


2. Date and place of collection: August 10, 1951. Udot, Truk district.

3. Date vitamin assays begun: April 29, 1952.

4. Preparation of sample after collection: Seventeen fruits from five different trees from different parts of the island were individually wrapped in aluminum foil and quick-frozen.

5. Transportation and storage: Kept at 0° F. in Trust Territory cold storage for 36 days. Kept at 10° F. for 3 days from Truk, Caroline Islands, to Guam, Marianas Islands, on a Trust Territory vessel. Kept frozen at 10° F. in Navy cold storage awaiting transportation to Honolulu on a Navy vessel for 27 days. Kept at 20° F. en route to Honolulu from Guam for 7 days. Stored at Pearl Harbor, in Navy cold storage at 0° to 10° F. for 1 day (vessel arrived on Sunday). Stored at commercial cold storage at 5° F. until analyzed.

6. Preparation for analyses: Bananas were thawed in original wrappings at room temperature. Total weights and weights of edible portions were recorded. Refuse (skin and fibers), 34 percent. Edible portions cut into chunks and blended in Waring blender before sampling.

Sample 2. Cooking banana, fresh.


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2. Date and place of collection: August 20, 1951. Moen Island, Truk district.

3. Date vitamin assays begun: March 17, 1952.

4. Preparation of sample after collection: Five bananas from five different sources were individually wrapped in aluminum foil and quick-frozen.

5. Transportation and storage: Same as Sample 1, but stored at 0° F. in Trust Territory storage box for 26 days.

6. Preparation for analyses: Same as Sample 1. Refuse, 37 percent.

Sample 3. Cooking banana, boiled.

1 and 2, same as Sample 2.

3. Date vitamin assays begun: March 17, 1952.

4. Preparation of sample after collection: Five bananas from five different sources were boiled in the skins for 20 minutes. The bananas were left in the skins and wrapped singly in aluminum foil and quick-frozen.

5. Transportation and storage: Same as Sample 1.

6. Preparation for analyses: Same as Sample 2. Refuse, 29 percent.

Sample 4. Apuch, fresh.

1. Trukese name: Apuch. Scientific name: *Crataeva speciosa*.

2. Date and place of collection: August 29, 1951. Moen, Truk district.

3. Date vitamin assays begun: February 7, 1952.

4. Preparation of sample after collection: Six fruits from six different trees were wrapped singly in aluminum foil and quick-frozen.

5. Transportation and storage: Frozen and kept at 0° F. in Trust Territory cold storage for 17 days. Remainder same as Sample 1 of banana.

6. Preparation for analyses: Samples were thawed at
room temperature in the original wrappings, peeled, sliced, and the creamy flesh and tender core were finely chopped and thoroughly mixed before sampling. Refuse (skin and stem), 22 percent.

**Starchy Aroids**

Sample 1. Wetland taro, baked.


3. Date vitamin assays begun: August 15, 1951.

4. Preparation of sample after collection: Skins removed from corms with coconut-shell scraper, washed, and wrapped in breadfruit leaves. Baked, June 24, 1951, in underground oven for 35 minutes. Cooled, wrapped in very heavy wax paper, quick-frozen, and stored at -20° F. for 1 day.

5. Transportation and storage: Shipped in frozen state in reefer of Navy vessel en route to Honolulu for 11 days. Transferred to Foods and Nutrition Department, aluminum foil added to previous wrappings, and stored at 0° to -5° F. until analyzed.


Sample 2. Upland taro, baked.


2. Date and place of collection: June 23, 1951. Village of Pavaiai, Western District Tutuila, American Samoa, from plantation high on the mountains. Collected by Commander Fred L. Losee.
3. Date vitamin assays begun: August 15, 1951.


5 and 6, same as Sample 1 of taro.

Sample 3. Upland taro, boiled.

1, 2, 3, 4, 5, and 6, same as Sample 2 except cooking. Three medium-size corms were immersed in water and boiled for 2 hours. Analyses were made on a composite of the three corms; total E.P. weight, 1100 grams.

Sample 4. Wetland and upland taro, roasted.

1. Trukese name: Oni or Otsu. Scientific name: *Colocasia esculenta* (L.) Schott.

2. Date and place of collection: August 18, 1951. Moen, Truk district.

3. Date vitamin assays begun: January 2, 1952.

4. Preparation of sample after collection: Samples were roasted over hot coconut charcoal for about an hour. Skin removed by using a shell scraper. Two corms about 10 x 5 inches and weighing approximately 4 pounds each were wrapped in aluminum foil and quick-frozen.

5. Transportation and storage: Kept at 0° F. in Trust Territory cold storage box for 28 days. Kept frozen at 10° F. for 3 days from Truk, Caroline Islands, to Guam, Marianas Islands, on a Trust Territory vessel. Kept frozen at 10° F. in Navy cold storage awaiting transportation to Honolulu on a Navy vessel for 27 days. Kept at 20° F. en route to Honolulu from Guam for 7 days. Stored at Pearl Harbor, in Navy cold storage at 0° to 10° F. for 1 day (vessel arrived on Sunday). Stored at commercial cold storage at 5° F. until analyzed.
6. Preparation for analyses: Brought to room temperature, weighed, and chopped in small pieces before sampling.

Sample 1. Cyrtosperma, fresh.

2. Date and place of collection: May 16, 1951. Majuro Island, Majuro Atoll.
3. Date vitamin assays begun: January 29, 1952.
4. Preparation of sample after collection: Two corms averaging \(4\frac{1}{2} \times 3\frac{3}{4}\) inches from two different sources. Skins removed, wrapped in wax paper, and frozen at 0° F. Average weight, 400 grams. Refuse, 36 percent.
5. Transportation and storage: Held in Navy cold storage in field for 12 days. Kept frozen at 12° F. on a Navy vessel for 9 days en route to Honolulu. Transferred to the Foods and Nutrition Department, rewrapped in aluminum foil, and kept frozen at 0° to -5° F. until analyzed.
6. Preparation for analyses: Brought to room temperature, weighed, and chopped in small pieces before sampling. Analyses made on composite of two corms.

Sample 2. Cyrtosperma, fresh.

2. Date vitamin assays begun: November 30, 1951.
3. Date and place of collection: May 16, 1951. Majuro Island, Majuro Atoll.
4. Preparation of sample after collection: One corm taken to Uliga, skin removed, weighed, wrapped in wax paper, and quick-frozen at 0° F. Refuse, 36 percent. All analyses on one corm. E.P. weight, 720 grams.

5 and 6, same as Sample 1, *Cyrtosperma Chamissonis*. 131
Sample 3. Cyrtosperma, roasted.


3. Date vitamin assays begun: January 29, 1952.

4. Preparation of sample after collection: Three different corms from three different sources were collected and baked in an earth oven for approximately an hour and a half. Measurements, 4 x 5 inches, average weight, 395 grams. Skins were removed. Refuse, 32 percent.

   Slurry prepared as follows: The cooked edible portions were put in a Waring blender using 200 milliliters oxalic acid for each 300 grams of corms; just before slurry was complete, 5 milliliters of chloroform and 3 drops of mixed tocopherols were added. Samples were transferred to brown glass bottles, the plastic caps screwed down tight, sealed with paraffin wax, and packed in a carton for shipment by air.

5. Transportation and storage: Held at 35° F. in field for 13 days in Navy reefer. Unrefrigerated for 2 hours from Majuro, Marshall Islands, to Kwajalein, Marshall Islands. Refrigerated for 20 hours at 36° F. at Kwajalein during a stopover. No refrigeration for 9 hours on plane from Kwajalein to Honolulu. Transferred to refrigerator of Foods and Nutrition Department and held at 36° F. until analyzed.

6. Preparation for analyses: Brought to room temperature before sampling. This sample used for moisture and vitamin-B assays only.

Sample 4. Cyrtosperma, fresh.


2. Date and place of collection: May 15, 1951. Majuro Island, Majuro Atoll.

3. Date vitamin assays begun: November 14, 1951.
4. Preparation of sample after collection: Taken to Uliga Island where weights were taken and skin was removed. Refuse, 26 percent. The corm (490 grams E.P.) was wrapped in wax paper and quick-frozen at 0° F.

5. Transportation and storage: Same as Sample 1, Cyrtosperma Chamissonis.

6. Preparation for analyses: Sample was thawed at room temperature. The corm was sliced, chopped, and mixed before sampling. All analyses were made on one corm.

Sample 5. Cyrtosperma, baked.


2. Date and place of collection: August 18, 1951. Moen, Truk district.

3. Date vitamin assays begun: January 2, 1952.

4. Preparation of sample after collection: One large corm, about 24 x 5½ inches at widest section and weighing about 10 pounds, was roasted, without paring, over hot coconut charcoal for about an hour. Cooled, skin removed, wrapped in aluminum foil, and quick-frozen.

5. Transportation and storage: Same as Sample 4, Colocasia esculenta.

6. Preparation for analyses: Same as Sample 4. Analyses made on one large corm only which was brought to room temperature, weighed, and chopped in small pieces before sampling.

Sample 6. Cyrtosperma, baked.


2. Date and place of collection: August 18, 1951. Truk district, Caroline Islands.

3. Date vitamin assays begun: February 8, 1952.

4. Preparation of sample after collection: Two corms
were baked in the earth oven, without removing skins, until they were soft, about 2 hours. The corms were large, about 7 x 8 inches, and weighed approximately 2000 grams each. Cooled, skins removed, wrapped in aluminum foil, and quick-frozen.

5. Transportation and storage: Same as Sample 5, *Cyrtosperma Chamissonis*.

6. Preparation for analyses: Brought to room temperature, weighed, and chopped before sampling. Analyses made on two corms from different sections of the island.

Sample 1. *Alocasia macrorrhiza*, fresh.


3. Date vitamin assays begun: July 7, 1955.

4. Preparation of sample after collection: Leaves and petioles removed from the stem or trunk and discarded. The trunk, which is the edible portion, with part of an adhering root was placed, without wrapping, in a refrigerator. A single stem, weighing 9 pounds, constituted the sample.

5. Transportation and storage: Sample stored in refrigerator at 38° F. for 3 days. No refrigeration on flight from Ebon to Honolulu. Held at 8° F. from July 2 to July 5, then at 38° F. until prepared for sampling.

6. Preparation for analyses: The trunk was cut crosswise into three sections; each was peeled and quartered lengthwise. Composite samples were made by taking one lengthwise slice from each quarter for raw and one for the cooked portion. The flesh was colorless, juicy, and very irritating to the hands. Even after cooking, it was irritating to the mouth and throat. Refuse (skin and small root), 18 percent.
Arrowroot Flour

1. Marshallese name: Mokmok.
3. Date vitamin assays begun: November 30, 1953.
4. Preparation of sample after collection: Sample, taken from a lauhala basket in which the family supply was kept, was put in a small lauhala bag about 6 x 6 inches.
5. Transportation and storage: Taken on LST from Wotje to Majuro, kept at room temperature for several weeks, and flown from Majuro to Honolulu via Kwajalein. Transferred to a glass jar with metal cover and kept on shelf in laboratory after delivery to Foods and Nutrition Department.
6. Preparation for analyses: Since the cover to the bottle containing the starch showed some signs of rust and there appeared to be a few specks on the surface of the starch, about one inch of the top layer was discarded, and the remainder was transferred to a bottle with a plastic top. The contents were thoroughly mixed before sampling.

Sweetpotato

2. Date and place of collection: August 18, 1951. Moen, Truk district.
4. Preparation of sample after collection: Three sweetpotatoes, each from a different part of the island, were collected and, without paring, were cooked by boiling in an iron pot over a coconut charcoal fire for 1 hour. Cooled and frozen.
5. Transportation and storage: Kept frozen at 0° F. in
Trust Territory cold storage box for 28 days. Remainder same as Sample 1 of banana.

6. Preparation for analyses: Samples were thawed at room temperature in original wrappings and weighed. Total E.P. weight, 1454 grams. Refuse (skin and hard ends), 8 percent. Edible portions were cut into chunks and blended thoroughly in Waring blender before sampling. These potatoes had purplish-red skins and smooth, cream-colored flesh.
SUPPLEMENT: SEAFOODS

Composition, Nutritive Value, and Use

of Some Seafoods from the Caroline and Marshall Islands

Chemical Analyses by Dr. Hiroyuki Iwao and Dr. Kunitaro
Arimoto (National Institute of Nutrition, Tokyo, Japan).

Text by Mary Murai and Carey D. Miller.

Fish, shellfish, and other seafoods constitute the most important source of animal protein for the inhabitants of most of the smaller, tropical Pacific islands. Weather conditions may interfere with fishing, and there are times when little or no fish or other seafoods are available and times of great plenty when schools of fish appear and more are obtained than can be utilized.

Regarding the use of fish as food in the Marshall Islands, one can find in the literature very divergent opinions. Kotzebue (32), when he was there in 1816, stated, "It is striking that they so greatly neglect fishing." Dr. O. Finsch, a reliable German scientist, reported in 1893 (19), that the situation was much the same, yet he goes on to give information about fishing methods and some account of the fishes caught. Probably it was not the kind of fishing he was accustomed to, as he states, "Fishing in our sense is unknown, as in general in the South Seas, and only came into use after the introduction of the European fishing hooks." (This statement may be questioned, as practically all of the island people made fish hooks out of bone, and the techniques and lore of fishing figured importantly in the life of the island people. C.D.M.) Finsch gives a rather detailed account of the periodic appearance of certain fishes which were caught in large quantities when they came into the lagoons in order to lay their eggs.

Kramer, in his report on the islands around Truk (34),
discusses fishing in considerable detail, the use of nets, hooks, traps, and poisonous bait, and states, "Fish are very plentiful. Most of the fishing can be done inside the reef."

Hall and Pelzer (24) state, "Next to agriculture, fishing is the principal economic activity of the natives of Truk. It has the character of subsistence rather than commercial fishing."

One of the authors (M.M.) observed that in the Marshall Islands the men did the fishing, mostly in the lagoon, but on Saturday afternoon they would go out in a group in canoes to the deeper ocean and stay until they had a good catch. They do not go fishing on Sunday, but neither do they cook nor do other chores. Women do little of the fishing, but they may go out at low tide to look under the rocks for shellfish, crustacea, and octopus. A fish drive using leaves of coconut fronds in the lagoons is a fairly common method of obtaining fish in the Marshall Islands (Fig. 32), especially when large schools of fish enter the lagoons. Hernsheim describes in detail such a fishing party and states that the approximate total of such a haul may be 400 to 500 pounds of fish (26).

In the Caroline Islands, it was observed by one of the authors (M.M.) that the women do most of the fishing. This
is confirmed by the observations of Hall and Pelzer (24), who describe the methods of fishing by men and women in the Truk area in considerable detail. At low tide the women go out with baskets tied around their hips. They turn over rocks or look under them for crustacea, octopus, or shellfish, as well as small fish. They usually carry spears and hand-nets to scoop up small fish.

The women also spend considerable time fishing in the lagoon with butterfly nets. These nets are shaped like butterfly wings. They are hand-made from fiber found in grass growing in shallow, brackish water. The net is fastened to two sticks which are triangular shaped. Each woman carries two of these nets, one in each hand. They often use them in the following manner: About 25 women form a semicircle with nets between them while one woman drives the fish toward the others by hitting the water with a spear. Gradually the semicircle becomes smaller as the women approach the shore. The woman who catches the fish or fishes in her net keeps them unless, as on certain occasions, it is a community project.

It was observed that about once in two weeks, the able-bodied women of Udot (Caroline Islands) left at sunrise in the chief's boat to go fishing in the ocean under the leadership of the chief's wife. They stayed out all day and returned at nightfall with quite a catch which they divided among the families of the community. They used the fruit of the Barringtonia tree to stun the fish. The fruit is crushed and spread upon the water. Since the fish are not poisoned, they have no ill effect when eaten by humans.

Seafoods observed in the Caroline Islands or consumed by the natives when the dietary study was made

Mr. Max Mori of Truk furnished the Japanese names of the fish and wrote the descriptions in Japanese, which were translated into English by the late Mrs. Hisa Murai. The classifications were made by Dr. Donald Strasburg on the basis of the descriptions.

The first word is the local name. If known, the second is Japanese, and the third, English, followed by the scientific name. In only a few cases are all the names known.
Awet. Gingyo. A silver-colored fish found in the Truk area.

Boro. Sasano habera. Wrasse. Family *Labridae*. A flat fish, 12 to 18 inches long; pointed mouth; strong upper and lower teeth; and two large teeth posteriorly on roof of mouth. Found in shallow waters. Not tasty.

Chukufun or Kufen. Small fish about 2 inches long; dark-brown color; large hard scales. Scales are removed but head and all bones are eaten.


Eli, Eni, or Eri. Kui. Sea Bass. *Cephalopholis argus* (Bloch). Purple-brown color, with six vertical brown stripes when young. When fish matures, the stripes disappear and it is called kunufou. Most tasty fish in this area.


Ikechon, Ikeson, or Maraun. Bera. Wrasse. Family *Labridae*. A long, flat fish with long head, pointed mouth, small eyes, thin lips, and weak small teeth, but one strong tooth posteriorly on roof of mouth. Dark brown on back and light green on stomach. White soft meat, very little fat.

Ikenot or Ikenoch. Wrasse. The names mean "reef fish" and it is of the family *Labridae*.

Meigyogyo, Meichocho, Umuno, or Ubura. Kawahagi. Trigger fish. Family *Balistidae* or *Monachanthidae*. Found in shallow waters but hard to capture. Five to 12 inches long. Trukese believe gills are poisonous but flesh is good and much favored for eating.

Meitsutsu. Any fish with many bones.

Motsu or Moch. A black, fatty fish.

Nis is similar to meigyogyo or meichocho but has poisonous gills and little fat.

Ogi or Petak. Asarigai. Baby clam. Taken from the reef.

Patsu. In summer called petu. Much like chukufun in color but with different marking—white horizontal lines. Found in shallow waters.


Puna. Hagi. Surgeon Fish. Family *Acanthuridae*. A
long fish; large, flat head with protruding forehead; large mouth; pop eyes; tough skin; very oily meat.

Sas. An off-shore fish.


Usop. Wrasse. Same as Ikechon but with two spots on each side of head.

Cooking and eating seafoods

Hernsheim (26) and Finsch (19) both report that smaller fish and shellfish are often eaten in the raw state. It was noted by one of the authors (M.M.) that children and adults may pick fish from a net and eat them raw discarding only bones, heads, and entrails. Larger fish are eaten raw after cutting them in pieces and dipping them in lime juice and/or coconut milk.

Methods of cooking fish observed in the Marshall and Caroline Islands were as follows:

Boiled. Whole (including head, entrails, and scales) small fish and pieces of larger fish are made into stews with green, mature breadfruit.

Roasted. Whole (with entrails, but not scales, removed) small fish or pieces of larger fish are wrapped in leaves, tied with coconut fiber, and roasted on hot coals.

Baked. Whole fish, or fish with entrails, but not scales, removed, are wrapped in dried breadfruit leaves and tied with a bit of fiber. The fish are placed on hot coals in an earth oven and covered so that the fish cooks in its own juice.

Fried. If the utensils are available, the fish may be fried.

Samples

All seafood samples analyzed were collected in the Truk district (except one, Luker, collected in the Marshall Is-
lands at Ronron) by one of the authors (M.M.) where they were quick-frozen in the raw state the day they were obtained. The frozen fish were taken to Hawaii in the reefer of a Navy vessel and transferred to freezers at the University. Some of the fish were identified by Dr. Robert W. Hiatt and Dr. Donald Strasburg, members of the University of Hawaii zoology department.

The frozen fish were packed in carbon dioxide ice and taken by Mr. Harold Coolidge by air to Tokyo, Japan, where they were submitted to Dr. Kunitaro Arimoto, Director of the National Institute of Nutrition. A member of his staff, Dr. Hiroyuki Iwao, made the analyses. Dr. Arimoto and Dr. Iwao submitted the data given in Table 14, and are responsible for the accuracy of the figures.

Analytical methods

The following A.O.A.C. methods (1945 edition) were used in analyzing the fish: protein, modification for meat, p. 361; ash, p. 360; fat, p. 422; moisture, reverse of total solids, p. 360; calcium, p. 240; phosphorus, p. 422. For vitamin A, an antimony trichloride method, written and published in Japanese, was used. The method for riboflavin is one outlined on pp. 192-196 by Akiji Fujita in Vitamin Research (Vitamin Kinkyu), published in 1944 in Japanese.

Composition

The edible portions of the various seafoods listed in Table 14 were 100 percent except for the following: kinfou, 48 percent; bula, 47 percent; miech, 66 percent; kuo, 60 percent; ar, 65 percent; and onon, 33 percent.

As may be noted from Table 14, all the fish analyzed were very lean with little fat, except senif which had about 5 percent. The values for protein are considerably greater than those reported for many fresh fish in Agricultural Handbooks 8 and 34, hereafter referred to as AH 8 and AH 34.

The calcium and phosphorus contents of musum and senif are what one would expect for fish analyzed with bone, but the figures for the flesh of the other fish far exceed those commonly reported for calcium and phosphorus.
Table 14. Proximate composition, calcium, phosphorus, vitamin A, and riboflavin of seafoods from the Truk area, Caroline Islands (per 100 grams raw edible portion)

<table>
<thead>
<tr>
<th>Local name</th>
<th>English name</th>
<th>Scientific name</th>
<th>Water (%)</th>
<th>Protein (g.)</th>
<th>Fat (g.)</th>
<th>Carbohydrate (g.)</th>
<th>Ash (g.)</th>
<th>Ca (mg.)</th>
<th>P (mg.)</th>
<th>Vit.A (I. U.)</th>
<th>Riboflavin (mg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fish</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ar</td>
<td>Parrot Fish</td>
<td>Scarus</td>
<td>71.52</td>
<td>26.55</td>
<td>0.48</td>
<td>1.44</td>
<td>99</td>
<td>219</td>
<td>0</td>
<td>0.040</td>
<td></td>
</tr>
<tr>
<td>Bula</td>
<td>Surgeon Fish</td>
<td>Naso lituratus</td>
<td>68.43</td>
<td>27.86</td>
<td>2.00</td>
<td>-</td>
<td>1.70</td>
<td>83</td>
<td>162</td>
<td>0.090</td>
<td></td>
</tr>
<tr>
<td>Kinfou</td>
<td>Sea Bass</td>
<td>Epinephelus macrospilus</td>
<td>70.11</td>
<td>26.70</td>
<td>1.45</td>
<td>-</td>
<td>1.73</td>
<td>180</td>
<td>232</td>
<td>0.040</td>
<td></td>
</tr>
<tr>
<td>Kuo</td>
<td></td>
<td>Siganus (punctatus?)</td>
<td>70.00</td>
<td>26.70</td>
<td>2.14</td>
<td>-</td>
<td>1.15</td>
<td>150</td>
<td>158</td>
<td>0.150</td>
<td></td>
</tr>
<tr>
<td>Meich</td>
<td></td>
<td>Siganus rostratus</td>
<td>69.80</td>
<td>27.46</td>
<td>1.38</td>
<td>-</td>
<td>1.35</td>
<td>146</td>
<td>179</td>
<td>0.120</td>
<td></td>
</tr>
<tr>
<td>Musum</td>
<td>Damsel Fish,</td>
<td>Contains several species belonging to the families Pomacentridae, Holocentridae, and perhaps others</td>
<td>68.64</td>
<td>24.23</td>
<td>2.09</td>
<td>-</td>
<td>4.83</td>
<td>824</td>
<td>1257</td>
<td>0.040</td>
<td></td>
</tr>
<tr>
<td>Senif</td>
<td>Small Sardines</td>
<td>A clupeid fish, probably of the genus Harengula</td>
<td>63.78</td>
<td>26.10</td>
<td>5.22</td>
<td>-</td>
<td>4.89</td>
<td>531</td>
<td>863</td>
<td>0.040</td>
<td></td>
</tr>
<tr>
<td><strong>Shellfish</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luker*</td>
<td></td>
<td>Canarium Luhuanum Luhuanum</td>
<td>70.38</td>
<td>25.31</td>
<td>0.92</td>
<td>0.10</td>
<td>3.28</td>
<td>77</td>
<td>171</td>
<td>0</td>
<td>0.030</td>
</tr>
<tr>
<td>Onon</td>
<td></td>
<td>Bivalves found in mangrove swamps</td>
<td>80.32</td>
<td>10.54</td>
<td>0.77</td>
<td>5.85</td>
<td>2.51</td>
<td>94</td>
<td>155</td>
<td>0.060</td>
<td></td>
</tr>
<tr>
<td>Nikoburu</td>
<td></td>
<td>Lucina edentula</td>
<td>78.33</td>
<td>18.96</td>
<td>0.65</td>
<td>0.60</td>
<td>3.45</td>
<td>96</td>
<td>230</td>
<td>0.065</td>
<td></td>
</tr>
<tr>
<td>Shu</td>
<td>Clam</td>
<td>Lambis sp.(probably L. lambis)</td>
<td>70.99</td>
<td>20.75</td>
<td>2.32</td>
<td>2.82</td>
<td>3.19</td>
<td>188</td>
<td>363</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td>To</td>
<td>Clam</td>
<td>Hippopus kiospus</td>
<td>67.14</td>
<td>24.67</td>
<td>2.97</td>
<td>2.04</td>
<td>3.17</td>
<td>135</td>
<td>284</td>
<td>1000</td>
<td>0.110</td>
</tr>
<tr>
<td>To-um</td>
<td>Clam baked in earth oven</td>
<td>Tridacna sp.(probably T. crocea)</td>
<td>70.05</td>
<td>20.90</td>
<td>2.39</td>
<td>4.26</td>
<td>2.39</td>
<td>99</td>
<td>219</td>
<td>800</td>
<td>0.180</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nippach</td>
<td>Octopus</td>
<td>Octopus sp.(probably O. cyanea)</td>
<td>74.91</td>
<td>22.12</td>
<td>0.97</td>
<td>0.10</td>
<td>1.89</td>
<td>88</td>
<td>189</td>
<td>0</td>
<td>0.040</td>
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<tr>
<td>(Large size)</td>
<td></td>
<td></td>
<td>72.54</td>
<td>23.99</td>
<td>1.03</td>
<td>0.20</td>
<td>2.23</td>
<td>113</td>
<td>199</td>
<td>0</td>
<td>0.030</td>
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<tr>
<td>(Small size)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penichon</td>
<td>Sea Cucumber</td>
<td>Holothurian</td>
<td>89.41</td>
<td>7.71</td>
<td>0.17</td>
<td>1.79</td>
<td>0.91</td>
<td>84</td>
<td>9</td>
<td>0</td>
<td>0.005</td>
</tr>
<tr>
<td>(Large size)</td>
<td></td>
<td></td>
<td>81.86</td>
<td>13.65</td>
<td>0.35</td>
<td>2.64</td>
<td>1.49</td>
<td>121</td>
<td>18</td>
<td>0</td>
<td>0.040</td>
</tr>
<tr>
<td>(Medium size)</td>
<td></td>
<td></td>
<td>78.79</td>
<td>14.59</td>
<td>0.63</td>
<td>4.21</td>
<td>1.77</td>
<td>134</td>
<td>35</td>
<td>0</td>
<td>0.005</td>
</tr>
<tr>
<td>(Small size)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* From Marshall Islands.
For example, the calcium contents (83 to 180 mg./100 g.) shown in Table 14 for only the flesh of such fish as parrot fish, surgeon fish, sea bass, and others, are all much greater than those reported for fish muscle in AH 8 and AH 34, indicating that either these fish have unusual quantities of calcium in the flesh or that we need more analyses of fish and other seafoods consumed by the island peoples. The calcium figures for clams are the only ones that are of the order of published values.

The figures in Table 14 indicate that only the clams contain vitamin A, though it might be expected that small whole fish, like musum and senif, would also contain some vitamin A.

The values for riboflavin are, on the whole, relatively low compared with published values. The *Tridacna* clams and two of the fish containing more than 0.10 milligram per 100 grams appear to be the best sources of this vitamin. The values for the various sizes of sea cucumbers seem inconsistent.

Use

The quantity of fish eaten daily varies greatly, largely with the catch which again depends on the supply and the weather. The natives are fond of fish and other seafoods and eat large quantities when they are available.

In the week-long dietary study in the Marshall Islands, canned sardines were eaten 223 times by 324 individuals, and a fresh fish, similar to a small sardine, was eaten 99 times. Pig was rather important as a source of protein among this group as it appeared in the diets 180 times.

In the Truk study of 97 individuals, the protein foods eaten most often were petu, a kind of mackerel, andikeson, a wrasse, each of which appeared more than 100 times; followed by motsu, 63 times; musum (various species of small fish eaten whole), 61 times; and octopus, 52 times. Most of the other seafoods appeared in the diet lists less than 20 times. Here, pig was less important than fish as an animal protein food as it appeared only 22 times, and many of the 97 individuals had pig less than 10 times.

In the study of 37 families in the Truk area, octopus was the seafood that appeared most often in the diet list—
32 times—followed by motsu, 29 times; meret, 27 times; and umuno, 24 times. Ikeson, to, and musum were about 20 times; and petu, eri, ikenot, and crab, more than 10 but less than 20 times. Here a great variety of fish appeared in the diet lists less than 10 times.

Calculations of the average quantities of seafoods (fish, clam, octopus) and pork per day indicate that they varied from less than 100 grams to 400 grams for the individual dietary studies of 97 people in the Truk area. Calculated for the individuals, from the study of 37 families in the same area, the quantities varied from less than 100 grams daily to more than 600 grams.

Nutritive value

Calcium

The average weight of the small fishes, locally called musum, is 25 grams. It would require only four of these tiny fishes, with a total weight of approximately 100 grams, to furnish 800 milligrams of calcium and 1200 milligrams of phosphorus. Since the dietary records show that a number of individuals in the Truk area ate as many as 100 to 300 grams of musum daily, it can be understood how readily the calcium and phosphorus needs would be satisfied.

The small sardines (senif), which were eaten whole in the Truk area, had more than 500 milligrams of calcium per 100 grams and a good proportion of phosphorus. The dietary records show that the natives often ate more than 150 grams of this type of fish, both in the Marshalls and in the Carolines; this quantity would satisfy the needs of the individual for calcium and even meet the present recommended dietary allowances of the National Research Council.

In the Marshalls, the fish eaten most often and in the largest amounts (50 to 300 grams daily) was canned sardines. The bones of these small fish are softened by the canning process and when eaten with the fish provided a readily utilizable source of calcium and phosphorus (AH 8 shows sardines to contain more than 350 milligrams calcium per 100 grams).

The quantities of octopus eaten per person per day varied from as little as 100 grams to as much as 800 grams. We may consider 100 milligrams calcium per 100 grams as an average value for octopus, so that only when
it is eaten in relatively large quantities will it and other seafoods with similar amounts of calcium make a valuable contribution to the day's needs for this mineral.

Protein

In the tropical Pacific islands, the foods, such as breadfruit, pandanus, and the starchy aroids, which satisfy the caloric needs have far less protein than do the cereal grains. Since the amino acids of these carbohydrate-rich foods have not been determined and laboratory experiments to determine just how well the small quantities of protein in them supplement each other or the animal protein foods, we should probably assume that fish and other seafoods with pork and tinned meat or fish are the only important sources of protein in the diet unless cereals are used.

The average protein content of all the seafoods listed in Table 14 is about 22 percent, but raw pork because of its high fat content is likely to have considerably less, approximately 16 percent. We could assume on the basis of the kinds of protein foods used in the dietary studies in the two areas that 100 grams of animal protein foods in the Marshalls would have about 20 percent protein and in the Carolines about 22 percent.

In the Marshall Islands, 100 out of 324 individuals had no animal protein (seafood of any kind, pork, or tinned fish or meat) during the week-long dietary study. Of those having animal protein foods, 140 had less than 100 grams daily, 69 had 100 to 199 grams, 12 had 200 to 299 grams, and only 3 had more than 300 grams daily.

Assuming that the animal protein foods had an actual protein content of 20 percent, it would mean that 140 people had about 20 grams of protein per day and 69 had about 30 grams per day, while only those few consuming 300 grams or more would have had a daily intake of approximately 60 grams of animal protein.

However, the total individual protein intakes for the Marshallese studied were greater than would be suggested by the above figures because the vegetable proteins were included, and since the majority of the families studied ate rice and/or bread, most of them had more than 40 grams of total protein per day (49).

In the Caroline Islands the situation was much better. Every individual or family studied had some animal pro-
tein food. Of the 97 individual dietary records, 28 had less than 100 grams of animal protein food, 47 had 100 to 199 grams, 19 had 200 to 299 grams, and 3 had more than 300 grams.

For the 37 families composed of 173 people 1 year of age and over, we calculate that 25 had less than 100 grams of animal protein foods daily, 65 had 100 to 199 grams daily, 54 had 200 to 299 grams, 14 had 300 to 399 grams, and 15 had more than 400 grams daily.

Although the intake of animal protein foods in the Caroline Islands was superior to that for the Marshall Islands, about 61 percent of them had 20 to 30 grams of protein from animal sources, 27 percent had 45 to 55 grams, and 12 percent had more than 60 grams.

The detailed dietary study for 270 Trukese (49) showed that for subjects over 6 years of age, the total protein intake ranged from 56 to 76 grams per person per day. Most were more than 60 grams, which by any standard and especially for people of small stature, is a reasonable quantity of protein.

Nitrogen balance experiments have shown that adults can maintain nitrogen equilibrium on 0.5 gram of protein per kilogram of body weight, but to provide a wide margin of safety in the United States, the National Research Council Recommended Dietary Allowance has been established at 1 gram of protein per kilogram of body weight. An evaluation of the protein intakes may be made on the basis of body weights of the subjects who co-operated in the dietary studies in the Marshall and Caroline Islands. Ninety men between the ages of 15 and 20 who were weighed in the Marshall Islands averaged 129 pounds or about 57 kilograms, and 82 men of the same ages in the Caroline Islands averaged 138 pounds or about 63 kilograms. Sixty-four women, 16 to 60 years of age, in the Marshall Islands averaged 114 pounds or about 52 kilograms, and 68 women of the same ages in the Caroline Islands averaged 124 pounds or about 56 kilograms.

Adults accustomed to a low protein intake can doubtless maintain nitrogen equilibrium on 30 grams of protein a day, which would be barely enough for most of the men and women, but would leave no margin of safety for pregnant and nursing women and growing children whose requirements are greater than 0.5 gram per kilogram. The Mar-
shallese and Trukese who habitually had less than 30 grams of protein in the diet were undoubtedly deficient in this nutrient.

Unfortunately, protein cannot be stored in the body in the same manner and to the same degree that fat and calcium may be stored; but limited storage no doubt results when a large haul of fish is obtained and the natives gorge themselves, partly because they are no doubt protein hungry and partly because they have no good means of preservation, though they may dry small quantities of fish that will keep for a week or more.

It is worth noting that the Marshallese, who had a lower protein intake, were of smaller stature and lighter weight than the Trukese (49) who had, on the average, a higher intake of protein. Since both protein and calcium may be growth-limiting factors, it is suggested that there exists a possible relationship between the protein and calcium intakes and the heights and weights of the natives in the two areas.

Summary

Fourteen species of seafoods representing 18 samples have been analyzed for proximate composition, calcium, phosphorus, vitamin A, and riboflavin. All but one sample of the fish were collected in the Caroline Islands; a single sample came from the Marshall Islands. The fish were transported in the frozen state from the Trust Territory to Hawaii and then to Japan where they were analyzed at the National Institute of Nutrition.

The data are summarized in table form and some comparisons made with published values.

The nutritive value of the seafoods are discussed in relation to the calcium which they furnish and the consumption of animal protein and requirements and dietary standards for these nutrients.

The greater abundance of fresh fish and other seafoods in the Truk area was reflected in a higher protein intake by individuals and families studied in Truk as compared with the natives in Majuro.

With few exceptions, the daily amounts of protein in the diet are far below Western standards, but in many cases they would probably cover the requirements of people of
small stature accustomed on the whole to a low protein intake.

A somewhat greater and more uniform consumption of fish and other seafoods is highly desirable and might be accomplished if the island people had some satisfactory means of preserving the surplus fish in times of plenty.
LITERATURE CITED


30. Kim, Dai You (District Agriculturist of Yap). 1954/. *Taro Culture as Practiced by the Yapese*. Trust Territory of the Pacific Islands. 12 pp., illus. (mimeo.).


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**PERSONAL COMMUNICATIONS**

70. Emory, Kenneth P. Ethnologist, Bernice P. Bishop Mus., Honolulu, and Associate Professor of Anthropology, University of Hawaii.


72. Luomala, Katharine. Professor of Anthropology, University of Hawaii.

73. Mason, Leonard E. Professor of Anthropology, University of Hawaii.

74. McTaggart, Earl L. Superintendent of Schools, American Samoa, 1934-1935.


76. St. John, Harold. Professor of Botany, University of Hawaii.

77. Scheuer, Paul J. Associate Professor of Chemistry, University of Hawaii.
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