A Guide to
SUBSISTENCE AGRICULTURE
in Micronesia

Trust Territory of the Pacific Islands

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A Guide to SUBSISTENCE AGRICULTURE in Micronesia

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FOREWORD

Growing of food crops is a natural profession to most Micronesians. It is hoped that the discussion in this bulletin may help to clarify the role of subsistence farming in the islands in these changing times. The objectives to promote a balanced diet in urban communities and establish continued truck gardening in suitable suburban areas are probably more desirable and profitable a program than production of export crops only. This will require intensive education, extension work and promotion of introductions and testing of new varieties of food plants. This is an important aspect in the role of agricultural development in the territory.

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I. INTRODUCTION

THE ISLANDS AND THEIR PEOPLE

The term, Micronesia, literally means "small islands". This area is a vast rectangle of 3,000,000 square miles of ocean in the western Pacific north of the Equator. The 2,140-odd islands represent a total land area of about 700 square miles which are inhabited by more than 93,000 islanders.

NATURAL ENVIRONMENT

The islands within the Trust Territory's administration are comprised of three island groups: the Marianas, the Carolines and the Marshalls. These extend from 1 to 20 degrees north latitude and from 130 to 172 degrees east longitude.

The climate is tropical and there is very little seasonal change throughout the Territory. Cool sea breezes help to temper the high daytime temperatures and humid nights. Daily temperature varies between 70° and 85°F, with an average humidity of 80 percent. Rainfall is variable but heavy, ranging from 60 to 90 inches in the northern section and 160 to 190 inches in the southern half. Storms are prevalent between August and December particularly in the northwestern islands. Typhoons may occur between July and December and these may be quite violent from 65 up to over 200 knots. These
cause considerable damage to crops, among other things, and have some influence on cropping in these islands.

GEOLOGY; SOILS; VEGETATION

Roughly, three types of islands are geologically defined in Micronesia. These are Coral islands which are atolls or raised reefs as noted in the Marshalls and outer islands in other districts; Volcanic islands of andesitic rock formation which are found in parts of the Marianas district and Continental islands of metamorphic rock formation found in Yap proper and the major islands of the Truk atoll. Generally though, Micronesian land or soil characteristics can readily be divided into volcanic soils and coral atoll soils.

The soils of Micronesia have been formed under very humid tropical climate, high temperatures and high average rainfall. Such climatic conditions and the kinds of parent rock material on the high volcanic islands have evolved to certain characteristic soil forming processes, the most important one being laterization. Upland areas where erosion is not rapid, soil formation is manifested by intense chemical weathering, the underlying rock is often weathered to great depths. As laterization proceeds, the base and silica compounds tend to be leached out and aluminum and iron compounds accumulate. Under Micronesian climatic conditions, geologic erosion tends to balance with soil formation on the steep slopes; soils are washed away about as fast as they are formed and shallow, stony soils occur. The least surface soil
disturbance, the better is an important principle to remember. This is why tree crops or forestry should be promoted on sloping land instead of other types of farming which require soil tillage. On the other hand, atoll soils consist largely of loose coral sand interspersed, in some cases, with coral limestone debris. These soils are composed mostly of calcium carbonate (lime) which are generally deficient in nitrogen, phosphates, potash and the minor elements plus organic material. The matter of determining the elements needed and supplying these is an important factor in agricultural improvement of atoll islands. Generally, the top ten inches of soil on atolls is comprised of a dark grey loose medium to coarse sand which is relatively high in organic matter and this is the most important soil zone of these low islands.

The vegetation of Micronesia is largely tropical in nature which varies from high island to coral atoll. High island vegetation is comprised of mangrove swamps on the shore, and grassland or scrub ascending to the rain forests in the central mountain areas. On the coral atoll islands, the predominant vegetation is generally the coconut palm and its related plant associates, pandanus and breadfruit, as well as other strand plants including *Scaevola, Tocnfortia, Guettarda, Thespedia* and *pemphis* scrub.

**TRADITIONAL AGRICULTURE EQUIPMENT**

The pointed digging stick was the most important agricultural implement in the Micronesian islands from long ago and it still is used in some of the high islands of the Carolines where taro and
other rootcrops are grown. This was made from a length of hardwood usually from species of mangrove, Casuarina or pemphis. Since the coming of the Europeans, suitable lengths of iron rod pointed or flattened at one end have replaced wooden digging sticks in many areas. A club-like hardwood stick or a spade-shaped piece were used for making holes in taro planting on some islands in the past. These have been mostly replaced by the spade or the fashioned iron bar. The low islanders used fashioned shell and turtle-bone for making spade tools and hoe-like implements for farming purposes. Presently, the metal hand tools of foreign manufacture are in common use. The most universal is the long bladed machette. Others include the shovel, pickmattock, crowbar, sickle, axe and Okinawan hoe. During the Spanish and Japanese era, carabao and oxen were introduced and used as draft animals. The single bottom plow was introduced and used especially in the Marianas for crop cultivation. Today in Micronesia small garden powered tillers, composting machines and medium-sized farm tractors are used for cultivation, tilling and mowing. In the Marianas bulldozers are employed for farm and ranch land clearing and smaller farm crawler tractors are used for tillage and cleaning work.

TRADE

In past days, ceremonial exchanges of food on occasions of births, deaths, marriages and special visits were practiced in Micronesia. This is still practiced in some of the districts even today. It has been often considered that the Pacific islander's
"savings bank is his garden, the ocean and his relatives". It is true that any profit he may make from cash crops usually serves to satisfy his immediate needs. This is borne out by the fact that copra production increases when the market price falls and decreases when the price rises. Purchasing power for consumer goods for everyday use, therefore, is maintained at a constant level. In many island areas, the habit of running up debts with local shopkeepers is another aspect of procurement of consumer goods since the development of modern living. The Pacific-wide custom of procurement of any article from a relative on request still exists in Micronesia today. The principle involved is "share and share alike", which is a form of social security. It holds then that the farmer who plans and plants for the "rainy day" or the shopkeeper who acquires luxuries of living will most certainly become the victim of less industrious clansmen. This system has its good points. Nevertheless, it has been perhaps the greatest deterrent of individual initiative in the Trust Territory islands.

In Micronesia shells, turmeric, turtle-shell, colored stones of unknown origin in Pulau, and the celebrated cartwheels of calcite rock of Yap have been used for ceremonial exchange from olden times and some of these articles are still in use today. It is obvious though that a cash economy based on foreign currency is now established in the islands.

The time when Micronesia had a purely subsistence economy is past. The presence of foreigners has had varying degrees of changing
influence depending on the area. The degree of change or development has been influenced by the size of the islands, amount of resources, location, presence or lack of natural anchorages, presence of many or few foreigners and suitable land conditions for introduction and diversification of cash crops. It is obvious that foreign influence has been considerable throughout the more important island centers of Micronesia. All islands are engaged today in cash-producing enterprises. All have benefited to some degree with foreign settlement and with the introduction of new food plants. It can certainly be said that few islands in Micronesia have maintained their traditional subsistence economy unchanged.

TRADITIONAL AGRICULTURAL SYSTEMS

It is most probable that the original agricultural systems, at least on the high islands, were either shifting agriculture or agriculture with bush-fallow rotation, involving burning for clearing garden space. Increased population and use of primitive techniques probably caused deterioration of vegetation and soils on most high islands. Because of decreased fertility, employment of semi-permanent forms of agriculture involving use of artificial fertilizers became necessary. Evidently, it was this need that led to development of taro growing in pits on low islands and irrigated valley terraces on the high islands. In all the islands, fishing and supplementary foods obtained from raising poultry and small animals as well as hunting helped to provide a balanced diet. Today ownership of land by individuals and families is common and agriculture
is on a more fixed, non-shifting system. Agriculture production on most larger high islands involve the employment of modern methods of selection of planting materials, some mechanized methods of cultivation, insect and disease control. The use of organic fertilizers is standard practice throughout the islands.

VARIATIONS IN VEGETABLE FOOD PATTERNS

Throughout the South Pacific before the European discovery, the number of species of vegetable food plants was less from west to east. All the food plants used in Micronesia are found in the area from the Philippines to Indonesia. The poorer soil areas of the atolls naturally support fewer food plants. Such areas have probably inhibited the spread of certain food plants throughout the Pacific. Generally, the same plants occur in most areas but the significance of each in the subsistence pattern varies from place to place. For instance, yams are of real importance only in Ponape and Yap. *Colocasia* taro is most important in Palau and Kusaie. Breadfruit is a staple food plant in Truk. *Pandanus* and arrowroot are important crops in the Marshalls.

In isolated areas, a particular plant species may have special importance in the food pattern as does the Polynesian chestnut in Yap, *Crataeva speciosa* in the central Caroline Islands and Chinese yam bean in the Marianas. These are all fairly common foods in these respective areas. The coconut palm has almost constantly remained a source of supplementary daily food in the islands. On the atolls, coconut and edible *Pandanus* have been or are important
food plants supplemented by certain aroids usually *Cyrtosperma chamissonis* and occasionally by breadfruit and banana. Polynesian arrowroot provides starch.

New subsistence crops were introduced with European colonization and these often competed with crops of pre-European time. Cassava now is a staple in Palau as the tuberous plant *Xanthosoma sagittifolium* was (or still is) in parts of the Marianas. New varieties of sweet potatoes which are rapid-maturing and heavy-yielding have replaced old varieties. The same is true of bananas and some taros. Also, today in many islands imported foods have gradually replaced the tubers, fruits and nuts which were formerly the basic diet. Rice, flour and refined sugar, for instance, are imported foods which are displacing traditional crops. As noted, vegetable food patterns in Micronesia have been enriched by plant introductions and exchanges since the coming of the European.

In some cases changes are almost to the point of transforming subsistence economics. Nevertheless, geographic variations have remained at least partially from early times.

THE PRESENT SUBSISTENCE ECONOMY

Subsistence crop production today still plays a vital role in the economy of all high islands in Micronesia. In many of these islands an estimated average of 70% or more of daily caloric intake of the population is derived from locally-produced crops. This is not the case in the district centers where the resident islanders are wage-earning transients or so-called urban dwellers. These
people in most cases have left their lands to take up work for
wages and generally subsist on a diet of imported canned or
processed foods including rice, flour products, sugar, canned fish
and meats, canned milk, fruits, coffee, tea and bottled artificially
colored and flavored carbonated drinks. The majority of the
population and all agricultural activity are generally confined
either to the coastal areas or to the interior valleys. Strand
soils are planted with coconuts, breadfruit and some row crops.
Swampy depressions behind the dunes are used for intensive culti­
vation of wetland taro. Above, clay and latoritic foothill soils
are used for growing bananas, citrus, yams and dryland taros.
Colocasia taro is also grown in irrigated terraces in the valleys
on some islands.

The Marianas district is currently unique in the high island
agricultural economy system of Micronesia. The production of copra
on the major islands of Saipan, Tinian and Rota has ceased. Ranching
and commercial truck farming using foreign techniques including
mechanized equipment has developed to supply the market demand
on Guam. The economy on Saipan is fast becoming commercial with
only the "ranch" or the home garden remaining as a vestige of the
former subsistence cropping pattern. The economy of Tinian and Rota
is agricultural with the larger percentage of income derived from
commercial vegetable crop production and sale of beef. Subsistence
agriculture is quite highly developed and important on these two
islands of the Marianas.
The atoll populations of Micronesia in olden times were dependent on subsistence agriculture and fishing for their livelihood. Some foraging for coconuts and other fruits and tubers was practiced. The copra industry was developed after the Europeans established settlements and began trading in the atolls to their heyday at the start of World War II. During World War II, the established Japanese military bases in these isolated areas were destroyed. The war and its resultant consequences led to a complete reversal of the economy of many of the atolls of the Trust Territory with a general decline of subsistence production on a number of islands. At present, the imported food stuffs represent a considerable portion of the diet of atoll dwellers. Estimates of population centers such as Majuro indicate that possibly 2,000 calories of daily intake are derived from imported foods consisting of rice, flour, sugar, canned fish and meats and vegetable cooking oil. The general tendency at present is toward a cash economy based on copra production and cash from government and military base employment. There are outlying islands in all districts of the Carolines and the Marshalls though, where subsistence production has retained some of its former importance.

SUBSISTENCE PROBLEMS

As we know it, the islands in Micronesia which export the least products are those where subsistence production is still the basis of the economy. These are also the islands with lowest living standards but the inhabitants generally enjoy a better diet.
In the islands where traditional food plants formerly produced the basic diet and now have given way wholly to imported foodstuffs, it is practically hopeless to attempt a return to subsistence agriculture. It would be pointless to suggest that Marshallese resume their former method of taro growing in pits or resort to the old, difficult methods of preparing food based on arrowroot or pandanus fruit. The same would be so in the case of other islanders who have become wage earners and live in district centers where farming is limited to a garden in the back yard or a weekend ranch. To these people, working for wages or making copra is far more important. Such modern ways of life provide more cash and enables them to buy desirable imported goods. The new diet also has a degree of prestige value. Therefore, the only possible desirable objective is to develop an improved diet through better preparation of imported foodstuffs and the use of supplements from home vegetable gardens.

The promotion of improved, hardy and suitable types of subsistence crops to restore a balance between subsistence and cash crops would be desirable where the agricultural and economic revolution have not reached such an advanced stage. This would involve the propagation of hardy productive varieties of dryland taro, sweet potato, yautia, yams, bananas, breadfruit and some vegetables; these could be grown in family gardens to provide a source of supplementary food of great value. The objective then, as mentioned earlier, is to promote the maintenance of a balanced
diet in the more urban communities. Establishment of truck gardening in suburban areas would also be desirable. Such programs will probably prove far more desirable and profitable than the production of export cash crops only. The development of such a program has been recommended as one of the Agriculture Division's objectives. This requires intensive education, extension work and promotion of crop introductions and testing of new varieties and species of food plants. This is probably the only means of reconciling the requirements of essential economic development with that of a suitably balanced diet.
II. STAPLE FOOD PLANTS

(The following list of staple food plants are discussed in their suggested order of importance in the subsistence pattern of Micronesia)

1. TAROS

Taros and taro-like plants belong to the large family Araceae which are Monocotyledonous plants characterized by a number of obvious features: heart-shaped erect leaves, by the oblong edible tubers which are produced, and by the spadix-type flower; these aroids of economic importance in Micronesia all prefer damp, swampy or irrigated soil conditions. All of these plants produce calcium oxalate crystals in the watery latex which is moderate to extremely irritating to the skin. There are four genera of the family Araceae which are important as starch producing plants in Micronesia. These are *Colocasia*, *Cyrtosperma*, *Xanthosoma* and *Alocasia*. In general discussion, reference to genus instead of the species is usually the practice.

(i) *Colocasia*—This is the most important genus and includes 13 species native to eastern Asia and the Pacific. *C. esculenta*, (Linn.), Schott, is the species grown all through Micronesia. Its origin is tropical Asia and its common name is taro. There are many varieties cultivated in Micronesia both as dryland and wetland types. There are a dozen or so good wetland varieties grown in Palau and Kosrae and a similar group of dryland types which are grown in fair quantities in the northern Marianas, Truk and Yap.
Colocasia esculenta

a, Habit of plant; b, "flower" consisting of spadix surrounded by spathes; c, spadix with male flowers above, and female flowers below; d, female flower; e, section of female flower; f, portion of spadix showing group of male flowers; g, single male flower; h, corms with roots attached; i, cleaned corms.
The plants have a very short stem which produce a number of large leaves carried on long petioles in spiral arrangements with short leaf sheath. The leaves are peltate with the petiole attached to the leaf blade at a point in the middle. This is the distinguishing feature from other closely related aroids. The plants when fully grown are two to three feet high and the corm (tuber) develops as a fleshy mass by thickening of the base of the stem. The tuber varies in size with the variety and often is more elongated than spherical. The corm is rough and the root system superficial and fiberous. The corms are packed with starch, the grains being very small.

The climate for proper growth must be tropical and the rainfall ample. As to soil type, the great distinction is between the wetland and dryland varieties. Both types prefer a protected situation with ample rainfall. Dryland varieties will grow well in fertile damp soils as commonly seen in the Marianas and Truk Atoll islands. The wetland varieties grow best in mucky soil situations to an intricate paddy type of irrigated cultivation as commonly practiced in Palau and Kusaie.

In preparing land for planting, selection of site is the first step. Dryland varieties will grow in low spots or open fields or on sloping hillsides with fairly deep sticky soils which are intermittently irrigated. Level, partially swampy areas are also satisfactory for dryland variety propagation. Wetland varieties need to be planted in paddies or meadows with access to steady
flow of cool water during the 8 to 12 months required for development from planting to maturity. Regardless of type, soils should be at least 8-12 inches deep, fertile and with a good percentage of humic material. The area for dryland taro planting must be clean-weeded and soil loosened several weeks before planting. Little else is needed except for lining and holing with a flat-ended bar, spade or stick in planting. In wetland taro culture, paddies should be drained when the soil is being prepared for planting. The soil then should be turned by spading and allowed to be exposed to air and sunlight for several weeks. The soil then should be well tilled before running the water back into the paddies, before lining and planting.

Colocasia taros are propagated from cuttings taken from the top of the tuber with all except the center leaf petiole cut away at their bases. These are planted in either dry or wetland conditions. Propagation from cormlets (small side tubers) are sometimes used but this is not the general practice. Colocasia is planted in rows spaced two to three feet apart and 18" to 24" between plants in the row. It is important in Micronesia that taro soils be richly composted before planting if satisfactory growth and production results are expected. Commercial fertilizers may be used but the economics of cost in freight, storage and application would be questionable for such subsistence cropping. Both wetland and dryland plantings should be kept free of weeds by regular weeding. Mulching is a recommended practice in
Dryland culture. Disturbance of the soil is not recommended during the growing period.

Colocasia taro corms may be harvested 8 to 12 months from planting and this depends mainly on the variety. Soil fertility has an influence on the size of corm at maturity. Three tons per acre is a fair yield; six tons a good yield. When grown with careful culture under irrigation as in Palau and Kusaie, yield can be as high as eight tons per acre. Under the subsistence pattern, small sections are planted at different intervals within the large paddy or field to allow for staggered harvesting at several times of the year. Colocasia taro does not keep well after harvesting therefore only quantities that may be eaten within several days must be pulled at any one time.

The socio-economics of taro culture varies with the several districts. In Palau, the women handle the cultivation of this crop (as they do with most all crops) and they have developed perhaps the most intricate and highly developed system of wetland taro culture in the entire Pacific. Men in other districts of Micronesia grow the crop. Colocasia taro is a prized food in all districts of Micronesia and it is used in all holiday or ceremonial feasting occasions in most districts. In the Marianas it is planted to mature in December and January when this food is prized for "fiestas".

Taro is usually prepared for eating by peeling, cutting into sections and boiling the sections till they are soft as with other...
roasted in a rock oven. In some districts, the corms are peeled then grated and mixed with banana, coconut milk or breadfruit and baked in an underground oven. In some islands as in Kusaie, the tubers are peeled, boiled them mashed and formed into inch-sized balls which are covered with coconut milk, coconut syrup or other forms of icing and served as a pudding dessert called "fafa".

Barrau and Massal have stated that: "As with all tubers, taros alone could not meet man's nutritional requirements unless eaten in large quantities. A ration of six pounds of taros, giving about 3,000 calories would provide about two oz. of vegetable protein, two oz. of fats and about 25 oz. of carbohydrates. In practice, these tubers are eaten with other foods rich in protein, fats and minerals plus vitamins such as fish, coconut and vegetables."

Taro does contain some protein, appreciable quantities of calcium and phosphorous, some vitamins A and B₁ and trace of C. Because of the small size of the starch grains, it is very digestable food and has a pleasant almost nutty flavor. When boiled, corms lose their slightly bitter taste due to the disappearance of calcium oxalate crystals. Fresh taro corms which have been boiled and mashed and mixed with water into a thin paste and then strained makes excellent food for hospital patients or babies.

At one time in the past, taro was the most important subsistence crop in most areas of Micronesia. It has lost its favored place over the years because of the difficulty of growing the crop.
due to mite, leafhopper and leaf chewing caterpillar insects as well as leaf fungus and corm rot diseases. It remains as the most important subsistence crop in Palau but the hardier much more easily grown Cassava plant has gained favor over the years. It is still an important dryland cultured crop in the Marianas and Truk despite the depredations of the leafhopper, giant African snail and fall caterpillars. It is grown in fair quantities in Yap but does not have the status of Cyrtosperma taro which is practically insect and disease free. It is hardly grown in Ponape because of the uncontrollable leafhopper insect and devastating Phytophthora leaf fungus disease. Colocasia taro does not grow well in the Marshalls and most other atolls because of unfavorable soil conditions. It is relatively disease and insect free in Kusaie and remains as the most prized food crop on that island in the Central Carolines.

(ii) **Cyrtosperma**- This is the second most important genus of aroids which is grown in most of the Caroline and Marshall Islands of Micronesia. There are several species but it is most likely that many varieties of the single species Cyrtosperma chamissonis (Schott) Merr. are grown in Micronesia today. Its origin is thought to be in Indonesia. The common name is giant swamp taro. Number of recognized varieties grown varies from a few varieties in the Marshalls, Truk and Palau to several dozen varieties in Ponape and Yap. It is the largest of the taros and is considered essentially the taro of Micronesia. The varieties of

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Cyrtosperma chamissonis (schott) Merr.
Giant swamp taro as cultivated on Yap,
Western Caroline Islands.
Cyrtosperma grow to about eight feet when mature, produce large corms, with six to eight very large sagitate leaves carried on long, thick petioles in spiral arrangement with a relatively short leaf sheath. When fully grown (in several years time) the plants are six to eight feet high. The corm develops by thickening of the base of the stem. Corm size varies slightly with the variety but mostly with age - the older the plant the larger the corm. Like other taros, the corm is rough and the root system fiberous. The corms are spherical in shape and rather dry and often become "corky" with age.

The giant swamp taro does best in a humid climate with heavy rainfall. It is tolerant to a wide range of soil types and acidity. It will grow well in moderate rainfall areas if the soil is deep and swampy and the area at least partially shaded.

Cyrtosperma taro may be successfully grown in natural swamps or artificially prepared swamp pits. On high islands of the Carolines it can be easily grown in swampy areas with or without irrigation water. Ideal growing conditions would be natural swampland rich in humus about two to four feet in depth with slow running irrigation water. In Ponape and some places in Truk and Palau it can be found growing wild in natural swampland. It is grown very intensively in man-made pits on the medium and high rainfall atolls of Yap, Palau, Truk, Ponape and Southern Marshalls. The swamp area or pit must be clean-weeded and lined. The lines should be at least four feet apart.
Water lanes (walkways) should be made between the lines by heaping the soil in the lines. The soil in the lines should be softened to a depth of at least a foot.

*Cyrtosperma* taro is generally propagated from suckers (cormlets) taken from the side of mother plants by separation. These cormlets develop from eyes at the base of the stem of older plants. Good medium-sized suckers are best. Cuttings taken from the tops of harvested plants may also be used as planting material. *Cyrtosperma* taro grows very large with big, broad leaves. Therefore, it is required to plant at least four feet between rows and two feet between plants in the row or random planting spaced at three feet. *Cyrtosperma* is regarded in many high islands of the Carolines as a reserve food. Unlike *Colocasia*, it does not have to be harvested and replanted annually and may be left for as long as 10 years or more before harvesting. *Cyrtosperma* is among the few subsistence plants which will grow on atolls. Pits must be prepared which reach the water lens; humus and topsoil added to develop artificial "swamp" conditions. For best results, plants need to be carefully lined and spaced, mulched and fertilized with green manures. Careful weeding and mulching is also common practice.

Giant swamp taro is slow growing and takes several years to mature. However, there are some early maturing varieties like the Sohn-Pon-Wehnu of Ponape which will produce a good-sized corm in a year's time under good growing conditions. Usual harvesting cycle is from two to three years. The plants are planted so that there
are mature plants available at all times of the year. The dryer periods on atolls curtails large-scale harvesting because of the need for immediate replanting. Because of its slow growth, annual tonnage per acre is not as high as Colocasia but four tons per acre per annum is attainable for this crop under moderate soil fertility and careful culture. Corm texture of giant swamp taro is fibrous and hard and if removed with a portion of the top, will keep for at least a month under cool dry conditions.

As with Colocasia taro, the socio-economics of giant swamp taro culture varies with the districts. It is not grown in the Mariana Islands. In Ponape and Palau it is regarded generally as a reserve food and not cultivated extensively. In Yap it is certainly wrapped in the intricacies of social life of women and old men who work the taro patches. There, and in Truk, it is cultivated in vast quantities as a daily staple in the diet pattern and as a reserve food supply. It is grown intensively in the high rainfall atolls of Truk and Ponape districts where it is prized as a staple food. Although it is grown in many atolls in the Marshalls, its culture is beginning to disappear; the younger generation prefers making copra and using cash to purchase imported rice and flour.

Cyrtosperma is usually prepared for eating by peeling, cutting into sections and boiling or grating fresh and mixing with banana or coconut milk and then it is baked in an underground oven. The grated and mixed material is made up into one or two pound cakes, wrapped with leaves then placed in the oven. Cyrtosperma tubers
are sometimes peeled, scalded then chopped into pieces and dried in the sun. After proper drying the pieces may be stored in cans for a month or two. Slow, oven-baked pieces of Cyrtosperma tubers can be kept and eaten for about a week or more.

The giant swamp taro does contain some protein and quantities of phosphorous and calcium and vitamins A and traces of B1. As mentioned earlier, it was an important starch crop in the atolls of the Marshalls; today its cultivation is disappearing in favor of imported foods. It is still one of the important subsistence crops of the atoll islands of the Ponape, Truk and Yap districts. It is regarded as a reserve food on Ponape and a very important starch staple on Truk. Cyrtosperma is king of the taros on Yap proper and holds the highest place on the list of food crops of that district.

(iii) Xanthosoma - This member of the aroid family is a fairly recent introduction to the Pacific area. It is native to Central America and the West Indies. The species X. sagittifolium, Schott, is the most important and it is commonly called Yautia. It has a short stem, upright sagitate leaves on long petioles with the petiole end attached to the edge of the leaf blade. The plants grow to a height of six to eight feet with large light green colored leaves which are arrowhead shaped. Although there are several species and many different varieties that are grown, only three common species are known in Micronesia. During the last four years ten named varieties of X. sagittifolium were introduced from the West Indies.
ARACEAE

Xanthosoma (yautia). a, Habit of plant; b, flower consisting of spadix surrounded by spathe; c, spadix with male flowers above and female flowers below; d, portion of spadix showing group of male flowers; e, single male flower; f, female flower; g, section of female flower; h, mature unopened infrutescence; i, mature infrutescence; j, single fruit; k, single seed; l, corm; m, single corm; n, transverse section of corm.
Yautia taro is strictly a dryland type that grows best in rich alluvial soils. It grows well in a wide range of soil types but does not thrive in the sandy, nitrogen, phosphorous, manganese and iron deficient soils of the atolls. The plant grows with a central corm which thickens and forms into a stem as in Alocasia when the plant gets older. Several months after plantings, the mother plant produces about a dozen elongated tubers which are usually harvested before they sprout. The tubers are fairly smooth and nutritious but not easily digestible because of their large-sized starch crystals.

Yautia requires a tropical climate, well-drained soil with plenty of compost. It has been quickly adopted as a subsistence food plant in many areas because it is easy to grow. It is generally propagated from tubers although pieces of the corm or cuttings taken from the top of stems may also be used. It is desirable to plant yautia in rows three feet each way in holes a foot across and a foot deep which are filled with good top soil. As the plants grow, they should be mulched and then "hilled" with soil to allow side tubers to develop properly. Otherwise, the plants require very little care. It is relatively disease and insect free.

Yautia tubers may be harvested in about six months after planting. The potato-like tubers are dug from the soil and removed from around the mother plant which can be left to continue growing as a semi-perennial plant. A good yield will give eight tons of
tubers per acre. As noted then, the good qualities of yautia are ease of cultivation, heavy yield, freedom from insect and disease problems and a nutritious product.

Yautia appears to be an important food crop in the Marianas for human consumption and domestic livestock feed. It is also grown in fair quantities in Palau. It is grown in small quantities in Yap and Truk and hardly at all in Ponape and the Marshalls Districts. Cultivation is performed by the same growers of other taros. It is not a featured food in ceremonies or feasts in any of the islands of Micronesia.

The corms of Yautia are usually washed and boiled then peeled in preparation for eating. These may also be roasted on a hot charcoal base. Cooked corms may be mashed and mixed with banana or coconut milk. The young leaves of yautia and another species, X. brasiliense are often boiled and mixed as a spinach with fish, pork or chicken in some islands of the Pacific. Its tubers contain quantities of protein, fats, potash, calcium, phosphorous, iron and carbohydrate and small quantities of vitamin A, B₁, C, niacin and riboflavin.

(iv) Alocasia - The most common species of this taro is the widely distributed Alocasia macrorrhiza (Linn.), Schott, found on all islands in Micronesia. It is an aroid with large, succulent, shiny, heart-shaped leaves and strong stems, which is the least important taro grown in these islands.
ARACEAE

Alocasia macrorrhiza (Linn.)
edible variety grown in Micronesia
The large corms of this plant are used to some extent as food on the atolls of the Central Carolines and Marshalls. It is strictly a dryland type of taro which is actually planted and cultivated on some of the poorer atolls as a reserve or emergency food plant. It is also used as domestic livestock feed on some of the high islands.

The tubers contain many needle-like calcium oxalate crystals which are destroyed by boiling or roasting. The varieties are many but only one or two recognized types are suitable to use as food. Alocasia is exceedingly variable in size, depending on the age of the plants and the conditions under which it is growing. The food value is due to the starch content of the tubers which is apparently limited.

2. BANANA

The banana plant is one of the oldest cultivated species; it was probably among the first foods of man. Today, it is found throughout the Pacific islands except on some of the smaller, drier atolls. The banana tree is a cultivated plant in Micronesia where it is considered as an important staple food. Considerable quantities of sugar bananas which are produced on Rota and Tinian islands are marketed on Guam but no formal, large-scale production methods are used.

The banana trees now grown in Micronesia belong to several different botanical species. At least one is indigenous; others were introduced before and after the European discovery of the
Musa sapientum

- a, Habit of plant; b, inflorescence; c, female flower; d, top of female flower with scale and perigonium removed; e, perigonium of female flower; f, scale of female flower; g, male flower; h, male flower with scale and perigonium removed; i, scale of male flower; j, perigonium of male flower; k, bunch of fruits; l, "hand" of fruits; m, transverse section of fruit.
islands. The main economic species of banana grown today in Micronesia is *Musa paradisiaca*, Linn., which is probably indigenous to the Indo-Malayan area. Bananas have not as yet been clearly and specifically classified but for our purpose, the following is used:

*Musa paradisiaca*, L. subsp. *Normalis*, O.K., which is the plantain or starchy banana which should be cooked before eating.

*Musa paradisiaca*, L. subsp. *sapientium* (L.), O.K., which produces the common sugar banana which is eaten when ripe.

There are as many as 50 recognized varieties of both starchy and sugar bananas grown in some districts such as Palau, Ponape and the Marianas.

Bananas grow well in most islands of the Trust Territory where rainfall is 60 inches per year or more. Because of various leafspot fungal diseases, bananas for food on high islands grow best intercropped under coconut palms, breadfruit or other large trees. The plant grows well in the sandy soils of atolls or along the shores or inland valleys of high islands. Most varieties grow best along protected river valleys where the soil is deep and fertile with large amounts of organic material present. Bananas will not grow in water-logged soils. In selecting bananas for atoll planting, the variety must be considered. Some varieties do well on atolls and others may not even produce fruit. A planter or Agriculturist must be familiar with the different varieties and where they grow.
best. As a matter of interest, the new sucker just emerged at the base of the mother plant is called a "peeper"; taller ones with unopened leaves are called "sword suckers"; the leaf sheaths together form the "trunk" or "pseudostem"; the unopened flower is called "flower bud"; the whole fruit is called "bunch" or "stem"; each cluster of fingers is called a "hand"; each single fruit is called a "finger"; a mature group of banana plants is called a "stool".

Generally, sword suckers two to three feet high are best for propagation. Larger suckers four to eight feet tall are also used. The suckers should be carefully removed from the parent plant with a sharp flat cutting tool which is placed halfway between the parent and the sucker plant. After the sucker is removed the roots and open leaves should be trimmed back to prevent loss of moisture. The suckers should be allowed to lay in the shade for several days to allow cut surfaces to dry out. Bananas grown for subsistence should be planted in good fertile soil which is well-drained. The plants should be protected from strong winds. The bush should be cleared away and used for mulching. A hole two feet in diameter and two feet deep should be dug. After the hole is partly filled with compost and good topsoil, the sucker is placed in the middle and covered with additional good topsoil so that the top of the corm is about six inches below the level of the ground. Bananas generally should be spaced with the smaller varieties such as Taiwan, Manila or Williams Hybrid about ten feet apart and the larger varieties like
the Largo or Lacatan about 16 feet.

In Micronesia cultivation of bananas, as with other plants, consists mostly of cutting weeds and bush between the rows of stools on an intermittent basis. Actually, banana plantings should be clean-weeded at least six feet around and mulched heavily to prevent competition from weed growth. Coconut leaves, old banana trunks and coconut husks make good mulching materials. The groves should be cleaned out at least once each month. Old leaves of the large banana plants should be cut away and trunks from harvested plants should be cut down and chopped up. Three older plants and no more than two following, a "peeper" and a "sucker" should be allowed to grow for best results. Other additional suckers that develop should be cut away below the ground at the growing point when the sucker is at the peeper stage. The male flower bud should be cut away about two to four weeks after the first hand has opened. It should be cut about eight inches below the end of the last hand on the bunch. Bananas grown for subsistence should be fertilized with compost or animal manures if these are available. Regular mulching is a good method of organic fertilizing. Bananas will produce ratoon crops for many years if the fertility of the growing site is maintained. After about five years though, the plants are literally "sitting" on the ground surface and replanting may have to be considered to maintain satisfactory production.

Banana fruit should be harvested for home consumption when the
fruits are still green but are full, round and light green in color. If the fruit is to be shipped involving a week's time or longer, it should be picked at an earlier stage when the fruits are still a bit angular. A producer learns this by experience. Sometimes early harvesting is necessary as a protective measure against bird or rodent damage. Wrapping bunches with leaves or burlap is done in some areas as a protection against these wild creatures.

The banana is one of the important carbohydrate food sources in most islands in Micronesia. It is a daily source of food in these communities and living would be difficult without it. It can be grown with very little effort and in many districts the starchy or plantain varieties are commonly used as a cooked food with coconut milk, yams, or with taro. Some sugar varieties such as the Manila are multipurpose in that it may be eaten boiled when mature-green, mixed when ripe with other plant starches and baked or allowed to ripen properly and eaten as a fresh fruit.

Ripe sugar bananas contain approximately 20% carbohydrates; 1% protein and 0.5% fat. The carbohydrates in green bananas are mostly starches while in ripe fruit these are mostly sugars. The energy value in both are the same. From a nutritional standpoint though, the sugars are directly and almost completely available; the starches need to be digested and transformed into available glucose and the coefficient of utilization is approximately 50%.
3. YAMS

Yams occupy an important status among the food crops grown in the Pacific and Micronesia being used in considerable quantities. It enjoys a high ceremonial status in Ponape, and to a lesser degree in Yap proper and the islands of the Northern Marianas. These tuber forming plants belong to the family Dioscoreaceae and genus Dioscorea, which has the most numerous and important species of this monocotyledonous family. These are climbing vines with ridged, cylindrical or spiny stems which twine either to the right or left. There are six main species of yams grown for human consumption in the Pacific islands all of which originated from the Indo-Pacific region. These include D. alata, L.; D. bulbifera, L.; D. esculenta (Lour.) Burk.; D. pentaphylla, L.; D. hispida, Dennst.; and D. nummularia, Lam. Specimens of all these species may be found in Ponape island.

There are over a hundred recognized and named varieties of yams grown in Ponape today. The cultivated species of yams rarely produce flowers and propagation is performed by use of pieces of the tuber. Tubers may be single or in a cluster, long and cylindrical, round, flat and branching. The tubers of some species contain dioscorein, a bitter poisonous alkoloid. These yams may be eaten if tubers are boiled several times and washed repeatedly in water to remove the alkoloid.

Yams generally require deep, loose, well-drained soil for proper growth. A small whole tuber or a piece of a large tuber
Dioscorea alata (yam)

- a. Habit of plant; b, aerial tubers; c, female flowers; d, female flower from above; e, side view of female flower; f, male flower from above; g, side view of male flower; h, underground corms.
usually taken from the crown are used for planting material. The selection of site, type of arbor to be used and preparation of planting hole depends on the variety of yam to be planted. This is the traditional empirical knowledge that is held in secret by the islanders and passed on from father to son only by demonstration and instruction. Short, small-tubered yams are usually grown on hard latterite soils; long varieties are grown on hillsides; large, thick type tubered yams are grown in deep soils, etc. A high climber is planted under breadfruit or similar sized and crowned trees. Low growing quick maturing yams are grown on wild hibiscus tree trellises which are pruned and eventually killed by burning or ring-barking to help the yam vine develop. Generally, the yam vines must reach the crowns of the arbor, whether it is a live tree or trellis, to get sufficient sunlight to develop properly. If the vines do not top the trellis, the tubers will not develop to full size. The technique used in Micronesia to train low climbing vines is to use low trellises or temporary poles for the vines to climb on. High climbing vines must be trained on strands of tough bark or string as aids for the climbing vines. Rock weights are tied to the ends of these strings and thrown up onto the first tier of branches; then the next following until the vine reaches up and over the crown of the tree trellis. The strands of bark eventually rot and the vines maintain themselves. Enough play must be allowed in the strands of bark stringers to allow the normal swinging of the yam vines. If the vines grow too straight
Dioscorea esculenta

a. Two habits with male flowers; b. male flower;

b. Section of male flower; c. group of roots; d. single root.
and taut, they will be broken from the tuber during windy times and the yams will die. There is very little other cultivation necessary except to check the vines and cut back wild competing plants. In some districts, yam plantings are individually protected with rock walls or large logs or with stakes as in Ponape. In other areas as in the Marianas, yam gardens may be fenced.

Since the majority of yam varieties are annuals, the growing period usually is from 8 to 12 months. The main harvest time in Micronesia is from November to January when the vines usually die back at the start of the dry season. This is the Christmas season and the traditional feast period in Ponape and the Marianas when feasting has great meaning and the intrinsic and cash value of the crop is at its premium. In Ponape much social prestige goes with yam growing and even up to present time a man has very little standing in the municipality unless he is a capable yam grower. Yams cannot be purchased for presentation at feasts in Ponape, therefore, each persons' prestige and station depends on his own capabilities. Some varieties produce huge tubers weighing several hundred pounds. Yams must be dug carefully to prevent damage to the tubers. Large tubers are usually tied to strong poles for lifting from holes and carrying to the village sight. Some varieties of yams may be allowed to grow for two years and a few varieties may be left for many years. The culture of perennial yams is the true, intricate technique which is not generally known by the average producer in the community. With the development of
Dioscorea spp. of yams in Micronesia - harvested tubers above and lower left from Ponape Island; lower right, yam planting with bamboo trellis, Yap Island.
cash crops and extra daily activities brought on my modern living, yam culture has become too arduous and time consuming work. Easier methods of artificial trellising and growing of a few varieties is the rule. Yams are heavy producers and on an annual per tonnage basis, 10 tons is an average yield and 20 tons is a good yield.

The best methods of cooking yams is by steaming in an underground rock oven. Yams are peeled, cut in sections, boiled and served with a sauce or meats. It is often boiled then mashed and mixed with bananas or coconut milk and eaten as a starch food. Yams are rather tasteless and gummy and not a complete food, therefore, should be eaten with a sauce, cooked in soup or cut in pieces and combined with chicken or fish with coconut milk added and then baked.

Yams store well and can be kept for several months if stored in a cool, dry, dark, well ventilated place. Therefore, unlike the breadfruit or the taro, it makes up for the seasonal harvest. The best cultivated varieties of yams contain about 20% carbohydrate, 2% protein, 1% ash. They are a fair source of iron with a smaller quantity of phosphorous. The purple varieties contain Vitamin B. The yam does not contain fat, calcium or Vitamin A.

4. BREADFRUIT

The breadfruit tree as regarded by foreigners is the symbol of romance in the South Seas. It immediately brings to mind the episode of the HMS "Bounty"; Captain Bligh, Tahiti, Pitcairn Island,
Artocarpus communis

1, Habit; 2, male spike; 3, transverse section of male spike; 4, view from above of a portion of male spike showing anthers and perianth; 5, transverse section of a young female inflorescence showing flat or rounded tips of anthocarps and inconspicuous stigmas; 6, whole fruit; 7, a fruit in section.

Breadfruit
Jamaica, and other places and voyagers who were after breadfruit as a tasty food which could be grown with little effort. The breadfruit tree belongs to the family Moraceae, a relative of the fig and mulberry and is known to botanists as Artocarpus altilis, Fosberg; (syn A. communis; A. incisa). Its origin is considered to be Indonesia-New Guinea. It includes about a 100 species of trees in southeast Asian tropics and throughout the Pacific islands. This tree is found on all inhabited islands of Micronesia. Breadfruit is a tall handsome tree that grows and produces well where rainfall is high and temperatures warm on well-drained soils especially on coastal plains in the high rainfall areas of Micronesia and other islands. The tree gives a white sticky latex which was (and still is) used as pitch in caulking for canoes. Its leaves, large, thick, rough and dark green in color are most often lobed or indented, sometimes entire. Male and female flowers are grouped separately in catkins on the same tree. The fruits are ovoid, round or pear-shaped syncarps which may be found at all stages of development on the same plant.

There are many varieties described in Micronesia which run to more than (70) in the Truk and Ponape districts where it is regarded as a major staple food source. Distinction of varieties is determined by the shape and size of fruit, leaf shape and formation, by the presence or absence of seeds, by its habit of fruiting, etc. The two common groupings as known to Pacific islanders are whether there is a presence or absence of seeds and
whether the variety is early, regular or late-bearing. The principle of year round production of fruit is most closely attained on the island of Ponape where breadfruit may be had during almost every month of the year. The annual rainfall, the range from coastal area to interior, and presence of many varieties appear to be factors bearing on this subject.

Breadfruit thrives on alluvial and coastal soils. It also grows and produces on the coral atoll soils. As in the case of other plants, some varieties of breadfruit appear to be tolerant to high saline conditions and these do best under atoll conditions; as noted, there are only a few varieties that do well in the atolls of the Marshalls. Although it is sometimes grown from seeds, the breadfruit tree is more often vegetatively propagated from a sucker or root cutting. A suitable hole should be prepared and the cutting staked well after planting; sometimes suckers are protected with a rock or wire enclosure but otherwise very little effort is required in cultivation. The main branches of breadfruit trees may be pruned back to keep branches low for easy harvest. Pruning is not practiced anywhere in Micronesia except on government agricultural stations.

Breadfruit trees start bearing in about four to six years after planting and under good climate and soil conditions, can produce for about 50 years. The whole female inflorescence develops into an aggregate fruit which changes from dark green to brownish-yellow when mature. The mature fruit averages about three pounds.
Breadfruit is regarded as the major subsistence food crop in Truk and is considered as an important food source in Pompe, Kusaie and the Marshalls. It does not grow well in Palau and Yap and is hardly used in subsistence cropping in those islands. It is consumed only in small quantities by the people of the Marianas. The greater quantities of breadfruit produced in the Marianas is used for feeding farm animals. There are only a few varieties of breadfruit in the Marianas and these are of poor quality. The prestige of other foods have restricted the use of breadfruit in this district. Both the flesh and seeds of seeded varieties of breadfruit are used in Micronesia. These fruits are ordinarily allowed to ripen well; the seeds are removed and roasted and the pulp is also roasted and eaten or mixed with other foods for cooking.

When cooked, breadfruit becomes yellow and bears a resemblance to a soft sweet potato in color, texture and taste. Breadfruit in Micronesia is commonly picked when mature but still hard. It may be peeled and boiled or merely scraped on the outside, cut in halves and roasted in an underground oven. Sometimes it is pounded into a mass after boiling and mixed with banana and eaten with an icing of coconut milk. It may be mixed with yam, banana or coconut milk, baked then eaten. It is sometimes peeled, sliced then fried in deep fat as chips.

The seasonal nature of fruiting which often results in over-production has led to various methods of preservation. Fruits are sometimes sliced thin and dried in the sun; in another method fruits
are cooked then made into a paste which may be mixed with pandanus or lime juice then dried in the sun in thin layers which are later wrapped in plaited leaves. In the islands of Truk and Ponape, the process of fermenting in large ground pits is used. The mature fruit is peeled, washed, split in halves, the core is removed and thrown away and the halved fruits placed in stone pits lined with leaves of the breadfruit plant or a common species of ginger. Sometimes old fermented fruit is added to the layers of halves as these are placed in the pit. When it is full, it is covered with leaves, rocks and earth. The fermentation causes intense acidification which preserves the resulting paste for many months or longer. Mature green breadfruit may be cut into half-inch by inch sized pieces and dried in the sun or artificial dryer for several days then put in sealed containers. It can be kept in this manner for about six months. The male inflorescence which has fallen from some varieties may be eaten. It is boiled, peeled and then cooked in spiced sugar syrup, removed, rolled in powdered sugar and dried in the sun. It is used as candied fruit.

Breadfruit, like all unconcentrated foods, would have to be consumed in great quantities to provide sufficient nutrition in the ration. Its low content of protein, fat, and Vitamin A requires supplementing with foods rich in these elements such as fish, meat, coconut, legumes and vegetables. Mineral content and food value analysis from the Philippines shows 6% carbohydrates, 0.55 fat, 2.2% protein, 0.8% ash, the remainder being crude fiber and moisture.
Breadfruit is a good source of Vitamins B and G and contains small quantities of the minerals, calcium, phosphorous and iron.

5. CASSAVA

Cassava is native to Central America where it was grown as a food plant from Mexico to Peru before the arrival of Europeans. In the 16th century it was taken by Portuguese explorers to Africa. It then spread to Madagascar, Java and Asia and the Pacific islands. This plant was probably introduced to Micronesia in the middle of the last century.

The plant belongs to the family Euphorbiaceae. The shrub grows six to eight feet high with soft, brittle, pithy stems. The leaves have long stalks and are deeply indented into five to seven segments. The roots are dark coloured, thick and fleshy, and divided into a number of tubers which grow to a length of about three feet. Two species out of about 150 are commonly recognized:

- *Manihot esculenta*, Crantz (*M. utilissima*, Pohl) commonly known as the "bitter cassava" because of the presence of large quantities of cyanogenetic glucoside, which readily breaks down to give prussic acid, which is toxic and bitter and spread through the layers of the tuber.

- *Manihot dulcis*, Pax (*M. palmata*, Muel.), known as "sweet cassava" because it contains only small quantities of cyanogenetic glucoside.
Manihot esculenta (cassava)
a. Habit of plant; b, flowering branch; c, cross section of root; d, flowers and a young fruit; e, female flower; f, male flower viewed from above; g, details of male flower; h, fruit; i, cross section of fruit.
In fact though, there are two separate cultivars which actually differ in appearance: \textit{M. esculenta} is a hardy plant with dark leaves whose stems tend to be red or reddish with winged fruits and \textit{M. dulcis} which is more fragile with leaves and stems which are usually light green and wingless fruits.

Cassava grows best in a warm tropical climate in areas with less than 100 inches of annual rainfall. Constant high humidity such as exists in Ponape, Truk and Palau increases growth of green parts to the detriment of the tuberous roots. Cassava will grow in a wide range of soils, from poor to very poor providing the soil is not waterlogged or subject to flooding. It prefers light alluvial soils to sandy texture but will produce in compact soil types if the soil is first loosened. The poor soils of Micronesia greatly depress the yields of other traditional tuber-producing plants and allows the development of cassava growing because of its hardier nature. The area for planting cassava should be marked out into lines three feet apart. The soil should be carefully loosened about 18 inches in diameter at three foot intervals in the lines. Hilling or ridging of lines may be desirable. Stem cuttings about eight inches long are always used. The best cuttings are those taken from the base of the stems. Two cuttings are planted 2/3 covered on the slant at about 60° at each three foot interval in the lines where the soil has been properly loosened. Two shoots should be allowed to develop on each stem and the area should be weeded and plants mulched until the plant branches have shaded the
ground. Planting should be carried out during the start of the rainy season. Because of rainfall and seasonal dry spells, the Mariana Islands and Yap proper are most suited for cassava production as a subsistence crop in Micronesia. It will not grow in the calcareous, mineral and nitrogen-phosphorous deficient soils of the atolls.

Depending on the variety, harvesting may be done from 8 to 18 months after planting when plants have stopped growing. Tubers develop at the base of the stem by a process of secondary thickening which is initiated in the adventitious roots. The chief storage material is starch, the grains being of medium size. On an extended subsistence plan, larger tubers may be taken from plants and the plants left for additional harvestings over an extended period of time. In the Mariana, Yap and Palau districts where cassava is grown in sizeable quantities, annual production of from two to four tons per acre is estimated. Generally, four tons is considered an average yield, eight tons a good yield and 16 tons a heavy yield.

In Micronesia, cassava is grown in the drier districts and those with poorer soils. Its hardiness and resistance to insect damage and disease has allowed it a place in these areas as a staple starch producing subsistence crop. The tubers are generally eaten peeled and boiled in water, roasted or baked in the oven. In Palau and the Marianas, peeled tubers are grated and sometime mixed with sugar or coconut milk, wrapped in leaves and baked. Boiling is undesirable as a method of preparation since mineral salts,
Vitamins B, C, riboflavin and niacin are soluble in water and lost during the cooking process. Cassava is a starchy, unbalanced food and must be supplemented with coconut milk, fish and greens.

Because of its hardiness, cassava can be grown on poor soils. Under these conditions, the local people tend to grow it in a continuous cropping system which causes complete soil depletion. A system of rotation should be developed with a legume like soybean, corn, cassava and then fallow as has been shown in Indonesia from the view point of productivity and maintenance of soil fertility.

Cassava starch hydrolyses easily, is readily digested and converted to dextrin. Young tubers contain about 6% sucrose and large quantities of starch. Mature tubers contain approximately 30% starch, 2% protein, 1% ash; low concentrations of the minerals, calcium, phosphorous and iron; an abundance of Vitamin C with low but adequate amounts of riboflavin and niacin. Fat and Vitamins A and D are absent.

6. SWEET POTATO

The sweet potato is a herbaceous plant with a smooth surface and long trailing vines which produce a milky juice. It belongs to the morning glory family Convolvulaceae and is known botanically as Ipomoea batatas, Lam. There are over 400 species of Ipomoea which are distributed throughout the tropics but Ipomoea batatas, the sweet potato, is the only species of importance. The plant is presumed to be a native of tropical America where it was grown as a food crop before the arrival of the Europeans. The flowers
Ipomoea batatas (sweet potato)  

a. Habit with flowers;  
b and c. details of flower; d. enlarged roots.
are funnel-shaped, ranging in color from light to dark pink; the leaves are either entire or lobed; the elongated tubers are used for food. The young leaves and vine tips may be consumed as cooked greens and the leaves used as fresh greens for livestock. The skin of the tuber ranges from light yellow to dark purple, and the flesh may be white, pink, purple, from light to bright yellow, red or brown.

The sweet potato is grown on all islands in Micronesia except the low coral islands where the soils are unsuitable because of their calcareous makeup. There are hundreds of varieties which are cultivated in the tropics and several dozens of these are to be found growing as a cultivated subsistence crop in Micronesia. There are two main groups of varieties: those that produce dry, hard white to yellow colored tubers which are referred to as the "boiling type"; and those that produce soft, sweet, watery fleshed orange to red colored tubers which are referred to as the "baking type".

Sweet potato grow best in light well-drained soils but heavier soils which are properly tilled to at least eight inches in depth and drained will grow a good crop. The plants are usually grown in raised rows or mounds about two feet between rows and a foot between plants in the row. Sweet potatoes are always propagated from disease and insect-free foot-long vine cuttings. These are placed at an angle with 2/3 of the cutting buried in several inches of topsoil. Once the vines spread and cover the
planting area, very little care is required. Planting should take place at the start of the rainy season.

In the warm tropical areas as in islands of Micronesia with good soil, harvesting takes place from four to eight months after planting, the time interval depending on the variety planted. Under average conditions in these islands, yields of three to six tons per acre are normally harvested per annum. Generally speaking, four tons is an average yield, six tons is a good yield and eight or more tons is exceptional.

The sweet potato has not developed in importance as the taros and yams in Micronesia because of high rainfall, limited sandy loam soils and insect and disease problems. However, it has a fairly important place as a supplementary subsistence crop in the drier islands of the Marianas. It is also grown in fair quantities in Truk, Palau and Yap. Like cassava, it grows well in areas with 100 inches or less annual rainfall with a marked dry season; it tends to produce copious vine growth and only a few small tubers in humid, high rainfall areas.

Sweet potato tubers may be cooked in many ways but the common methods are simply washing the tubers and then boiling, baking in oven, or roasting in the fire. Tubers may be peeled, sliced and boiled with meat and spinach as a soup or stew. It can be sliced and fried plain or covered with batter and then fried. Sometimes the tubers may be mashed and mixed with coconut milk and other starches. The tubers can be stored for several weeks or months.
CONVOLVULACEÆ

Ipomoea aquatica (kangkong).  a, Habit; b and c, details of flower; d, fruit

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if stored in an airy, dark, cool place. The tubers should be
dried for several days in the sun before storage. Sweet potato
tubers contain approximately 25% carbohydrates, high quality
protein and are rich in Vitamin A and contain some Vitamin B and C.

A second species of Convolvulaceae botanically described
as Ipomoea aquatica, Forsk., grows throughout the islands and is
used as a green feed for livestock and as a cooked spinach for
human consumption. It is referred to by the common names "Kang
Kong" or "Water morning glory". It grows easily in damp, swampy
areas or in pools or streams where the current is not too swift.
The plant is an excellent spinach and good source of minerals
and vitamins for both humans and domestic animals. It contains
4% protein and 3% carbohydrates.
III. SUPPLEMENTARY FOOD PLANTS

1. COCONUT

It is not necessary to dwell on the fact that the coconut palm is the most important commercial plant in the Pacific area and Micronesia. Aside from this, human life on atoll islands would hardly be possible without it; on other islands, it is most often the main source of supplementary food.

The origin of the coconut palm is not clear but it is believed by many to be the tropical areas of the Old World, particularly the shores of the Indian Ocean. It belongs to the family Palmae and is known botanically as Cocos nucifera, L. A rainfall of at least 60 inches well distributed through the year with humid temperatures of 80 to 90°F. or more from sea level to about 2,000 ft. is suitable. The palm grows well at low altitudes and especially near the coast. It prefers the rich loose soil of strand areas and, as we know, is tolerant to an appreciable degree of saltiness. It grows well under atoll conditions which have a suitable fresh water lens. The coconut does not thrive on clay soils with a high water table a foot or two from ground surface.

There are many varieties of the coconut palm which have been described in most tropical countries of the world. Broadly, there are two main types, the common tall and the dwarf. The tall palm cross-pollinates and its female flowers must be fertilized with pollen from another near by palm which is producing pollen at the particular time. The reason is that though individual palms produce
Cocos nucifera (coconut).  a, Habit of plant; b, inflorescence with male and female flowers; c, male flower; d, female flower; e, bunch of fruits; f, fruit; g, longitudinal section of fruit;
male and female flowers on the same fruit bunch, the female flowers are not receptive until the male flowers have dissipated all their pollen. The dwarf is generally self-pollinating and breeds true in more than 80% of nuts produced. An intermediate hybrid is produced when these two palms are cross-pollinated.

Coconuts propagated for general purposes should be selected from good mother palms. There are certain tall types that produce many sweet-watered delicious tasting nuts when picked at the proper drinking stage. Generally though, good drinking, sweet husk and sweet-meat types are interspersed throughout village groves. The dwarf types which are either green, yellow or red-fruited are planted in the village area or near to farmsites for food and ornamental purposes. Nuts from particularly good tall trees may be saved and germinated around the home or in a field nursery for later planting. After a suitable site or field is selected, six month old seedlings are planted in 1 x 1 foot holes. The young palms will grow well if weeds are kept down and mulching around the seedlings properly done. Very little additional care is required.

The coconut palm has many uses and is unexcelled by any other tropical crop that is grown in Micronesia. Its trunk produces timber; its unripe nuts food and drink; its inflorescence fermented and unfermented drink; alcohol; vinegar; thatching material; strips and fiber for making baskets, mats, hats, rope, brushes, brooms; fuel; caulking material; utensils for household use such as bowls,
Coconut palm with bamboo tubes for collecting tuba attached to inflorescence stalks.
cups, spoons; oil for food, cooking, illumination, for making soap, lard, substitute for butter and ointment; and oil cake for feeding domestic animals and fertilizer. The bud makes a good salad. The palm is ornamental and often used for landscape. The young fronds are used for decorations. The young nut is used daily by everyone for its refreshing nutritious water and albumen. Fresh coconut toddy is a very important baby food in the low islands. The older, half-ripe nuts are used for drinking and a quick meal also. The ripe nut is daily grated and the milk squeezed out for mixing with starches and protein foods in meal preparation, the residue goes for poultry, hog and dog feed. The copra produces oil for cooking and ointment. The meat is also made into candies.

It is estimated that coconuts from 25,000 acres of land are consumed annually as supplementary food by the 93,000 inhabitants of the Trust Territory. Coconuts are ever-present and no preservation measures, except for copra manufacture, are necessary. Mature coconut meat and coconut milk contain fair quantities of fats, carbohydrates, some protein and ash. Analysis of expressed coconut milk show 27% fat and 4% protein. The mature nut is a poor source of calcium but good in iron and phosphorous. It has no Vitamin A or C, a poor source of thiamine and riboflavin and a fair source of niacin. On the other hand, the water from young nuts contain a good quantity of calcium; the phosphorous content is variable and iron is negligible. Coconut water is acid and water
samples from very young nuts having little or no meat have an average pH of 4.7.

2. POLYNESIAN ARROWROOT

The Polynesian arrowroot known botanically as *Taccas leontopetaloides* (L.) O. Ktze. (syn. *T. pinnatifida* Forst., *T. Hawaiiensis* Limpr.) is referred to locally as Mokmok and is related to the yams. It is found growing as a volunteer plant on every inhabited island of Micronesia and perhaps the Pacific. It is believed to be a native of tropical Asia; it is also found in Australia and Africa. The plant has a petiole two to three feet high with broad, deeply lobed, divided leaves about a foot across. The flowers are small with six or more leafy bracts and numerous thread-like bractlets. The tubers are potato-like and each plant may produce from 10 to 30 tubers at maturity.

There appears to be two varieties of *Taccas* reported in the low islands. The common variety produces a large number of potato-sized tubers, the number and size depending on the fertility and other favorable factors. The second variety is described as producing only a single large tuber. In the atolls of the Marshalls, arrowroot is a "volunteer" subsistence crop which is allowed to grow under the coconuts, breadfruit and pandanus trees. It grows with other plants such as banana and papaya. Often times large areas of underbrush are burnt out under the coconut groves in the dry season. The bush plants are killed and the *Taccas* plants immediately re-sprout and predominate.
TACCACEAE

Tacca leontopetaloides or polynesian arrowroot mature plant showing seed cluster and tubers.
(Majure, Marshall Ids)
Arrowroot sprouts in early spring, flowers in the summer months and matures in the late fall to mid-winter in the Marshalls. The leaves turn yellow and the plant dies back and this indicates the time for harvest. The tubers are dug up with a spading tool, the larger ones are taken and the small ones are left to produce new plants. A good-sized tuber runs around six ounces.

The plant is relatively disease and insect-free and is a natural reserve starch food for atoll soil conditions. Tubers of Tacca may be processed immediately or stored in an underground pit or cool dry place for several months. The tubers are peeled with a knife or the rind may be scrubbed off with a blunt instrument or sea shell. The tubers are then grated, strained with fresh or sea water to clean and remove the bitter acid. The acid must be washed out before the grated starch residue can be eaten. The grated material is thrown away and the starch is allowed to settle. After several hours, the water is poured off and the starch residue may be washed for one or two more times. After the final washing, the starch is bound in a cloth and hung to allow the water to drain. After several hours the starch is sundried, then worked into a fine powder. Arrowroot starch crystals are fine and are easily digested. The starch may be stored in a jar for later use.

Arrowroot starch is tasteless. To prepare as food in the Marshalls, it is mixed with sugared water, toddy, pandanus fruit paste, or coconut apple and mixed with hot water or baked. Innovations
of the above methods depends on the initiative and desires of
the matron performing the task. It is an excellent starch for
laundry work. This plant is not used much any more in Micronesia
except in the Marshall Islands and some atolls in the Caroline
Islands.

3. EDIBLE PANDANUS

The Pandanus plant belongs to the family Pandanaceae which
includes three genera and about 250 species. It is known from
tropical Asia and the Pacific islands. The tree grows to about
40 feet, is much-branched, has long prop roots and aerial roots
that extend downward from side branches. The plant is dioecious,
that is, stamenate male flowers and pistilate female flowers and
fruits are produced on separate trees. The leaves are long,
narrow, pointed and arranged in spirals at branch tips. Sharp
spines border the margins of leaves and the midribs. The male
flowers are white and borne on a rachis close to the branch tip.
The fruit is a syncarp, sometimes referred to as a bunch or cone.
The fruit is made of many phalanges or keys which are green on
the outer end and the inner portion, which is the fleshy edible
part, is attached to the central receptacle; this turns bright
orange, soft and sweet-tasting when ripe. The edible types have
a small percentage of raphide crystals which is the irritant
factor. Edible cultivars of P. tectorius are found in the Marshalls,
Eastern Carolines, the Gilbert and Ellice Islands. The kernels
Pandanus tectarius (edible beach pandan) showing young tree with mature fruit (Majuro, Marshall Is)
found in the keys are edible in many varieties also. The kernel of a large-bunched variety called pahong is commonly eaten in the Northern Marianas.

_Pandanus_ plays an important part in the diet of the atoll dwellers of the Marshall, Caroline, Gilbert and Ellice islands, especially in the drier areas where breadfruit, taro and bananas cannot be easily grown. There are as many as a hundred recognized varieties and the _Pandanus_, besides being used as food, is a supplier of timber, thatching and material for weaving mats and other handicraft.

_Pandanus_ in the atolls of Micronesia produce flowers and fruit in the spring; fruits mature in about six months with peak harvest in December-January which is the opposite of the heavy breadfruit season. A single tree produces from eight to twelve bunches in a single annual season. Good varieties are always propagated from branch cuttings which develop aerial roots. The leaves and roots should be trimmed back on branches before propagation. Ordinarily, a new plant grown from a cutting will produce first fruits in about five or six years.

_Pandanus_ fruits are allowed to tree-ripen. Several varieties are favored for eating fresh in the Marshalls; these are "joibeb", "mijel", "uttotot" and "erdwaan-en-an-nelu". Other tougher edible varieties are tree-ripened then boiled or baked to soften the keys for chewing. Analyses of _Pandanus_ fruits, paste and flour in Hawaii indicate that both fresh and cooked _Pandanus_ contain
less than 0.5% protein and fat; 14% to 18% carbohydrates.

Percentages of calcium, iron and phosphorous compared favorably with apples, peaches and apricots. Thiamine, riboflavin and Niacin are also found in appreciable amounts in Pandanus fruits. It is a good source of provitamin A. Although the Vitamin C content is low, Pandanus is consumed in large quantities and it is an important source of this vitamin for atoll dwellers.

4. CITRUS SPECIES

Citrus species are widely scattered throughout the islands of Micronesia with the exception of the small dry coral atolls where it cannot be grown because of unfertile calcareous, salty soils, lack of moisture and devastating salt spray. It is not an indigenous plant to the Pacific islands and was probably introduced by early voyagers during the last century or earlier. The genus Citrus is of the family Rutaceae; it is a tropical fruit which, through history of its cultivation, appears to have originated in the South Asia, Indo-Malayan region. Citrus varieties have been cultivated for thousands of years in China and the Mediterranean countries. There are 150 genera and about 1,600 species mostly found in the tropics. The genus Citrus supposedly contains 16 species. The leaves are a simple entire lamina (blade) carried on a winged petiole; the trees are aromatic, the flowers white and sweet smelling, occurring singly or in clusters. The fruit that is produced by Citrus species is a special form of berry.
RUTACEÆ

*a. Fruiting branch; b. flower; c. section of flower; d. fruit; e. transverse section of fruit.*

*Citrus aurantium (sweet or sour orange)*
The oils from the rind as well as the fruit pulp have commercial importance.

The sweet orange in the form of the Valencia variety is found in abundance in Yap and the islands of the Northern Marianas. These are of good quality and selections for extensive cultivation need to be made. The common Polynesian orange is found in great quantities in Kusaie (where it grows best) as well as in Ponape, the islands of the Northern Marianas, Truk, Yap and Palau. It grows well but is not as good as the Valencia. Seed of this variety may be used for rootstock for budding in the process of vegetative propagation.

The King or Mandarin orange is found in varied forms and in large quantities in the Northern Mariana Islands, Yap and to lesser extent, in Kusaie and Ponape. Much more work should be done in the selection and large-scale propagation of good quality stock for subsistence and commercial production. There is great importance in large-scale propagation of high-quality Mandarin oranges in all districts since this species appears to grow and produce well. This work should be promoted to the fullest extent.

Several good varieties of pomelo and grapefruit are to be found in the Ponape district. These were introduced many years ago and are being selected and propagated for distribution in all districts. These species are hardy and grow well in the hot humid areas of the Carolines and stand up well under the devastating sweeps of the yearly typhoons in the Yap and Northern Marianas areas.
Citrus maxima (pomelo, or *Asian* grapefruit).  

*a*, Fruiting branch;  

*b*, flower;  

c, flower with a petal detached to show parts;  

d, section of fruit.
Citrus nobilis (gala mandarin). a, Fruiting branch; b, fruit; c, section of fruit.
The limes in the form of the Mexican, Kusaie, Rangapur and Calamondin are widespread throughout Micronesia and is the most important Citrus of the low coral atolls where it is grown for use as a spice with fish, in drinks mixed with sugar and water and other forms of seasoning. The other larger-fruited types of Citrus do not grow or produce satisfactorily under atoll island conditions.

The only lemon of consequence found in Micronesia is the Meyer’s variety. It is common in the Northern Marianas, Yap and Ponape and has been introduced to Palau and Truk recently. It grows well and produces large crops of medium to large juicy fruits.

Citrus grows best on well-drained, open soils. If the surface is good, tillable earth with a fair mixture of sand to open it up, and the subsoil is heavier so as to hold moisture and prevent leaching, the ideal soil conditions for Citrus growing have been found. Generally, sweet oranges, tangerines and Mandarin orange types should be propagated by the vegetative method called budding. The Polynesian orange or wild hardy Mandarin types as found on Ponape make good rootstock for this purpose. The grapefruits and pomelos should also be propagated by this method. The limes can be propagated by seed or vegetatively by use of cuttings. The oranges, pomelos and grapefruit types should be spaced in the field at about 30 feet; the Mandarins and tangerines at a minimum of 24 feet; the lemons and limes at about
Citrus limon (Villafranca lime). a. Fruiting branch; b. flower; c. flower with one petal and some stamens removed; d. transverse section of fruit.
Citrus microcarpa

Citrus mitis (Calamondin)
20 feet for ideal production results. Very little pruning is required except when the trees are young to shape by pruning lower branches and topping to allow trees to spread and keep from getting too high. The close planting and improper spacing of citrus causes crowding, elongated growth and poor production results.

In Micronesia, **Citrus** fruits are eaten as ripe fresh fruits, are used for mixing and garnishing in cool drinks, as a seasoning and as a marinating sauce for fish, shellfish and chicken. It is one of the more important supplementary subsistence food crops in these islands. It can be developed into a sizeable commercial industry for home consumption in the Territory in the form of fresh fruit and juices if transportation and marketing as well as processing problems can be solved. There are no serious **Citrus** disease problems including the devastating viruses in Micronesia. No citrus vegetative stock whatsoever, or even seeds, should be allowed to be introduced into the islands of Micronesia from Guam, Hawaii, Japan, the U.S. or any other country.

Though acid in taste, oranges leave an alkaline residue in the body. It is a good source of the minerals calcium, phosphorous and iron. It is an excellent source of Vitamin C, good source of provitamin A plus thiamine and a fair source of riboflavin.

5. **POLYNESIAN CHESTNUT**

The "Polynesian" or "Tahitian" chestnut is known throughout the high island groups of the Pacific and it is believed to have
LEGUMINOSÆ

Polynesian Chestnut

a. Habit with flowers and fruits; b. single flower; c. details of flower; d. fruit; e. section of fruit; f. seed.
developed in the Malayan-Polynesian region. It is of the large bean and pea family Leguminosae botanically described as *Inocarpus edulis* Forst. This subsistence food plant is found in abundance in the islands of Yap proper, Palau and Ponape and to a lesser degree in Truk atoll; it is not grown except as a curiosity in the Mariana and Marshall Islands. The Polynesian chestnut is a medium to large handsome tree with simple, pointed, leathery leaves; small greenish white flowers, which produce kidney-shaped pods containing a large bean.

The tree prefers low, swampy, damp, high rainfall areas along the strand or near taro swamps in the interior valleys; it is also tolerant to saline soil conditions. There appears to be two varieties; a smaller columnar tree that produces small fruit pods and the large spreading, buttress-trunked form which produces large fruit pods. Both produce good fruits.

The Polynesian chestnut is an important supplementary food plant in Yap and is eaten in appreciable quantities in Palau and Ponape. In these islands, it is not carefully cultivated and regarded as a reserve food source. The tree produces fruit in large quantities twice yearly. The pods are picked when mature (or allowed to fall to the ground) and boiled. The beans resemble chestnut in flavor and are very nutritious.

6. **PINEAPPLE**

The pineapple was probably introduced to Micronesia by the
Ananas comosus (pineapple, sweet cayenne variety). a, Habit of plant; b, inflorescence; c, section of inflorescence; d, section of single flower; e, young fruit; f, mature fruit; g, section of fruit.
Spaniards in recent times and is widely cultivated throughout the islands except on the atolls of the Marshalls and Carolines where it will not grow because of unsuitable soil conditions. This plant is a native of the tropical regions of South America where it was grown for food, medicine and production of wine long before the Europeans arrived. Some of the wild types have become naturalized and are found growing in the bush on some of the high islands of Micronesia. By and large, though, the pineapple is a cultivated supplementary food plant in these islands. Several varieties are grown and it is eaten at home or marketed to foreigners as a fresh fruit.

The pineapple is a bromeliad belonging to the family Bromeliaceae and its botanic classification is *Ananas comosus* (Linn.) Merr. The plant is a short-lived perennial or biennial with a short main axis which first produces a rosette of leaves then later producing numerous spirally arranged elongated leaves one above the other. Each plant produces a fruit in about 18 months and plants develop on the crown of the fruit, on the peduncle at the base of the fruit and also along the lower part of the stem which subsequently develop and produce ratoon crops if allowed to remain in place.

It grows well in temperatures from 60° to 90°F. and rainfall about 50 inches spread throughout the year. An acid clay type well-drained soil is preferred. The pineapple may be propagated
commercially from the slips and suckers that develop on the plant. Base suckers will produce fruit in about 15 months; slips developed on the peduncle produce in about 18 months. Crown slips are slow to develop and produce fruit in about two years.

The fruit matures six to seven months after flowering and is formed by an extensive thickening of the flower axis and coalescence of small berry-like fruits produced from each flower. There are a hundred or more individual fruits arranged spirally around the thick central axis, the whole forming a broad, tapering aggregate fruit.

The pineapple has long been valued for its special flavor and refreshing quality. The smaller local varieties are sweeter than the larger popular smooth Cayenne and these probably are richer in minerals and vitamins also. Ripe fresh pineapple is a good source of sugar and fair in calcium. It is a fair source of Vitamin A and B and a good source of Vitamin C. People find that eating large quantities of fresh pineapple may cause soreness to the mouth and throat; this may be caused by acid combined with the enzyme bromelain and calcium oxalate crystals. Pineapple fruit contains no starch that will change to sugar, therefore, will not increase in sweetness after picking. The sugars are formed in the leaves of the plant and transferred to the fruit. Pineapple fruits in the islands, therefore, are sweeter in the long sunshiny days of the summer months. Pineapple will probably never be developed
as a commercial fruit in Micronesia because of climate, soil conditions and limited land area. Nevertheless, it is an important supplementary crop for fruit in season. The richer, better tasting, medium sized local varieties are preferred to the smooth Cayenne.

7. PAPAYA

The papaya plant is native to the West Indies and tropical America but it is one of the early immigrants to the Pacific and the islands of Micronesia. *Carica papaya* L. is a member of the Caricaceae family; there are four genera and about 50 species of the papaya family. It is a perennial plant propagated from seed at sea level to a thousand feet elevation. It prefers a rich well-drained loose soil, not too much rainfall, and high temperatures, but it will thrive in a variety of soils and a varied environment. The tree is small - 10 to 25 feet high - and ordinarily unbranched. Branches will readily form if the top is cut away and the hollow trunk opening kept dry. The trunk is gradually tapering, hollow within and has a light colored bark that contains a caustic milky juice. The smooth broad leaves are deeply seven-lobed and divided; these are clustered at the top of the tree on long hollow stems. The cream-white fragrant flowers and fruits that follow are borne in sessile form at the leaf bases.

The papaya begins to bear fruit within a year's time after planting and ordinarily produces heavily for about five years; it will produce for as long as 15 years. The fruit varies in shape
Carica papaya (papaya). a, Habit with fruits; b, branch with buds and flowers; c and d, details of male flower; e, female flower; f, section of fruit.
and size; a large fruit may weigh eight pounds but the smaller commercial types run about a pound each. The fruit may be eaten fresh when it ripens; used as greens at the mature green stage; baked like a squash; cooked in stews; made into jams with other fruit; or candied. The sap of green fruit from wild types is collected and processed as papain, a meat tenderizer; it has other uses.

In Micronesia, the papaya is semi-cultivated like other subsistence crops which are usually found in the wild. The fruit is often collected from jungle trees and eaten as supplementary food or used to feed livestock. The green mature fruit is sometimes grated and used in a pickled salad. It is an important supplementary food crop in the atolls where producing fruit plants are scarce. The ripe, fresh pulp is a good source of calcium, sugar, and Vitamins A, C and G. The variety grown has a bearing on the available food value. The solo variety which is commonly grown commercially in Hawaii is found to be a good source of provitamin A, and excellent source of Vitamin C, and a fair source of riboflavin.

The papaya plant ordinarily is dioecious, with male and female flowers borne on different plants. However, hermaphroditic types that bear short-stemmed flowers are self-pollinating and the offspring of these breed true to parent type. Since papayas are to a large degree wind and insect pollinated, the only way to assure properly pollinated seed is to encase the flower (and ovary) in a
small bag before it opens and assure that it is self-pollinated or pollen from another desirable parent is used. Much more breeding and development work on papaya should be performed in the Trust Territory and this fruit should be improved and developed as a source of fresh fruit in district centers.

8. MANGO

The mango is one of the oldest cultivated fruits, its origin being the Indo-Burma-Malaya region. The tree is now grown throughout the tropical world and was probably introduced to Micronesia during the Spanish occupation. It is of greater importance to millions of the inhabitants of the tropics than the apple or citrus is in the temperate regions. In many parts of Micronesia it now occurs in a semi-wild state. It does not grow in the atoll islands because of unsuitable soil conditions and sensitivity to salt spray. It belongs to the family Anacardiaceae and is botanically described as *Mangifera indica* L. There are over 40 species and thousands of varieties.

The mango requires a tropical climate with about 50 inches of annual rainfall and needs a distinct extended dry season for proper fruiting. It grows from sea level to a thousand feet and prefers a heavy, acidy clay soil which is well-drained. It is a large, spreading evergreen tree to 60 feet high, producing first fruits in six to eight years from planting. The flowers are reddish-pink to almost white and carried in large panicles at the ends of the branches. The flower panicles carry both perfect and male blossoms.
Mangifera indica (mango)  

a. Flowering branch; b. male flower;  
c. female flower; d. fruiting branch; e. section of fruit; f. seed.
The male flowers are far greater in number than the perfect flowers. The female blossoms open in early morning and are pollinated by small flying insects. The mango is polyembryonic like some citrus varieties that produce vegetative embryos which reproduce true to type. The fruit is a large ovoid drupe and takes between three to four months to mature, depending on the variety and locality. It is yellow, green to red in color and has a smooth, fairly thick skin. The pulp is fleshy and bright orange in color and from fiberous to smooth in texture. The seed is light brown, smooth and shaped like a large bean.

The mango is rarely planted as a backyard fruit in Micronesia. It grows along the roadside or on farms from castoff seeds. No selections are made and care, pruning or fertilization is the exception rather than the rule. All trees are harvested in season, though, which generally occurs in Micronesia during the early to late summer months. Fruits are commonly knocked to the ground while still immature, peeled and eaten with salt or soy sauce. This is not a bad practice since the Vitamin C content is highest in the green fruits. Ripe mangoes are high in sugar content, but contain little if any calcium, phosphorous or iron. The ripe fruit also is a good source of Vitamin A and a poor source of all the B Vitamins.

Micronesia cannot grow mangoes on atoll islands. All districts have average annual rainfalls which are way too heavy for proper mango culture. Very few months are ever rain-free. Therefore,
growing and producing good mangoes under field conditions is not possible and the mango will never be an important food crop in these islands. There are years of unusually dry weather when there is a good set of fruit in the lesser rainfall areas like the Northern Marianas and Yap. The Marianas are the best islands for mango culture in Micronesia but strong typhoons are a limiting factor. It is possible that good grafted mangoes can produce fruit in the Northern Marianas if the trees are pruned and kept low and well protected by windbreaks. Otherwise, mangoes do not deserve careful propagation in Micronesia. The hardy, wild type should be continued to be grown on high islands as a volunteer crop.

9. SUGAR CANE

The sugar cane is a member of the grass family Grammineae and its botanic description is *Saccharum officinarum* L. Its original home is regarded as possibly New Guinea or South East Asia. The plant is assumed to have been introduced to the Pacific islands by the early settlers from Indo-Malaysia. It is a large perennial grass growing only in cultivation. There are many varieties which have been developed over the last century as a result of its commercial exploitation. Cane is propagated by means of stem cuttings about two feet long. These are placed two or three in a clump with the ends protruding from the soil. As the plants grow, old dead leaves should be stripped
Saccharum officinarum (sugar cane). a, Habit of plant; b, portion of stem (culm); c, transverse section of culm; d, panicle; e, spikelets; f, details of single spikelet; g, pistil.
and the plant stools mulched. Very little additional care is necessary. Some canes kept for ceremonial feasts are braced and tied to large strong support poles.

The best subsistence types grown for home consumption are of the original early stock which are very susceptible to rat damage because of the soft stems. Sugar cane can be harvested for eating at about 12 to 18 months. The older stalks are merely broken off and the younger stalks allowed to remain and mature as ratoon crops. This plant will not grow on atoll islands because of the unsuitable soil conditions.

Sugar cane has been grown by Micronesians as a subsistence food plant for its sugar for many generations. Its juice is hardly ever extracted and stored or processed in food preparation. Instead it was (and still is) consumed by chewing the freshly cut stalks. These may be peeled with a knife or with the teeth, sections chewed and the sugary sap swallowed. It was a very important food crop in years past but, like some other crops, is beginning to be replaced by imported sugar products. It still has a place in the subsistence farming pattern of the outlying areas of these islands. Among other elements, raw sugar juice contains approximately 12% sucrose, is refreshing to consume and a quick source of energy out in the field.

10. SOURSOP

The fruit known as soursop, Annona muricata L. is a member of the Annonaceae family - more than 70 genera and over 600 species
Annona muricata (crown)
a. Flowering branch; b. Flower opened to show parts viewed from above; c. Details of flower after removal of perianth; d. Fruit and section of it.
of shrubs and trees in many tropical and temperate regions. This plant species is a native of tropical America and was introduced to Micronesia in recent times. It is a small evergreen tree about 15 feet high branching with shiny leaves and dark green, softly spiny heart-shaped fruits about six to eight inches long and about four to six pounds when ripe. The pulp is like cotton saturated with a sour-aromatic liquid from which a pleasing drink can be made. The pulp contains many brown seeds from which it is propagated.

Soursop is semi-cultivated in Micronesia in that it is allowed to grow as a volunteer around village homesites and throughout farming areas. It will grow in a wide variety of conditions except the calcium carbonate soils of the atolls. The fruit is ordinarily consumed by workers or children at random at home or in the field. Rarely is it processed into a drink or dessert except by foreigners or islanders who have refrigerators or access to ice. Ripe fruit in the field is generally eaten by wild birds, poultry and hogs.

It serves as a source of supplementary food as needed but is not popular or very important in the subsistence food production system. The ripe soursop is a fair source of phosphorous and contains some calcium and iron; it is a good source of riboflavin and niacin and a fair source of thiamine and ascorbic acid.
Cucurbita maxima (squash or calabash). a, Habit; b and c, details of male flower; d and e, details of female flower; f, different kinds of fruits; g, section of fruit; h, seed.
CUCURBITACEAE

Lagenaria lecantha  

a. Habit; b and c. details of male flower; d. female flower; e. different kinds of fruit; f. section of fruit.
11. CUCURBITS

The cucurbits of the gourd family Cucurbitaceae are well represented as subsistence crops throughout the islands of Micronesia. The most important is probably the field pumpkin Cucurbita pepo L., a hairy annual vine with branched tendrils. It is a native of America and is grown in Micronesia for its fruits; its vine tips are also used as a cooked spinach with meats in soup in the Mariana islands. It is grown and eaten as a reserve food on the atolls especially in the drier islands where a variety of foods are lacking. This crop is grown in many islands as feed for livestock or poultry. It is a good source of Vitamin A and contains some carbohydrates.

The Luffa acutangula (Linn.) Roxb. gourd is a native of India and is grown in some islands and used as a cooked vegetable with fish and meats. The long cucumber-shaped fruits are picked when still young and tender when about eight to ten inches long. Young fruits of this plant are a good source of phosphorous and iron and a fair source of calcium. The old dried fruits of Luffa cylindrica contain a fibery tissue which is tough and is used as a kitchen scrub brush. Species of Lagenaria, Sechium, Benincasa, and Momordica are sparingly grown as food plants mostly by foreigners in parts of Micronesia. These are all herbaceous annual vines that produce edible fruits or leaves.
FLACOURTIACEAE

Pomfretum edule (palmil).
12. PANGIUM

The plant Pangium edule Reinw. belongs to the Flacourtiae family, native of the Malay Archipelago. It is found on Ponape, Palau and Yap and rarely in the Marianas and Truk Atoll. It is a medium to large-sized, long-lived deciduous tree. It has large shiny, broad heart-shaped leaves on eight inch long leaf stems. Male and female flowers are borne on separate trees. The fruit is a brown, oblong, rather rough, thick-walled capsule five by ten inches, containing many oval, grey-white hard seeds about two inches long.

The tree is poisonous throughout owing to the presence of prussic acid. The ripe fruit is not poisonous but people who have eaten the pulp sometimes develop a headache. The ripe fruits are eaten by people in Palau and Ponape. The yellowish, sweet, aromatic pulp surrounding the seeds is quite tasty. The mature fruits should be picked without bruising and kept till they soften before cutting and eating. The seeds contain prussic acid in quantity in the oils and may be dangerous for eating unless properly treated and prepared by an experienced person. Pulp from the grated seeds of Pangium in Ponape are fed to wild chickens which become weak and easily caught in a short time. The tree is well-established as a volunteer plant on Ponape and Palau. The plant is propagated from seed.

13. CRATAEVA SPECIOSA
CAPPARIDACEAE

Crataeva speciosa, Volkens - shown on Ulithi Atoll, Western Caroline Islands. Full grown trees above; fruits below.
The plant *Crataeva speciosa*, Volkens, belongs to the family Capparidaceae and is commonly called "apouch" or "abich" in the Caroline Islands. It is a fruit-bearing tree that is found growing in Yap, the eastern atolls of Yap district and in Truk atoll and the outlying islands of that district. The tree's origin is unknown but appears to be a food plant of long standing in the western and central Caroline atoll islands.

The tree produces oblong, heart-shaped fruit about four inches long which turn orange when ripe and give off a sweetish fermented smell, during the winter months. Very little is known about its habit of fruiting and value as a food plant. It is not very tasty and no doubt used for food by the islanders, fresh or cooked, when there is little else available. There seems to be a number of varieties which vary in quality and quantity of fruit. The plant grows from seed but is easily propagated from cuttings which will grow in almost pure beach sand. It is certainly adapted to atoll soil conditions.

14. **SPICE PLANTS**

The development of culinary methods is accompanied by increased use of various vegetable spices and flavorings. The use of plant spices in the tropics has long been established and the everyday food of tropical peoples is much more highly spiced than that of inhabitants of temperate regions of the world. There are several of these plants that are commonly used in food preparation in Micronesia and the more important ones are listed here.
Capsicum frutescens (chile pepper)

a. Habit with fruits and flowers;
b and c. Details of flower;
d. Fruit;
e. Section of fruit;
f. Seed.
CHILLIES - The plant *Capsicum frutescens* Linn., the common chilipepper from which cayenne pepper is produced, is found on all inhabited islands of Micronesia. It is extensively used as a condiment in food preparation in the Marianas, Ponape, Palau and to a lesser degree in Yap and Truk. For some reason, it is hardly ever used in the Marshall islands; this may be because the plant doesn't grow well there and the people have not acquired its use because of their unfamiliarity with the plant. The plant *C. frutescens* is a perennial branching shrub native to Brazil and Central America, about three feet high that produces red ripe fruit about 1" to 4" long called capsules or berries. The ripe fruits are harvested and mashed then mixed with soups or added to water and mustard for use as a fish sauce. The ripe fruits may be picked and bottled with vinegar and water for use as a sauce. *Capsicum* fruits derive pungency from a volatile phenolic compound closely related to vanillin, known as capsaisin which tends to collect in the peduncle and seeds and is present in the fruit mainly in the placenta. The young leaves are also extensively used as a green vegetable. Green dye is extracted from the plant parts. The fruit and leaves are an excellent source of calcium and iron and good source of phosphorous; they are also a good source of Vitamin A and B. The other important species of this genus is *Capsicum annum* Linn., the round or sweet pepper. It is the more important commercial variety of pepper in the temperate zones where it is grown as a vegetable and eaten in
the fresh green form. The ripe fruit is also used as garnish and as a mild condiment. This is an annual shrub that never grows much over two feet and is quite variable, producing many different forms of fruits. This species is produced in quantity in the Marianas district in the dry season for sale mostly on the Guam market.

(ii) GREEN ONION - Although the green onion Allium fistulosum L. is considered a green vegetable, it is widely used as an ingredient in condiments and sauces by the people of Micronesia. It would not be possible to properly prepare the famous Chamorro sauce "Finadene" without the use of green chopped onion leaves. The people of Ponape, Truk, Palau, Yap and the Marianas grow different varieties of green onion in home gardens for daily use. Green onion leaves contain calcium, phosphorous and some iron, also Vitamin A and C.

(iii) GINGER - The ginger plant, Zingiber officinale Roscoe., is the most valuable root spice known. It is grown and used as a spice in cooking in the Marianas, Palau and Ponape. It was known in China many centuries ago and that region is regarded as its place of origin. The ginger is obtained from the rhizomes (underground stems) of the plant and large quantities are used throughout the world for flavoring, medicinal purposes, for production of beverages, as a constituent of curries and as a pickle and candied condiment. The plant is an annual which should be planted in the spring and harvested in the drier winter months when it dies back
Zingiber officinale (ginger). a. Habit of plant; b. inflorescence; c. flower; d. section of flower.
naturally. If the rhizomes are not dug up, the older fleshy parts serve as food for young regrowth that develops from the tips and the plant re-establishes itself; new rhizomes are thus formed and the old ones rot away. It requires loose sandy soil to develop good rhizomes. The rhizomes are strongly aromatic and contain about 3% volatile oil, about 50% starch and varying quantities of fixed oils and resins which confer the aromatic and pungent properties associated with the product.

Most of the fresh and preserved ginger used in the district centers of Micronesia are imported. It would be much more desirable to have the crop grown in home gardens for use as needed to improve food quality and conserve cash.

(iv) TURMERIC - The Turmeric, Curcuma domestica Valet., is a spice relative of the ginger plant which is found on all high islands of Micronesia. It is of ancient cultivation from India and is not known in the wild state. Like ginger, the root is used as a spice especially in curries and as a dye for coloring cloth. Some forms are used in medicine and others are used in perfume.

The inner tissues of the turmeric root are bright orange-yellow color and have a very distinct smell and taste. The plant grows to about two feet tall in the spring and dies back in the fall and winter months. It requires a hot, moist climate and fairly light soil. The leaves of this plant are used by the islanders for many purposes as a handy covering or layering material. The roots are used in food coloring and seasoning. The plant contains
Curcuma (turmeric). a, Habit of plant; b, inflorescence; c, details of flowers; d, rhizomes.

Curcuma domestica

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starch, fat and some protein; also phosphorous, calcium, potash and some Vitamin A and B.

(v) BLACK PEPPER - The pepper of commerce, Piper nigrum Linn., a native of southwestern India, is one of the oldest and most important spices as a food flavoring. It is being grown in Ponape as a commercial crop and has been introduced to Truk and Palau. Considerable quantities of black pepper are imported into the Territory but this is really unnecessary since it can be easily grown as a backyard crop or purchased from the local supply on Ponape. Black pepper is a stout, climbing perennial vine that climbs by means of adventitious adhesive roots. The leaves are oval, light green, rather leathery. The flowers are small and are on long spikes. These develop into berries and the long flower stem is called a catkin. The plant climbs upon a six inch diameter ferm log or hardwood post, which is called a standard, about 8 to 10 feet long, which should be set strongly in the ground in a vertical position. Pepper needs a good well-drained soil and must be grown in open sunlight with a good windbreak. The system of pruning, cultivation and harvest is simple and easily performed. When a few berries on a catkin turn red, it should be harvested. The red berries are processed into white pepper by fermenting off the outer skin, then drying. The whole green pepper berries are scalded, then dried and ground or packed whole as black pepper. The fresh pepper of Ponape is superior to the imported commercial stocks since it is so fresh and far more carefully processed. Pepper is hot and spicy and
Areca catechu (betel palm). a. Habit of plant in fruit; b, spadix; c, a branch of spadix; d, male flower; e, male flower with corolla removed; f, female flower; g, female flower with calyx removed; h, female flower with calyx removed and petals partially removed; i, bunch of fruits; j, fruit; k, longitudinal section of fruit.
used to flavor meat, fish, soup and other cookery. The pungency of pepper is due to presence of resins and a yellow crystalline alkaloid, piperine, which is present at 4% to 8% in the dried berries. Another species of the pepper family, *Piper betle*, Linn., is used as a spice in the process of betel nut chewing. It is cultivated in Yap, Palau and the Northern Marianas where its leaves are combined with lime and green fruits of the betel nut palm and chewed for its mildly narcotic and stimulating effects. The pepper leaf serves as a spice and astringent in this process.

(vi) Other spice plants are present in Micronesia. *Mentha* spp. is grown as a garden plant in district centers of Micronesia for flavoring drinks, salads and used with meats. The mint, *Ocimum sanctum* Linn., is known as the holy basil and is a sacred plant in India. It is found on all inhabited islands of Micronesia where it is used for scenting coconut rubbing oil. The vanilla orchid of commerce, *Vanilla fragrans*, (Salisb.) Ames (syn. *V. planifolia*), is grown on Ponape. The clove tree, *Eugenia aromatica* (L.) Baill., is well established on Ponape and grows and produces fruit in large quantities there. Nutmeg, the tree *Myristica fragrans* Houtt., from the East Indies has been introduced to Ponape also; the spice, mace, is also produced from this tree. The Cinammon tree, *Cinnamomum zeylanicum* Bl., grows well on Ponape and is used for ornamental plantings there. The Allspice, *Pimenta dioica* (L.) Merr. (Syn. *P. officinalis*), has also been introduced to Ponape.

The Annatto, *Bixa orellana*, L., is a small tree that is found in all high island districts where its ground seeds are used for coloring food preparations.
Bixa orellana (annatto tree)
a. Habit with fruits; b and c, details of flower; d, section of fruit; e, seed.
15. MISCELLANEOUS FRUITS

(The miscellaneous food plants used by Micronesians are not numerous. Atoll dwellers are least favored and this is caused mostly by factors restricting plant growth on the low coral islands. Micronesia benefited from a number of introductions made by foreigners, first by the Spaniards, then Germans, Japanese and, most recently by Americans. The plants listed are considered in order of their relative importance to the food pattern of Micronesia.)

(i.) AVOCADO - All races of the avocado are natives of tropical America where they have been under cultivation for centuries. There are three races of avocado, *Persea americana* Mill.:

- **West Indian** - Summer and fall ripening; fruit large; rind leathery and medium in thickness.

- **Mexican** - Leaves small and scented; fruits small and thin-skinned.

- **Guatemalan** - Winter and spring maturing; fruit large; rind ¼ inch thick, woody.

The tree is medium to large, spreading and starts to fruit at five to six years after planting and will produce for many years. Grows well in a high rainfall, tropical climate in varied well-drained rich soils. It reproduces from seed but grafting of good varieties is the desirable method of propagation. The fruits are pear-shaped, round, or ovoid and weigh up to
Persea americana (avocado).  a. Branch with mature fruit; b. fruit; c. longitudinal section of fruit (b); d, longitudinal section of another fruit; e, female flower; f, male flower.
three pounds. The shiny green skin which changes in some varieties to red and purple as the fruits mature, varies from smooth to warty in texture. The yellow, light green flesh surrounding the single seed is smooth and has a nutty flavor; the best varieties have very little fiber in the flesh. Avocados of the West Indian and Mexican types are found in abundance in the Marianas, probably being introduced by the Spaniards many years ago. These also occur in lesser numbers in Palau, Truk and Ponape. The most common ways of serving it is in salads and fruit cocktails - it goes best with acid fruits and vegetables like pineapple, citrus, tomatoes, or with vinegar or acid dressings. Only the olive fruit surpasses the avocado in oil content; it varies from 10% to 25% depending on the variety. Avocado fruit is a fair source of iron and phosphorous; also provitamin A and thiamine; and a good source of niacin and riboflavin.

(ii.) COMMON GUAVA - The common guava, *Psidium guajava* L. originated in Brazil and has spread to all the warm parts of the world. It is found in varied forms in all districts of Micronesia except the Marshalls where it does not grow because of unsuitable soils. It has been grown from seed and has extreme variation in type and quality of fruits. There are two forms of fruit, the round and pear-shaped. The fruit color is from creamy white to dark pink. The flavor varies from mild sweet-flavored fruit suitable for dessert to highly acid ones suitable
Psidium guajava (guava). a, Habit with fruits; b and c, details of flower.
only for making jellies. It prefers rich soil and good moisture. If undisturbed, it forms a medium-sized tree in a few years. As trees get older, fruits become small. If large fruits are desired, the tree should be pruned back to stimulate new growth. The guava does not grow well in Micronesia because of poor soils and damage to foliage from mites. The fruits are also damaged from local species of fruit flies; if fruits are not covered, most are filled with maggots on ripening. Otherwise, it could become a serious pest as in some other tropical countries. From a dietetic viewpoint, the guava is one of the most valuable fruits. It has a high content of calcium and phosphorous. The tart red-fleshed varieties have a high content of Vitamin C and A.

(iii.) CAIMITO - The Caimito or star apple, Chrysophyllum cainito L., is a tropical tree from Central America with sticky, milky-white sap. The caimito has been grown in the Marianas for many years and has recently been introduced to Ponape, Palau, Truk and Yap. It grows well and the fruits are fair eating. It also is an excellent dooryard landscape plant. It grows from 30 to 60 feet, angular branching, with six inch long ovate leaves which are shiny-green above and silky gold underneath. The fruit looks like an apple about two to four inches across with purplish skin covering whitish edible pulp. About eight dark seeds form a star pattern arrangement from the fruit center. The pulp is milky, sweetish and mushy. It contains carbohydrates, some fat, some calcium, phosphorous and Vitamin A and C.
Chrysophyllum cainito (sugar-apple)

a. Habit with flowers; b. habit with fruit; c and d, details of flower; e and f, sections of fruit; g, seed.
(iv.) PASSION FRUIT - The common yellow passion fruit from Brazil, *Passiflora edulis*, forma *flavicarpa*, has been spread to all parts of the tropics. It is a quick-growing, perennial vine. It requires a trellis for proper expansion of growth. The leaves are lobed and tough and the vines can be pruned back annually like a grape. The fruits are slightly round to oval and deep yellow when ripe. The thin tough shell encloses a gelatinous mass of seedy pulp which is very tart and good for making cold drinks. The pulp may be eaten fresh from the shell. The juice is very acid due to about 3% citric acid. The juice of yellow Passion Fruit is found to be a good source of provitamin A, niacin and riboflavin; and a fair source of ascorbic acid. The yellow Passion Fruit has been introduced to Ponape, Palau, Yap, Truk and the Marianas where it grows and produces well. It makes a good backyard crop and should be grown as a food plant in the high islands. Another species, the giant granadilla is found in Ponape, Palau and the Marianas but is of no importance as a food plant.

(v.) BARBADOS-CHERRY - The Barbados-cherry or acerola from the West Indies, *Malpighia glabra* L. (syn. *M. punicifolia* L.) is a large, strong bush growing to about ten to twelve feet high. The tree fruits about three times throughout the year (spring to fall) producing one inch diameter fruits which are slightly fluted and triangular, varying from pink to dark red in color when fully ripe. The acid of the fruit is malic, giving the fruit an apple flavor. It resembles the apple in shape and
Malpighia glabra (barbados cherry). a, B. lowering branch; b, flower; c, details of flower; d, fruit; e, cross section of fruit; f, longitudinal section of fruit; g, seed.
color and fruits on the mature twigs like an apple. The fruits make good jelly, jam and wine and is famous for its high content of ascorbic acid. It prefers a heavy clay soil, warm climate and ample rainfall. Varieties in Puerto Rico are reported to produce fruit one of which is sufficient to supply the daily Vitamin C needs of an adult person. The fruit also contains phosphorous and calcium and some Vitamin A and B. The acerola has been introduced to Ponape, Truk, Yap and Palau where it appears to grow and produce well. It merits extensive cultivation for its valuable vitamin and mineral content for the growing population.

(vi.) SAPODILLA - This evergreen tree from tropical America produces one of the principal fruits of that area and is botanically classified as Manilkara zapotilla (Jacq.), (syn. Achras zapota L.). It is a tree from 20 to 60 feet, dense head of dark green leaves and grey-brown bark. It is a desirable shade tree and seldom requires pruning. Young trees should be well-fertilized for good growth. Organic fertilizers and mineral fertilizers will make conditions favorable for production of good-quality fruits. The fruits mature and ripen in the fall months. The sapodilla is a dessert fruit to be eaten raw. It can be used for sherbets or ice cream. It contains appreciable amounts of calcium and phosphorous as well as Vitamin A, B and C. The plant has been introduced to Ponape and Palau where it appears to grow well and its propagation and development should be promoted as a fruit, timber and shade tree.
Achras sapota (sapodilla or chico). a, Habit with fruits; b and c, details of flower; d, habit with fruit and flowers; e, section of fruit.
MANGOSTEEN - The Mangosteen, Garcinia mangostana L., is a native of Malaya. It is a medium-sized tree to about forty feet with large dark leathery oblong, pointed leaves and campanulated branching. It prefers a heavy clay soil with high rainfall and protected from heavy winds. It produces fruit from seed-planting in eight to ten years. The fruit is about three inches in diameter, dark violet when ripe with white, creamy, sugary segments with a few seeds. It is regarded as one of the most delicious of all tropical fruits. It produces fruit in summer that mature in the late fall months. The tree has been introduced and propagated in Ponape where it appears to be well adapted. It should be propagated extensively in that district. It contains sugar, phosphorous and calcium and a small quantity of ascorbic acid. The tree has also been introduced to Palau but has not been properly cultivated over the years to determine its adaptability there.

CARAMBOLA - Like a number of other fruits, the carambola, botanically described as Averrhoa carambola L., is considered to be native of southeast Asia. The history of its introduction to Micronesia is not known but is believed to be in recent times. It is grown in semi-cultivation in all districts of Micronesia except the Marshalls where the soil is unsuitable for its proper growth. Its upright pendulous growth is rapid and reaches about 25 feet in a few years. The leaves are pinnate and the four to five inch long yellow-green five-ribbed fruits are
Averrhoa carambola

a, flowering branch; b, fruiting branch;
c, flower; d, section of flower; e, fruits; f, transverse sections of fruits
borne throughout the crown twigs. The thin waxy rind encloses a juicy pulp and several smooth brown seeds. There are two varieties known in Micronesia, the sweet and the sour fruited carambolas. Carambola juice contains 10% sugar. It is a fair source of niacin and a good source of Vitamin C. The sweet variety is good as a fresh fruit and makes a handsome dooryard plant. The soft pulp of the fruit has a pleasant taste and is refreshing when eaten ripe or used in an iced drink.

(ix.) TERMINALIA - The **Terminalia catappa** L., or tropical almond, is a medium to large tree from the East Indies grown as an established plant throughout the tropical world and Micronesia. It is found on all inhabited islands of the Territory. It thrives near and within the sandy strand of the islands. The branches are horizontal, widespread, arranged in tiers and bear large rosettes of thick shiny, inverted-ovate, short-stemmed leaves 6 to 12 inches long. Among the green leaves is often a scattering of red leaves. The tree drops its leaves, then a new flush sprouts immediately. It is a handsome tree, good for strand landscape, timber and the nuts serve as a source of food to be eaten fresh or roasted and made into candy or condiments. It is a tree of economic value and should be planted for strand landscape, shade and food production in Micronesia.

(x.) MALAY APPLE - The Malay apple, *Eugenia malaccensis* L. (syn. *Syzgium malaccense* (Linn.), is a native of the Malayan Archipelago. It is an established plant in Palau, Ponape, Yap and
Terminalia catappa
the source of Indian almond oil.
MYRTACEAE

Syzygium malaccense

e, Habit with flowers; b and c, details of flowers;
d, fruits; e, section of fruit.

Malay apple
Truk where it appears to do well under heavy shade in the mountain valleys of these areas. The tree reaches 50 feet, is columnar in growth habit and produces flowers from the trunk and branches in six to eight years. Fruits develop in late summer and the fall. The fruits are light red to crimson skinned when ripe and the pulp is white encasing two brown seeds. The fruits are eaten fresh or made into pickles. This fruit is a fair source of Vitamin C but poor in other vitamins and minerals. The fruits are crispy, sweet to bland depending on the variety. There are other species found in the islands of Micronesia including the *E. uniflora* (Surinam cherry); *E. jambos* (Rose apple); and *E. aquea* (the wax or bell apple).
IV. SUMMARY

1. Secondary Plants Grown in Micronesia

In this category are listed annual vegetable crops which are grown mostly in the Mariana Islands and in the district centers of the Caroline Islands; these generally include Chinese cabbage, cucumbers, corn, beans, okra, radishes, leaf lettuce, sweet peppers, head cabbage, tomatoes, green onions, eggplant and melons. Vegetables are produced primarily for export to the Guam market and sale to foreigners in district centers.

There should be strong effort made to teach the use of more vegetables to maintain a balanced diet by Micronesians living in district centers. This can be done by training in dietetics and home economics in the schools and by promoting the growing of proper school gardens. Priority should be given to establishment of a suitable vegetable marketing system in all main population centers of the Territory.

Other economic plants which have been introduced and established in the Territory are the Chinese yam bean (Pachyrhizus erosus, Urban); the Pomegranate (Punica granatum, L.); African oil palm (Elaeis guineensis Jacq.); the governor’s plum (Placourtia spp.); the giant almond (Terminalia kaernbachii, Warb.); the Panama berry (Muntingia calabura, L.); the Mammee apple (Mammea americana, L.); the pili nut (Cannarium commune, L.); the Malabar
Chinese Yam Bean
Punica granatum (granada or pomegranate).  a. Habit with fruits and flowers; b. section of flower; c. section of fruit.
Annona squamosa (sugar apple)  

a, Flowering branch; b, branch with mature fruit; c, longitudinal section of fruit; d, details of flower.
chestnut (Pachira aquatica, Aubl.); the horseradish tree (Moringa oleifera, Lam.); the edible Barringtonia (Barringtonia edulis, (L.) Kurz.); the sweetsop (Annona squamosa', L.); the rambutan (Nephelium lappaceum, Linn.) and the Inga tree (Inga laurina). All of these plants will add to the improvement of diet, timber resources or leguminous shade and windbreak and these plants should be cultivated under the proper conditions throughout the Territory.

2. Technical Problems of Subsistence Agriculture

(This subject must be considered separately for low coral islands and high islands.)

(i.) Low Coral Islands - Agriculture on these islands is restricted by three main factors; salt spray, rainfall and nature of soil. The salt spray factor is constant and crops that are susceptible to damage must be grown in the interior, the lee side of islands or protected by windbreaks. Those coral atolls which receive less than 40 inches of annual rainfall are very limited because of prolonged drought; those with 40 to 100 inches of rainfall are more favorably disposed for cropping but are also limited in fresh ground water supply; those with over 100 inches of annual rainfall are most favorable for crop production. There are only a few uninhabited islands of the Northern Marshalls that are in the first category. Other inhabited atoll islands of Micronesia receive enough rainfall to maintain enough ground water to grow coconut, breadfruit and other food crops.

As mentioned earlier, low island soils consist almost entirely
of calcium carbonate. These soils are not productive unless they contain large quantities of humus. Excess of lime causes cultivated plants to develop the abnormality known as chlorosis, the yellowing of leaves and in extreme cases, death of the plant. The islanders' answer to this situation was the development of "pit" cultivation which takes into consideration the availability of water and improvement of soil by accumulation of humus. The development of copra production and other economic activities has caused the gradual abandonment of this system of low island farm practice. This is still applicable though, where population pressure, limited financial resources and isolation require intensive food production methods.

Other techniques that must be employed to maintain a good subsistence agriculture program include intensive use of prepared compost in garden soils to improve texture and fertility; continuous mulching to reduce evaporation and suppress weed competition; the use of iron and manganese salts or by burying of metals in the soil; by cultivation and utilization of cover legumes and green manure for addition of nitrogen and humus to soils; the use of proper windbreaks.

It will probably not be possible to maintain or re-establish traditional farming methods on atolls in Micronesia now and for the future. The use of imported foodstuffs will most likely become widespread in most low coral islands. There are two possible answers to the resultant diet deficiency. One is migration
and the other is production of supplementary vegetable foods in home gardens.

(ii.) High Islands - On some high islands of Micronesia there is a need for establishing a balance between the continued development of cash farming and the maintenance of a suitable level of subsistence horticulture; increasing population and urban development will add to this problem. This may be obtained by a system of semi-commercial subsistence production in which a few farmers produce subsistence crops by concentrated, intensified methods. Other ways are to promote intensified gardening methods through crop rotation and artificial fertilization with compost, green manure and commercial fertilizers.

There are some high islands of Micronesia which may develop the problem of too little arable land to ensure proper subsistence for the population by traditional methods alone. There are islands where the central hills have been depleted by natural weathering, by burning, or by harmful agricultural practices and agricultural activity is restricted to the lower slopes and coastal areas. The higher interior areas of Palau and Yap are good examples. Reforestation of the depleted areas and growing of taro in swampy coastal areas is a solution. Improvement of the vegetable food pattern and employment of improved agricultural methods is another.

3. The Modern Vegetable Food Pattern

Since the time of the arrival of the early Europeans, there
has been a continuous program of economic plant introduction to
the islands of Micronesia. The early missionaries and even
whalers introduced plants to the islands or carried certain
desirable plants between the islands. The Spanish colonists
brought in many useful plants. During the German administration,
formal agricultural stations were established in some islands
and these were continued and expanded to the maximum for plant
introduction and testing during the Japanese administration.
The American administration has continued the program of plant
introduction and testing in all districts. New species and
varieties of coconut, cacao, Colocasia taro, banana, Xanthosoma
taro, mango, breadfruit, avocado, cassava, sweet potato, spices,
timber and annual vegetable crops have been introduced, tested,
propagated and distributed to local inhabitants for propagation
as commercial and food crops. The continued evaluation of the
quality of local varieties of crops and introduction of new
species into the Territory to control disease, resist insects
and improve quantity and quality of production is of prime
importance to the life of the people and a necessary function
of the agriculture program.

The attempt to improve subsistence agriculture in Micronesia
should be based on maintenance of soil fertility to permit
intensive land utilization. Good examples of intensive land
utilization by established local techniques are Colocasia taro
production in Palau and yam culture in Ponape whereby careful
soil preparation and fertilization techniques produce heavy crops. The above traditional techniques are time-consuming though, and modern methods of soil fertilization and crop rotation will be a sound program for development.

Each high island district needs to work out a subsistence crop rotational pattern for the major islands involved. These may involve a given unit of acreage and crops such as yams, taro, sweet potatoes, legumes, vegetables, bananas. In the Marianas this may involve temporary legume fallow and pasture. In Ponape it could involve cash crops such as pepper and rice. In any event, development of this program will depend on strong agricultural promotion and extension work programs. An intensive cropping system must also include the use of artificial fertilizers. The relative value and cost of compost, green manures, cover crops and inorganic fertilizers must be taken into account in their selection for employment. Irrigation established for use in taro and rice lands and vegetable cropping areas in some districts should be retained.

Since the trend in modern Micronesia is abandonment of subsistence economy, the problem confronted is the avenues remaining for local farm production. The following development possibilities are suggested by many Pacific territorial agriculturists and administrators:

(i.) Establishment of a system of agriculture based on cash and subsistence production.
(ii.) Development of home gardens.

(iii.) Production of selected local crops for nearby centers of population by intensive truck farming using modern methods of production.

Where subsistence agriculture is partially maintained then, an attempt should be made to hold a balance with cash crop production. Where it has been abandoned for imported foods, an effort should be made to encourage home gardens. The establishment of a system of truck farming for production and sale of vegetables to wage earners in urban centers will need to be developed in all districts.

4. Agriculture Extension Program

Island agricultural assistants must be well-trained, energetic and devoted and must be respected in the community. It is important that agricultural officers and assistants know that their purpose is to promote new crops and methods without upsetting or destroying techniques based on long understanding of the local conditions.

It has been continually recommended in the past that district agriculture stations establish collections of common varieties of economic staple food plants grown in the area. The purpose of this is to observe the habit of growth, maturity rate, yield and disease and insect tolerance. This is a simple method for selection of better varieties and improved methods of culture. This will permit development of simple demonstrations for all types of crops for training students, teachers and observance by local farmers. On the whole, both subsistence and cash crop agriculture must be directed, modernized and strongly supported by the government.
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