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File: HPED / Nutr

March 1, 2000

Marjorie,

These are some articles from the Nutrition files for you. There are more references on the bookshelves too, if you need additional info. Please share with your publicist/editor.

The "Hawaiian Moving Company", KGMB Sunday night had a story about a women who saved her daughter's life w poi. She's now trying to make a commercial product of her poi concentrate. Call Michael Perry for more info

Mahalo for the wonderful evening. My Kauai family loved the products

Aloha
Claire

SOME DIETETIC FACTORS INFLUENCING THE MARKET FOR

Poi in Hawaii

VIRGINIA DERSTINE and EDWARD L. RADA

AGRICULTURAL ECONOMICS BULLETIN 3

UNIVERSITY OF HAWAII

JULY 1952

SOME DIETETIC FACTORS INFLUENCING THE MARKET FOR *Poi in Hawaii*

with emphasis on a survey of the use
of poi by the medical profession
and allied institutions

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AGRICULTURAL ECONOMICS BULLETIN 3
UNIVERSITY OF HAWAII, COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
DEPARTMENT OF AGRICULTURAL ECONOMICS
JULY 1952

ABSTRACT

Scientific studies of poi, as reported in the literature, indicate that it is a carbohydrate food of high nutritional quality. If it is permitted to ferment for a few days, it has the unusual ability of undergoing a self-purifying process by which the number of bacteria in it are ultimately reduced and during which any pathogenic bacteria that might be present are killed. The fermentation process appears to be associated with the ease of digestion and the high assimilability of its component elements, such as calcium and phosphorus. This trait is very important for infants with comparatively weak digestive systems and for the aged and convalescent who find digestion difficult.

The mineral content of home-mixed poi (diluted to about 18 percent solids) compares favorably with that of white potatoes and rice on a per-serving basis. The calcium content is higher than that of white potatoes and rice. The phosphorus content is slightly lower than that of rice and potatoes and substantially lower than that of most enriched cereals as listed by Bowes and Church (Appendix A, table 4). The calcium and phosphorus of poi are well utilized by humans. On a per-serving basis, home-mixed poi contains more iron than potatoes and rice. Analyses of taro have shown the presence of minerals other than calcium, phosphorus, and iron; it also contains copper, magnesium, manganese, potassium, sodium, and zinc in small quantities.

Taro starch is as readily assimilated as that of rice and more so than potato starch. Like potatoes, but unlike rice, poi has an excess of basic elements in the ash which may be important in building and maintaining sound teeth. Poi in general is not a satisfactory source of vitamin A, but home-mixed poi contains more per serving (as reported by Bowes and Church, Appendix A, table 4) than potatoes or rice and most cereals or cereal products, which are practically devoid of vitamin A. It contains less ascorbic acid (vitamin C) and thiamine than cooked white potatoes. Rice and other cereals, however, contain no vitamin C. A serving of home-mixed poi has a higher caloric value (and a higher carbohydrate content) than brown and white milled rice, white potatoes, and the enriched cereals. All the food values of home-mixed poi are lower than those in an equal amount of taro because of the water that is added in converting taro to consumable poi.

Cooked taro compares favorably with rice, potatoes, and cereals (not enriched) in its B-vitamin content. It has more thiamine than white rice and about the same quantity as white potatoes and cooked brown rice. The riboflavin and niacin contents of cooked taro about equal those of rice and potatoes. Only the enriched cereal products have higher B-vitamin values.

Prepared baby foods, such as Pablum and other cereals with which poi would have to compete as a baby food, are all heavily fortified or enriched

with minerals and vitamins, especially thiamine (vitamin B_1), calcium, and phosphorus.

The survey of the medical profession revealed that a majority of the doctors in the Territory recommend poi both as a staple food for healthy infants and children and as a food for individuals with specific health problems. There is no substantial difference between the number of doctors who consider poi a good food for children and those who so recommend it in actual practice. The principal merits of poi as a food for children, in the opinion of territorial doctors, are that it is a nutritious carbohydrate food, highly digestible, with a good mineral and vitamin content, and that it is well tolerated and practically nonallergenic. It is impossible to determine from the returned questionnaires exactly how many allergies to poi have been known, but they seem to be relatively rare.

Poi's most popular therapeutic uses are in convalescent or soft diets, cases of malnutrition, allergies to cereals, for elderly persons without teeth, and for people with gastric ulcers. The specific ailments checked depend to some extent on the type of practice of the individual physician. For instance, a high percentage of pediatricians consider poi useful in cases of malnutrition and allergies to cereals, and the highest response from internists was for convalescent, soft diets (90 percent) and elderly persons with no teeth (90 percent), followed by malnutrition (70 percent), cereal allergies (60 percent), gastric ulcers (40 percent), and hyperacidity (40 percent).

A few doctors consider poi not sufficiently sterile for a baby food or for therapeutic use. It should be noted, however, that the questionnaire made no distinction between canned and fresh poi. Canned poi is generally considered sterile. There was no preponderant opinion as to whether poi should be eaten fresh or sour. Only five doctors (4 percent of the 126 replying) recommended sour poi or indicated that the fermentation of poi kills most of the harmful bacteria that might be present in it before it ferments.

The frequency of feeding poi to healthy infants and children apparently depends on the individual child—weight, age, appetite, or other factors. Most doctors suggested that babies should be started on poi at 2 to 4 months of age, 3 months being the age most frequently indicated. The majority of doctors responding indicated that, as a baby food, poi should be packaged in about 4-ounce sizes, but for therapeutic uses in 8- to 16-ounce sizes. Response to the questions concerning cereal allergy cases and patients on poi-containing diets was inconclusive. The only significant conclusion derived from the suggested improvement in poi is that almost half of the respondent doctors thought processing conditions should be more sanitary.

Six out of 97 doctors considered the likes and dislikes of the patient or family as a major factor in recommending poi. About half of the doctors stated that they leave the choice of taste, that is, "sweet or sour," to the patient or family. To obtain satisfactory answers to these questions, studies are needed to determine consumer taste preferences for poi and

whether its competitive position with other foods can be enhanced by altering its flavor, appearance, consistency, texture, or composition.

A number of doctors said they did not know enough about poi, and some requested data as to its food value and composition (see Appendixes D, E, and G). This report should satisfy the need for such information.

The institutional survey indicates that the use of poi in hospitals varies widely. Dietitians in general regard it as high in nutritional value and include it in many restricted diets (especially soft diets) and for children, although some consider it merely a substitute staple carbohydrate food for rice or potatoes. It appears that more poi would be used in several hospitals if they could afford to buy it. Tuberculosis hospitals serve poi to their patients to a considerably greater extent than do general hospitals (tuberculosis patients receive an average of slightly more than 1 pound per week per patient). Poi is well received by mental patients. Hansen's disease patients are the greatest consumers among the hospitals, averaging about 4 pounds per person per week. This may be because sufferers from this disease seem to have unusually large appetites and consume all foodstuffs in large quantities. The per capita consumption of poi among them is somewhat higher than the 3.6 pounds per week per patient used by a home for Hawaiians and part-Hawaiians, who might be expected to be heavy poi users.

As to the type of people who will or will not eat poi, opinion differs, although it seems that elderly people of any race not native to Hawaii are unlikely to eat it. People of any racial background may like poi if they are long-time residents, and are likely to eat poi if they have been accustomed to it since childhood. The preference for poi in the institutions, among the people who eat it, depends largely upon the meat dish, more patients choosing poi with fish than with meat. Only one institution reported that children will not accept poi readily, the experience in most hospitals being that they do.

The results of research and experiments to date lend confirmation to the general opinion that poi is a food of considerable nutritional value. There is need for more laboratory research to study further the nutritive qualities of poi and for clinical research by the medical profession to test its usefulness in various types of disorders or diseases.

CONTENTS

ACKNOWLEDGMENTS

The assistance of territorial physicians, dietitians, and members of the administrative staffs of hospitals and allied institutions in supplying information in this survey is gratefully acknowledged. Special recognition is due those doctors, Department of Health officials, and personnel in the Agricultural Experiment Station and other departments within the University who cooperated in pretesting the medical questionnaire and who contributed advice and assistance. The Hawaiian Sugar Planters' Association librarians and Territorial Medical Association personnel were helpful and most generous with their time. We extend thanks to all who rendered assistance in this investigation.

This study was conducted with funds allotted to project 7x by the Industrial Research Advisory Council, under Act 122 of the 1949 Territorial Legislature and Act 217 of the 1951 Territorial Legislature, and to project 355 under the Research and Marketing Act of 1946.

Cover picture courtesy of Stewart E. Fern

INTRODUCTION

This study was conducted in the spring of 1951 as part of an investigation of mainland market potentialities for Hawaiian taro products. Taro is an important agricultural crop in the Territory. For centuries poi, the most important taro product in the Islands, was a staple food for the Hawaiian people, but grain foods have largely replaced poi as the staff of life in the diet of most of the present residents of Hawaiian ancestry. However, poi is still a staple carbohydrate food for many people, particularly Hawaiians and individuals of part-Hawaiian ancestry. It is said that the fine physiques and sound teeth of the ancient Hawaiians testify to the adequacy of their diet (**1, 9, 11, 13, 16**), yet that diet was lacking in two items which are generally considered essential: grain and milk. The principal staple foods were taro (mostly in the form of poi), fish, and sweetpotatoes. The fruits available were coconuts, breadfruit, bananas, berries, and mountain apples. The main green vegetable was luau, the leaves of the taro plant; seaweeds were eaten, but as a relish rather than as a vegetable (**12, 13, 14**). It is also said that the early Hawaiians consumed as much as 10 to 20 pounds of poi (30 percent solids) daily, depending on the nature of their work and the amount of poi available (11). Since poi was consumed in such quantities and the Hawaiians possessed such fine bodies and teeth, it is generally assumed that poi was of special nutritional importance in their diet.

It is unlikely that poi can be introduced readily into the diet of the mainland adult population as a staple food, for several reasons: (1) the difficulty of changing eating habits of the usual mainland adult; (2) the inadequacy of taro production in Hawaii to supply an extensive mainland market; and (3) the abundance of less expensive competitive foods. The most likely immediate market for poi on the Mainland, therefore, would be as a therapeutic and/or baby food rather than as a staple.

Before instituting research to determine the size of a mainland market for poi as a therapeutic and/or baby food, an investigation was made and information assembled on the use of poi in the Hawaiian Islands for these purposes. Literature was reviewed to ascertain whether scientific investigations or clinical tests of the chemical and nutritional properties of taro and poi substantiate the established belief that these products have special nutritional importance. A mailed questionnaire survey of territorial physicians was conducted to determine the extent to which poi is recommended by them as a food for healthy infants and children and for therapeutic use. An investigation was also made of territorial hospitals to procure information on the actual consumption of poi in the hospitals and to obtain the comments of dietitians as to its use. A similar investigation was made of Oahu institutions other than hospitals, such as children's homes and homes for the aged.

MICROBIOLOGICAL, CHEMICAL, AND NUTRITIONAL PROPERTIES OF POI

Nearly all the scientific studies on the properties of poi have been conducted by the University of Hawaii, mostly in the past quarter century. A flurry of investigations took place in the 1930's when local interest was high in what appeared to be rosy prospects for the manufacture and export of nutritious taro products. Basic composition studies were completed at that time, but little follow-up work in nutritional and clinical tests has been performed. Condensed results of the important scientific investigations conducted to date that have a bearing on the planning and findings in this survey are presented in this section.

Poi is manufactured by a simple process of grinding the cooked taro corm (the bulbous, potato-like, underground stem) into a paste and mixing it with water. The amount of water added depends on the individual preference. By regulations of the Territorial Board of Health,[1] poi can be marketed in three consistencies: (1) that labeled "Poi" must contain at least 30 percent total solids; (2) poi containing sufficient water to make it less than 30 percent but not below 26 percent solids must be labeled "Substandard Poi"; and (3) poi mixed with water and containing less than 26 percent but not less than 18 percent solids must be labeled "Ready-Mixed Poi."

MICROBIOLOGICAL ASPECTS

One of the interesting aspects of fresh poi is the fermentation process which it undergoes. When freshly ground poi is mixed with water and left at room temperature to ferment, it smells slightly and changes from a heavy, sticky substance to a lighter and less viscous material, acquires an acid odor and a sour taste, and, depending on the variety of taro, bleaches or changes color. Some consumers prefer freshly ground poi, while others claim that it has a flat taste and that the sour, fermented product is more palatable.

Paiai, the cooked, crushed taro corms (not mixed with water), when wrapped in ti leaves as done by the early Hawaiians, could be kept for several months without fermentation. When water was added and the poi left to incubate, it fermented (**1, 11**). Canned or bottled poi, sterilized and hermetically sealed by heating, does not undergo the natural fermentation process after the container is opened. If exposed, however, this poi will mold or spoil in a few days. Fermentation does not occur in taro flour or dehydrated, ready-mixed poi when water is added. In this case, the acid-forming organisms normally present on cooked corms and in poi are killed during the drying process (**5**). The freezing of poi also stops fermentation.

The acid fermentation process that takes place in fresh poi is similar to that of the souring of milk or the preparation of sauerkraut and is due primarily to the action of lactic acid-producing bacteria (**1**). The micro-

[1] Public Health Regulations, Board of Health, Territory of Hawaii, chapter 4, section 5.

organisms present attack the carbohydrates, and, as fermentation proceeds, the starch content of poi decreases slightly (3, 11). Acid production is usually very rapid within the first 24 hours, changing from pH 6.3 to 4.5. Acidity increases less gradually thereafter; the lowest pH is reached during the fifth or sixth day of fermentation (1).

More recent bacteriological studies show that fresh poi, experimentally inoculated with pathogenic enteric bacteria and stored at room temperature, could purify itself—the pathogenic bacteria being killed—in about 3 days, probably in consequence of the fermentation process (6).

MINERAL AND VITAMIN CONTENT

A number of analyses have been made of the composition of taro and poi, and, as could be expected, the findings vary with the product analyzed. The research team of Bilger and Young (3), for instance, found the composition of fresh poi to be as shown in table 1.

Table 1.—Composition of fresh poi.

Component	Percent
Moisture	69.3
Starch (takadiastase)	27.0
Pentosans	1.3
Reducing sugars	0.5
Sucrose	0.03
Protein	0.31
Fat	0.07
Crude fiber	0.39
Ash	0.46
Phosphorus	0.057
Calcium	0.018

Earlier, Carey D. Miller (11) analyzed steamed taro corms (Appendix A, table 1) and the composition determined approximates that in table 1. Later, Payne, Ley, and Akau (15) analyzed air-dried, cooked taro of four different varieties (Appendix A, table 2). Their findings show some variation in composition among taro varieties. The upland varieties contained less starch but more of the complex sugars and ash than did wetland varieties. These investigators went farther than the others and determined the kinds and amounts of inorganic elements present in taro (Appendix A, table 3). They found that taro contains quantitatively more potassium than any other inorganic element. Phosphorus, calcium, and magnesium, as well as a number of other minor elements, were found in lesser amounts.

Again, the upland varieties, particularly **Mana opelu**, were the highest in mineral content. Nutritionists at the Hawaii Agricultural Experiment Station (11, 14, 16) have been concerned also with the vitamin content of taro and poi. The food values, including vitamin content, of taro and home-mixed poi and those of selected competitive foods are reported on a per-serving basis in Appendix A, table 4. Home-mixed poi (diluted to about 18 percent solids) is used for comparative purposes because this is the form in which poi is generally consumed. Standard and substandard

poi (see p. 8) are considered much too viscous to be eaten readily. About three fourths of a cup of home-mixed poi is the amount of the average serving.

In general, home-mixed poi has a vitamin-A content about three times that of potatoes and almost as much vitamin B_1 (thiamine). The thiamine content is substantially greater than that of white rice and about three fourths that of whole-wheat flour (16). Miller, Louis, and Yanazawa (14), in a recent study (1947) of the vitamin values of various foods grown and used in Hawaii, state that taro and poi are good sources of thiamine when compared on the caloric basis with whole-grain products. They conclude that, of these foods (including breadfruit, potatoes, sweetpotatoes, squash, and pumpkin) high in starch and sugar, it would seem to be as true as of whole grains that they have "adequate thiamine to take care of the metabolism of the carbohydrates which they contain. . . ."

Taro, for human use, must be cooked in one way or another to destroy the calcium oxalate crystals in the raw corms and leaves that cause extreme irritation in the mouth and throat (15).

Cooked taro is a highly nutritious, starchy food (Appendix A, table 4). Its caloric and carbohydrate values are slightly greater than those for cooked or baked white potatoes and brown rice but are slightly less than for cooked white rice. Its vitamin content of thiamine, riboflavin, and niacin about equals that of cooked white potatoes and generally exceeds that of rice.[2] The vitamin-A content is superior to that of potatoes and rice and all cereals and cereal products. Its mineral composition compares favorably with that of potatoes and rice and it exceeds both in calcium content. The greatest deficiency of taro and poi is in their protein content, as compared with potatoes, rice, and cereal foods. Almost all of the cereal foods listed in Appendix A, table 4, except rice and tapioca, are superior to taro and poi in protein content. Most of the cereals listed in this table are enriched with calcium and the B vitamins and cannot, therefore, be fairly compared with taro and poi in their content of these nutrients.

As a staple food, poi must be eaten in relatively large quantities to provide what nutritionists consider the minimum basic food requirements. It has been calculated, for example, that 5 pounds of poi (30 percent solids) daily would provide about three fourths of an adult's daily calcium requirement and more than the minimum daily requirement of phosphorus (11). Based on the information contained in Appendix A, table 4, it appears that the food values are somewhat lessened when taro is cooked, milled, and diluted with water to make poi.

ALKALINITY

In some foods the acid-forming elements exceed the alkaline, and in others the alkaline-forming elements predominate. The chief acid-forming elements in food are sulfur, phosphorus, and chlorine, usually found in meats and foods rich in protein. These foods are acidic in their effect

[2] Unpublished findings of the Foods and Nutrition Department, Hawaii Agricultural Experiment Station.

on the body. The important alkaline-forming elements—sodium, potassium, calcium, and magnesium -are generally predominant in fruits and vegetables (with some exceptions). These foods are alkaline in their effect on the body. In taro and poi the alkaline-forming elements exceed the acid-forming ones (Appendix A, table 3).

It has been claimed that a diet providing the proper acid-base balance with an alkali excess will insure sound teeth (9). When babies at the infant feeding center of the Ewa Plantation Health Project (started in 1930) were fed a diet in which poi and sweetpotatoes provided the carbohydrate supplement (potential alkalinity of the diet, 36 to 40 cc. N alkali solution), none developed odontoclasia (a form of tooth decay). A diet in which grain foods constituted the carbohydrate supplement (potential alkalinity of the diet, 6 to 10 cc. N alkali solution), fed to another group of children, did not prevent or arrest odontoclasia. Those who conducted the feeding experiments attribute the beneficial results of feeding taro and sweetpotatoes to the potential alkalinity of these foods. They believe that the type, rather than the amount, of carbohydrate in the diet seems to be the important factor in maintaining sound teeth in Hawaii (8).

DIGESTIBILITY

Langworthy and Deuel (10) found by experiment that the raw starches of rice and taro root were considerably more digestible than arrowroot and potato starches, taro starch being 98.8 percent assimilable. They concluded that there seems to be a direct relationship between the size of the starch granules and their digestibility. Payne, Ley, and Akau (15) measured the starch granule size of one variety of taro (**Kau uliuli**) and found it to be approximately one tenth the size of a potato starch granule but about the same order of magnitude as the starch granule of rice.

Studies on the utilization of calcium and phosphorus by rats and humans indicate that these elements are well utilized physiologically. The study with rats (17) showed that the calcium and phosphorus in taro were found to be 90 percent as readily utilized by young rats as that of calcium acid phosphate salts (the control diet). Generally, the calcium and phosphorus, as they exist in natural foods, are not always as well utilized.

In a separate study (18), calcium and phosphorus balances were determined on two healthy women (a Caucasian and a Japanese) on two diets, one high in taro and one high in white rice. Taro (in the form of poi) furnished about 80 percent of the calcium and 40 percent of the phosphorus in the first diet; rice furnished about 30 percent of the calcium and 35 percent of the phosphorus in the second diet. The conclusions were that the calcium and phosphorus of taro are well utilized by women, but that "the need for additional calcium balance experiments on Oriental and Caucasian subjects seems indicated."

NONALLERGENIC PROPERTIES

Historically speaking, the study of food allergies, their causes, and their effects is of recent origin in medical and allied professions. Starch allergies, especially corn and wheat, are known to be prevalent in the United States. A review of the literature on the subject and correspondence with

allergists indicate that little consideration has been given to the use of poi on the Mainland as a substitute nonallergenic food.

Dr. Albert H. Rowe (**19**), in an allergy handbook published in 1944, noted that "The most commonly eaten grains produce most allergy. Thus, wheat is certainly the chief offender in America, whereas in Japan rice, and in the Scandinavian countries rye may be the chief cause of allergy." He says of taro: "Taro, kalo (**Colocasia antiquorum esculenta**) is grown in many varieties in the Hawaiian Islands, Tahiti, Japan and the East and West Indies as an important source of starch. Poi is fermented paste pounded from its roots. The roots may be eaten as potatoes. The cooked leaves are a palatable vegetable." However, this author does not indicate whether he has tried taro or poi in any of his allergy-elimination diets.

Dr. Walter C. Alvarez (**2**) suggested taro or poi as a substitute allergy food, saying that "This tuber is tasty and highly digestible, and so different botanically from any American food that it should be acceptable to many highly allergic patients."

At one time, taro flour was produced in Hawaii by cooking the corms and grinding them into poi which is then refrigerated, shredded, dried, ground, and sifted. According to Payne, Ley, and Akau (15), Christine Laird, of the University of California Hospital in San Francisco, investigated taro flour for its allergic properties. They quote her report as follows:

> Our products were made egg-, milk-, and wheat-free. They were distributed to patients attending the clinic and also to allergenic patients in the Hospital. Recipes were frequently altered to fit the restrictions of the patient's diet. At no time did we find a case which was sensitive to taro flour.
>
> Due to the mineral and vitamin content, alkaline ash and caloric value of taro products they are a valuable adjunct to hospital diets.

Dr. Lawrence J. Halpin, an allergist of Cedar Rapids, Iowa, and a contributing editor to **Annals of Allergy**, states in a letter to Edward L. Rada (March 21, 1951) that, while stationed in Honolulu with the armed services in World War II, he "... had the opportunity to use poi as a cereal or grain substitute. It was very satisfactory for the purpose for which it was employed in my patients at that time. Such substitution of poi has not been continued since my return to the Mainland."

In another letter to Mr. Rada (June 12, 1951), Dr. Halpin mentioned a discussion with other mainland allergists on the possible use of poi:

> Most of the comments on poi which I have received from my fellow allergists during the past several weeks have been made up of requests for samples of the material to try on known wheat-sensitive or other grain-sensitive patients. None of those men that have corresponded with me or with whom I have talked have had any personal experience with the use of poi. They, therefore, understandably have been rather reluctant to express an opinion other than the desire to try it and see whether such a substance would be an adequate substitute for wheat or any other grain to which a patient may be allergic.

SURVEY OF THE MEDICAL PROFESSION

The survey of the medical profession was conducted by means of a mailed questionnaire. The purpose was to obtain information from territorial physicians on the extent to which they recommended poi as (1) a staple food for healthy infants and children and (2) a therapeutic food for chil-

dren and adults. The doctors were encouraged to give frank, personal opinions about poi and to make suggestions for improving the product now marketed. A copy of the questionnaire is included in this report as Appendix B.

DESIGN OF QUESTIONNAIRE

Part A of the questionnaire (Poi as a Staple Food for Healthy Infants and Children) was designed to determine the extent to which poi is recommended as a staple food for healthy infants and children and its suggested or prescribed manner of use. It was believed important, preliminary to inquiring about recommended use in actual practice, to learn whether physicians considered poi a good staple food for children. If physicians theoretically consider poi a nutritional food but do not actually recommend it for children, it was felt that the reasons for the discrepancy between theory and practice might be significant. Therefore, doctors were asked to state whether or not they considered poi a good staple food and to give the reasons for their opinions.

Part B of the questionnaire (Poi for Therapeutic Uses) attempted to determine the extent to which poi is recommended by physicians for individuals (of any age) with specific health problems. Several specific health problems were listed—those which seemed (from the published data on the nutritional value and composition of poi) the most likely cases for which poi would be recommended. Special interest in the possible use of poi as a nonallergenic food in cases of allergy to wheat and other cereals prompted further inquiry along this line. Doctors were asked to state how many persons they knew to be allergic to poi. If poi allergies were common, particularly among cereal allergy cases, its use as a nonallergenic food would hardly be practical.

An illuminating response was not expected from Part C of the questionnaire (Suggested Improvements), except on nutritional questions, such as whether poi should be fortified with vitamins and minerals. The other questions were better suited to a consumer preference study, but they gave physicians an opportunity to make known their opinions. If a physician found the container, texture, color, or some other aspect of the product objectionable, it would probably have a bearing on the extent to which he would recommend poi to his patients.

NUMBER OF DOCTORS QUESTIONED AND RESPONSE TO QUESTIONNAIRE

Pretested questionnaires were mailed to physicians at the addresses listed in the "Roster of Physicians Licensed by the Territorial Board of Health as of August 15, 1950." The 351 physicians questioned excluded eye, ear, nose, and throat specialists, anaesthologists, and psychiatrists. Territorial Department of Health officials, retired doctors, those out of the Territory, or others not in active practice in the Territory at the time of the survey were not included in the 351 total or in any of the tabulations and calculations. The exclusions were based on information obtained from the Territorial Department of Health, the Territorial Medi-

cal Association, and returned questionnaires. The locations of the 351 practicing physicians questioned and of those responding are presented in table 2.

Table 2.—Number of territorial physicians questioned and responding and percentage responding, by location.

Location	Questioned	Responding	Percentage responding
Honolulu	235	104	44.3
Rural Oahu (all areas outside the city of Honolulu)	27	11	40.7
Hilo	26	9	34.6
Rural Hawaii (all areas outside the city of Hilo)	16	8	50.0
Maui	24	13	54.2
Kauai	16	8	50.0
Molokai	5	4	80.0
Lanai	2	2	100.0
Total	351	159	45.3

The total of 159 usable questionnaires (45.3 percent) returned was considered representative of the Territory's practicing physicians. About 75 percent of the physicians practice on the island of Oahu (which includes the city of Honolulu); consequently, their response materially affected the percentage of total questionnaires returned.

Professional classification of the 351 doctors questioned and the number responding are shown in table 3.

Table 3.—Number of territorial physicians questioned and responding and percentage responding, by professional classification.

Professional classification	Questioned	Responding	Percentage responding
General practitioners	204	76	37.3
Plantation doctors	41	28	68.3
Surgeons	28	14	50.0
Obstetricians–gynecologists	23	8	34.8
Specialists in internal medicine	18	11	61.1
Pediatricians	17	14	82.4
Dermatologists–allergists	10	7	70.0
Bone specialists	6	0	0.0
Tuberculosis specialists	4	1	25.0
Total	351	159	45.3

A composite tabulation of the number of physicians questioned and responding by location and type of practice is presented in Appendix C, table 5.

FINDINGS OF THE SURVEY

Answers to the three basic questions

Do you consider poi a good staple food for healthy infants and children?

Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children?

Do you, in actual practice, recommend the use of poi to individuals with specific health problems?

were tabulated and computed as percentages of the 159 questionnaires returned. The bases used for converting the answers to questions, other than the three basic questions, into percentage terms are indicated in the text below.

"Do you consider poi a good staple food for healthy infants and children?"

In answer to this question, 140 out of the 159 doctors responding answered "yes" (Appendix C, table 6). This represents 88.1 percent of respondent doctors. All 14 responding pediatricians considered poi a good food for children and 126 other doctors (almost 90 percent of those responding) were of the same opinion. Five answered "no"; four said they "did not know"; and 10 did not reply. Four of these 19 doctors, in reply to a subsequent question, however, stated that they recommend poi for children in actual practice (Appendix C, table 8). Three of the 10 physicians who did not answer th question replied that they did not see children in their practice. The reasons given by the five doctors who did not consider poi a good staple food for healthy infants and children are included in the list in Appendix D, pages 00 and 00.

Physicians who considered poi a good staple food for healthy infants and children were requested to state their reasons. Of the 149 responding, 98 (70 percent) complied (Appendix C, table 7). Many doctors listed several reasons, the most frequent (39 percent of the doctors responding) being that poi is nutritious, a good source of carbohydrates or calories, or a good substitute for cereal. (Included in this category were such answers as "Higher protein and calories than other baby food" and "Comparable to rice, potato, or bread.")

Other more specific properties of poi were mentioned. High digestibility was given as a reason by one fourth of the doctors who consider poi a good food for children. About one out of eight said that poi is well tolerated or at least apparently not allergenic. The high mineral content of poi was mentioned by 23 doctors; minerals enumerated included fluorine, calcium, and iron. High vitamin content was listed by about 11 percent (one doctor thought it high in vitamin D). Only six doctors mentioned that poi leaves an alkaline ash and two that poi aids in preventing, or at least does not contribute to, dental caries. Approximately 9 percent (13 doctors) said that poi is palatable or well liked. Ten of the reasons (7 percent) were rather general, simply indicating that children seem to thrive on poi, or that observation, experience in feeding, or tests have proved it to be a good food for children. (See Appendix D for these reasons.)

"Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children?"

In answer to this question, 79 percent of the physicians who returned questionnaires answered "yes" (either in all cases or in some cases) and 18 percent answered "no." The remainder (less than 3 percent) did not

answer the question (Appendix C, table 10). Of the 140 doctors who consider poi a good staple food for healthy infants and children, 122 recommend it in actual practice, indicating a slight discrepancy between theory and practice. (See Appendix C, table 8.) All 14 respondent pediatricians recommend poi for children in their practice; 43 percent recommend it in all cases and 57 percent in some cases. Doctors other than pediatricians do not always recommend poi for children in their practices. Twenty percent do not recommend it in actual practice, 36 percent recommend it in all cases, and 41 percent recommend it only in some cases. Four doctors did not answer the question.

Geographically, the percentages of doctors who recommend poi in actual practice for healthy infants and children differed -74 percent in Honolulu, 78 percent in Hilo, and 91 percent in all other areas (Appendix C, table 9). The 3 percent who did not answer the question practice in Honolulu.

Doctors who do not, in actual practice, recommend poi for all healthy babies and children were asked to state their reasons. (See Appendix C, table 11, and Appendix D for added comments.) One fourth of those who recommend poi in some cases (17 out of 68) gave the following reasons for not recommending it in all cases.

Likes and dislikes of the patient was the most important reason given. Others were that poi is expensive and not always easily available or sterile enough. Only two doctors felt that poi is not a necessity, and two doctors considered the inconvenience of preparation a reason for not always recommending poi.

Twenty-nine of the 97 doctors replying to this question do not recommend poi at all for children in their practice. The principal reason is that two thirds of the doctors (18 out of 29) do not see children in their practice. Three doctors consider poi not sufficiently sterile and two others consider the processing not sufficiently sanitary. Two doctors believe that poi has harmful results if eaten in excess.

There seems to be some divergence of opinion among doctors as to the age when the feeding of poi to infants should begin (Appendix C, table 12). About 64 percent of the pediatricians and 55 percent of the other doctors would start feeding poi to babies from 2 to 4 months of age. Thirty-two of the 126 respondent doctors (25 percent) felt that poi feeding should begin after the age of 4 months. (One doctor stated that he would not start babies on poi until they were 18 months old.) On the other hand, 18 doctors reported that they would feed poi to infants under 2 months of age.

Physicians were asked how frequently poi should be fed to infants and children (Appendix C, table 13). More pediatricians (43 percent) checked "Not daily, but in rotation with cereal foods" than any other answer. Other pediatricians (21 percent) would feed babies poi "Every day, as part of a main meal." None indicated "Every day, as a between-meal feeding, in a milk drink." Some combination of the three suggested answers was checked by almost one third of the pediatricians. One did not answer the question. More than half of the other 112 doctors who recommend poi

for children indicated "Not daily, but in rotation with cereal foods"; one out of four checked "Every day, as part of a main meal"; and only 8 of the 112 doctors checked "Every day, as a between-meal feeding, in a milk drink." The remainder checked some combination of the three suggested answers and three did not answer the question.

Physicians were also asked whether they recommend that poi be fed to children in the sweet state or the sour, or whether the choice should be left to parents (Appendix C, table 14). The majority of the 126 doctors replying were rather evenly divided between the opinion that sweet poi should be given and that the choice should be left to the parents. "Sweet" was the answer of 42 percent of respondent doctors, and "Leave choice to parents" of 43 percent. Only 5 of the 126 doctors who recommend poi suggested that the sour state is preferable. One general practitioner, who recommends sweet poi, added "sterilized." A plantation doctor who leaves choice to parents commented, "I always recommend that poi be heated [boiled] before giving it to infants and babies so it will be sterilized." Remarks by two pediatricians were, "I recommend only 'canned poi,' or, if fresh poi is used, I request that it be pasteurized in a double boiler, which is a great nuisance" and "I recommend sterilized poi for infants, either sterilized at home or purchased in sterile containers (glass)."

"Do you, in actual practice, recommend the use of poi to individuals with specific health problems?"

In reply to this question, 113 doctors (71 percent) of the 159 who returned questionnaires answered "yes." Table 15 (Appendix C) indicates that there is little difference geographically in the opinion of territorial doctors on this subject. More than 70 percent of the doctors in all areas recommend poi therapeutically. Table 16 (Appendix C) shows that the response to this question by type of professional practice varies somewhat. Ten of the 11 doctors who practice internal medicine recommend poi for therapeutic use. More than 70 percent of the general practitioners and plantation doctors (considered as one group) and pediatricians and two out of three of the other specialists recommend poi for therapeutic purposes.

Reasons given by doctors who do not recommend poi for therapeutic use are grouped in Appendix C, table 17. The exact comments are listed in Appendix E. Six of the 43 doctors who do not recommend poi therapeutically gave reasons, such as not believing poi to be of any particular therapeutic benefit or no better than or not as good as other available foods. Five general practitioners do not recommend poi because they do not consider it sterile enough or because it is not manufactured under sufficiently sanitary conditions. Surprisingly, however, two of them do recommend it in some cases for healthy infants and children. About two thirds of the reasons given for not recommending poi for therapeutic use indicated that the physicians had never thought of it, that no need for it had arisen, or that they were not familiar with the food value and composition of poi.

Physicians were asked to check the specific health problems for which they recommend poi (Appendix C, table 18). Seventy percent of the doc-

tors (79 out of 113) indicated "convalescent, soft diet" as a specific use. "Malnutrition" was next in order, at 59 percent; "allergies to cereals" third, at 56 percent; and "elderly persons with no teeth" next, 53 percent. Poi is also recommended for gastric-ulcer patients (31 percent), nursing mothers (19 percent), prenatal cases (18 percent), and hyperacidity cases (13 percent).

Almost all pediatricians recommend the use of poi in cases of malnutrition and allergies to cereals. Two pediatricians included answers in addition to those checked—"Sometimes it helps constipation" and "Useful during febrile illness, because of palatability."

Internists, on the other hand, indicated almost unanimously that they recommend the use of poi when a convalescent, soft diet is required or for elderly persons with no teeth. A majority recommend poi for malnutrition and allergies to cereals. It is also recommended extensively for hyperacidity, gastric ulcers, and nursing mothers. One internist prescribes the use of poi in mild gastroenteritis, and another in certain types of colitis.

General practitioners and plantation doctors (81 percent) indicated "convalescent, soft diet" more than any other therapeutic problem as the principal reason for recommending poi. More than half recommend it for cases of malnutrition, elderly persons with no teeth, and allergies to cereals. Poi is recommended by this group less frequently for gastric ulcers, nursing mothers, prenatal cases, and hyperacidity.

Other therapeutic problems not listed on the questionnaire but for which physicians stated they have prescribed poi are: "Weight gaining diets"; "some cancer patients"; "supplementary feeding"; "nervous dyspepsia"; and "feeding problems."

Replies to the questions asking how poi should be fed (sweet or sour) showed that 66 percent of the doctors who recommend poi for therapeutic use would leave the choice to the patients; 23 percent specified sweet poi and 4 percent sour poi. A few stated that their recommendation depended on the individual case (Appendix C, table 19).

"How many 'at home' patients now under your care are on a poi-containing diet, at your recommendation?"

This question was answered by less than half of the doctors who recommend poi for therapeutic use (Appendix C, table 20). Of the 62 doctors who answered the question, 44 had patients on a poi-containing diet, and 18 did not.

In connection with the above question, physicians were asked "How many of them have cereal allergies?" The responses to this question were such that it is impossible to show a relationship between cases of cereal allergies and the number of individuals on poi-containing diets. Neither was it possible to ascertain exactly how many individuals are allergic to poi (Appendix C, table 21). Seventy-nine percent of the 159 doctors returning questionnaires stated that they have never known of anyone allergic to poi, and 12 percent did not answer the question. Only 9 percent (14 doctors) indicated that they have known of poi allergy cases. Seven of these doctors were pediatricians. Six doctors have each known of only one individual allergic to poi. The other eight answered as follows:

"I have no definite figures on allergic reactions to poi. I probably see five or six a year. Cereal allergies are much more frequent—more so in mainland practice."
"A few."
"Five or six suspected, never confirmed in whole group. Two patients definitely allergic to poi."
"Only two cases."
"Several—perhaps two to six."
"Unknown."
"Rare case."
"About 1 percent, roughly. Have not time to go through my records but from memory would say this figure is about correct."

SUGGESTED IMPROVEMENTS IN POI

The percentage of doctors responding to the section on suggested improvements in poi was not high, and a wide variety of opinions was obtained from the doctors who did respond. (See Appendix F for remarks of doctors.) "Should be a uniform color" was checked by 41 doctors (26 percent). The preferred colors were diverse, including gray, pink, lavender, yellow, white, red, brown, and purple. Seven doctors checked "Texture should be changed," and four said that either it should not be changed or that the texture does not matter. A total of 41 doctors (26 percent of respondents) expressed an opinion on the question of fortifying poi with vitamins. Twenty-six of them thought poi should be fortified with vitamins; 10 doctors said it should not be; and 5 doctors said it was not necessary. "Fortify with minerals" elicited a response from 33 doctors, 17 of whom thought poi should be fortified with minerals; 10 doctors said it should not be; and 6 doctors said it was not necessary. Forty percent of the 159 doctors returning questionnaires thought the price of poi should be lower; 31 percent said the product is not sufficiently sterile; and 45 percent thought that processing should be more sanitary. Dehydrating to a powder form was considered a good idea by 41 (25 percent) of the doctors returning questionnaires.

In response to "Preferred type of container," 27 percent of the 159 doctors indicated glass, 9 percent tin, 20 percent cellophane bags, and 44 percent had no specific preference or did not answer the question.

Forty-nine percent of the doctors responding indicated a preference in size of container for baby food: 12 percent indicated 1 to 2 ounces; 18 percent, 2 to 4 ounces; 13 percent, 4 to 8 ounces; and 6 percent, 8 to 16 ounces. As a therapeutic food, 41 percent of the 159 doctors indicated preferences for size of container: 3 percent, 2 to 4 ounces; 14 percent, 4 to 8 ounces; 22 percent, 8 to 16 ounces; and 2 percent, 2 pounds.

Several interesting comments and suggestions were made by doctors, and considerable interest was shown by them in the various aspects of poi as a local baby and therapeutic food and for potential sale on the Mainland. Some doctors commented on their personal experience with poi—two said they did not like it themselves, two said they were brought up on it, and five mentioned the beneficial effects of poi on their own children (Appendix G).

Several questionnaires returned by doctors not in active medical practice were not usable for tabulation but nevertheless contained pertinent information. Their comments are listed in Appendix G.

INSTITUTIONAL SURVEY

The Hawaii Diet Manual (7) includes poi as a mid-afternoon poi cocktail in its recommended "full, house, regular, or general diet" and in many restricted diets. The latter diets include light or convalescent, edentulous, soft, full liquid, bland, modified Meulengracht, low residue-smooth, anemia, diabetic, pregnancy and lactation, elderly, and normal children's diets. Poi is also suggested as a substitute food for wheat allergies in infants (as Taro-Lactin or plain Taro-co). Publication of this manual was approved by the Honolulu County Medical Association and by the Hawaii Territorial Medical Association for the use of doctors, hospitals, clinics, plantations, and schools.

It was deemed of interest to ascertain the extent to which hospitals and other allied institutions include poi in the diets of individuals under their care. Therefore, Oahu hospitals and institutions such as homes for children, elderly people, and indigents were surveyed in the spring of 1951 to obtain information on the use of poi. Personal interviews were held at all Oahu institutions with head dietitians or other officials working with diets for patients, except for three plantation hospitals which were questioned by letter. Similar information was obtained by personal interview from most of the hospitals on Hawaii, Kauai, and Molokai. The remaining hospitals were questioned by letter. Answers were not received from five hospitals on Maui.

HOSPITALS

The weekly consumption of poi in territorial hospitals at the time of the survey is shown in table 4.

Table 4.—Amount of poi consumed per week by patients in territorial hospitals in spring, 1951.

Island	Hospitals	Patients	Poi consumed per week
	number	number	pounds
Oahu (includes one plantation health center)	21	5,264	2,041
Hawaii	10	366	340
Kauai	3	188	99
Molokai	2	275	1,125
Maui (five hospitals did not respond)	2	200	430
Lanai	1	5	—
Total	39	6,298	4,035

For the purpose of classification and analysis, the 39 hospitals are grouped by types as follows: general, plantation, tuberculosis, leprosarium, mental, private (convalescent homes and doctor-owned and -operated), children, and maternity. See Appendix C, table 22, for tabulation of hospitals by types, number of patients, and poi consumed per week.

Sixteen general hospitals in the Territory, with a total of 2,524 patients, reported the use of 461 pounds of poi per week. In one large hospital serving rice three times a day, poi is fed twice a day to tuberculosis patients, but to others only at their specific request. Those who request poi constitute less than 10 percent of the total number of patients and are mostly Hawaiians and Orientals. Occasionally a doctor will recommend poi to children in allergy cases. In another large general hospital, poi is served twice a week to those patients who choose it instead of rice or potatoes (10 to 15 percent of the total patients), but is given in the form of a poi cocktail to all soft-diet patients at 10, 2, or 8 o'clock, or oftener if desired. Poi is included in the elimination allergy diets.

In three out of four medium-size general hospitals (120- to 270-bed capacity), doctors occasionally recommend poi for children with allergies and for gastric ulcer cases, and it is included in other restricted diets (soft, diabetic, low sodium-high calcium). In one of these hospitals, poi is served on the house diet three times a week and would be used every day if the price were lower;[3] practically everyone likes it except elderly Caucasians and Orientals. In another medium-size hospital, about one out of eight patients requests poi regularly instead of rice or potatoes (sometimes three times a day) and about half want it on "fish days." If this hospital could afford it, poi would be served to the staff also. Another hospital, which serves poi once a week with fish, would put it on the regular menu if the price were lower; it reported good results with children. The other medium-size general hospital serves poi only when it is specifically requested (only about 1 out of 85 asks for it), it is never on the house diet; and the dietitian "would not think of using it as a substitute for whole-grain cereal," believing that "one serving of poi per week might be all right," but that "it is no better nutritionally than rice or potatoes," and that "doctors have gone too far in recommending it, without checking the food value."

Sixty percent of the 16 small general hospitals (less than 120-bed capacity) reported that doctors occasionally recommend poi (in two of the hospitals, for sick babies); 40 percent reported that doctors do not. In 50 percent of these small hospitals, poi is included on restricted diets without recommendation from doctors, but the patient is given a choice between poi and rice or potatoes. Only one third of the small general hospitals occasionally include poi on the regular house diet. Two of the 16 small hospitals do not serve poi unless it is specifically requested. One hospital does not serve poi at all, but would if the price were lower.

One small hospital would like to give poi to all babies and serve poi cocktails to all soft-diet patients but cannot afford to do so at present prices. In another hospital, Hawaiian patients bring their own poi.

Comments from three of these small hospitals are as follows: (1) No trouble with children under 8 or 10; among Orientals, the 30- to 40-year

[3] Paying 20 cents per pound in February. The average retail price of poi per pound in February 1951 was 20.6 cents; of rice, 11.7 cents; of potatoes, 6.3 cents (from the records of the office of Research and Statistics, Territory of Hawaii, Department of Labor and Industrial Relations).

age group is most likely to eat poi; (2) Orientals do not like it; (3) Filipinos will not eat it.

In six plantation hospitals, patients receive poi only upon specific request; in one case it is used "for special occasions." One plantation hospital reported that poi is recommended for home use in children's diets; another, that more would be used if the price were lower; and in four, doctors occasionally recommend it for specific cases. One hospital reported that poi is given to anyone who wants it as often as desired.

A plantation which operates a health center (not included in the six above-mentioned) includes poi in school lunches for 250 children who consume 240 pounds of poi per week and has fed it for 20 years to children from 3 months to 6 years of age.

The four tuberculosis hospitals, with a total of 994 patients, reported consuming 1,112 pounds of poi per week. The largest (in which about 95 percent of the patients are Orientals) has poi on the menu every day, and patients may choose it instead of rice or potatoes. On fish days practically everyone wants poi, elderly Orientals being the least likely to select it. This hospital also has requests for poi cocktails. Children receive poi every day.

Another tuberculosis hospital indicated that poi is on the menu every day at noon and that many Filipinos and Japanese like it, even employees. In the other two tuberculosis hospitals, patients who choose poi instead of rice or potatoes may have it. One hospital reported that the demand varies with the meat dish, those wanting poi being mostly Japanese and Filipinos who learned to eat it as children.

Approximately 360 Hansen's disease patients consume about 1,425 pounds of poi per week. It is served every day and practically all the patients eat it.

One mental hospital, where 450 pounds of poi are needed for one meal, does not purchase it regularly. It is sometimes used in edentulous diets but is rarely served to all patients; when used, it is served with a fish meal. More would be used if the price were lower; the hospital cannot afford it when the price rises above 14 or 15 cents a pound. (In this hospital, too, there is the problem of washing the poi off the stainless steel plates by hand before they are put into the dishwashing machine; this entails added labor.)

The other mental hospital serves poi twice a week (600 pounds per week) and reported that all 700 patients seem to like it. About 50 children (epileptics and those without palates) on liquid diets also receive it regularly.

Both children's hospitals reported that children take poi very well. It is served on the regular house diet, and one hospital gives it to babies and all those on soft diets.

The maternity hospital gives poi to the patients who prefer it to potatoes or rice. Only about 6 percent of the patients ask for it, and they are mostly Hawaiians and Portuguese.

Of the six private hospitals (capacity 8 to 50), two reported that doctors occasionally recommend poi for ulcer patients and high-carbohydrate, high-caloric diets. Four serve poi in the house diet (in two cases, once a

week), one reporting that "all races like it," and another that "patients do not take to poi cocktails." One hospital reported that its clientele is largely Oriental and that Hawaiian patients bring their own poi.

OAHU INSTITUTIONS OTHER THAN HOSPITALS

Homes for indigents, children, and the elderly, caring for a total of 1,283 persons, reported using approximately 385 pounds of poi per week. Kamehameha Schools, with 768 boarders, consume 345 pounds of poi for one meal per month. Poi would be served twice as often if the price were lower.[4]

A home for men and women of any age who are at least part Hawaiian, with 55 people, serves poi once a day, using 200 pounds per week. Everyone eats it, including four diabetics.

A home for children, with 46 girls ranging from 5 to 18 years of age, uses about 20 pounds of poi once a week. All eat poi, and twice as much would be used if the price were lower.[5]

A home for men of any age or race, with about 70 at present, uses 50 pounds per week, and poi is served twice weekly. Most of them eat it.

A home for girls (53 at present, ranging from 3 to 18 years of age) uses 24 pounds of poi every Friday with a fish meal. About three fourths of them eat poi.

A home caring for 71 boys serves poi only every 3 or 4 months, having tried it once a week and finding that the boys did not particularly like it.

Four other institutions use no poi at all: (1) a home for children (caring for 70 at present, between 5 and 16 years of age) reported that "lots of children do not like it"; the home served poi once daily up until 2 years ago; (2) a home for elderly Chinese men (100 at present) reported that "Old Chinese men do not use it"; (3) a home for unmarried expectant mothers (25 at the time of the survey) reported that poi is too expensive, and, although nutritional, it is too starchy for pregnant women; little rice or potatoes are served either; (4) a home for Caucasian women over 65 years of age (25 at the time of the survey) reported that most of the women have resided in the Islands only a few years and many will not eat any native foods.

[4] Paying 15 cents per pound in February 1951.
[5] Paying 22 cents per pound in February 1951.

APPENDIX A

Chemical and Nutritional Properties of Poi

Table 1.—Composition of steamed taro corms.

Component	Percent
Water	64.0
Protein (N×6.25)	1.18
Fat (ether extract)	0.169
Starch (acid hydrolysis)	29.31
Starch (saliva hydrolysis)	24.56
Sucrose	1.40
Reducing sugars	0.391
Ash	0.588
Calcium	0.0263
Phosphorus	0.0612

Source: Carey D. Miller, "Food Values of Poi, Taro and Limu," Bernice P. Bishop Mus. Bul. 37: 3–23. 1927.

Table 2.—Composition of air-dried cooked taro by varieties.

Component	Wetland varieties		Upland varieties	
	Piialii	Piko uliuli	Lehua palaii	Mana opelu
	percent	percent	percent	percent
Moisture (vac. 70°–75° C. for 18 hours)	6.60	6.37	6.40	4.05
Starch	71.60	73.70	69.60	69.12
Ash	1.76	1.43	1.83	2.38
Crude fiber	1.45	1.31	1.17	1.68
Dextrins	0.47	0.48	0.55	0.95
Ether extract	0.54	0.52	0.47	0.68
Pentosans	2.48	2.37	2.06	3.40
Protein (nitrogen×6.25)	1.75	1.85	1.91	2.36
Reducing sugar	0.49	0.48	0.66	0.77
Sucrose	0.08	0.10	0.10	0.09

Source: J. H. Payne, G. J. Ley, and George Akau, "Processing and Chemical Investigations of Taro," Hawaii Agr. Expt. Sta. Bul. 86. 1941.

Table 3.—Inorganic elements in air-dried cooked taro, by varieties.

Component	Wetland varieties		Upland varieties	
	Piialii	Piko uliuli	Lehua palaii	Mana opelu
	percent	percent	percent	percent
Ash	1.91	1.54	1.96	2.48
Calcium	0.059	0.089	0.106	0.169
Chlorine	0.081	0.069	0.084	0.109
Copper	0.0001	0.0003	0.0004	0.0001
Iron	0.0050	0.0043	0.0042	0.0050
Magnesium	0.054	0.082	0.086	0.114
Manganese	0.0012	0.0010	0.0001	0.0001
Phosphorus	0.119	0.150	0.113	0.274
Potassium	0.500	0.408	0.632	0.879
Sodium	0.0076	0.0066	0.0020	0.0042
Sulfur	0.0196	0.0147	0.0296	0.0316
Zinc	0.0001	0.0001	0.0005	0.0007

Source: J. H. Payne, G. J. Ley, and George Akau, "Processing and Chemical Investigations of Taro," Hawaii Agr. Expt. Sta. Bul. 86. 1941.

Table 4.—Food values of selected foods based on portions commonly used.

Food	Weight	Approximate measure	Calories	Protein	Fat	Cho	Ca	P	Fe	Vitamins						Approx. excess		Fiber
										A	Thiamine	Ribo-flavin	Niacin	Ascorbic acid	D			
	gm.			gm.	gm.	gm.	mg.	mg.	mg.	I.u.	mcg.	mcg.	mg.	mg.	I.u.	acid	base	gm.
Vegetables & Vegetable Products:																		
Poi, fresh (17% solids)	200.00	¾ cup	124	1.2	0	30.2	24	58	1.2	70	96	—	—	10	—	—	—	1.0
Potatoes:																		
Baked (wt. without skin)	100.00	1 medium, 2¼" diam.	98	2.4	0.1	22.5	13	66	0.8	20	110	50	1.1	17	0		10.6	.5
Boiled, unpeeled	100.00	1 potato, 2⅜" diam.	83	2.0	0.1	19.1	11	56	0.7	20	100	40	1.2	15	0		9.0	.4
Taro:																		
Hawaiian, steamed*	100.00	¾ cup, cubed	130	1.2	0.2	31.1	26	61	0.9	75	105	—	—	5	0		—	.8
Japanese (dasheen)	100.00	4 small	66	1.4	0.1	15.3	13	32	0.2	80	125	—	—	4	0		—	.7
Cereals & Cereal Products:																		
Cream of wheat, 5 minute†	28.35	¾ cup, cooked	100	3.4	0.3	20.7	143	160	12.0	0	150	34	0.4	0	0			.1
Farina, Quaker, enriched†	28.35	¾ cup, cooked	103	2.9	0.1	21.8	125	32	1.5	0	125	77	1.0	0	400			.1
Gerber's barley cereal†	28.35	1 oz., 13 tbs.	107	3.8	1.0	20.7	137	239	19.6	0	570	170	2.9	0	0			.3
Gerber's cereal food†	28.35	1 oz., 11 tbs.	108	4.4	1.1	20.2	153	251	17.6	0	570	160	2.1	0	0			.3
Gerber's strained oatmeal†	28.35	1 oz., 13 tbs.	111	4.6	2.2	18.2	141	248	15.3	0	570	140	1.4	0	0			.3
Pabena†	28.35	¾ cup, 12 tbs.	100	4.0	0.6	19.8	227	210	8.5	(0)	300	—	—	0	0	0.3		.4
Pablum†	28.35	¾ cup, 12 tbs.	105	4.3	0.9	19.8	221	184	8.5	(0)	300	100	—	0	0		1.4	.3
Rice:																		
Brown†	28.35	1 oz., ⅓ cup, cooked	102	2.1	0.5	22.0	11	86	0.6	(0)	91	14	1.3	0	0			.2
White, milled†	28.35	1 oz., ¾ cup, cooked	103	2.1	0.1	22.5	7	39	0.2	(0)	20	8	0.5	0	0	2.2		.1
White, cooked	168.00	1 cup	201	4.2	0.2	44.0	13	76	0.5	(0)	20	10	0.7	0	0	3.6		.1
Tapioca, granulated†	10.00	1 tbs.	36	0.1	Tr.	8.6	1	1	0.1	(0)	0	0	0	0	0	Neutral		Tr.
Wheatena†	28.35	⅔ cup, cooked	101	2.9	0.6	21.7	8	93	0.1	(0)	37	43	1.1	0	0	3.1		.5

* Values after cooking.
† Dry weight before cooking.
Source (except for poi): Anna de Planter Bowes and Charles F. Church, **Food Values of Portions Commonly Used.** 7th ed. Philadelphia, 1951.

APPENDIX B
Medical Profession Questionnaire

Professional Title (Pediatrician, Plantation Doctor, General Practitioner, etc.) _____ City or District _____ Island _____

Part A—POI AS A STAPLE FOOD FOR HEALTHY INFANTS AND CHILDREN

Do you consider poi a good staple food for healthy infants and children? ☐ Yes ☐ No

If you do, please state your reasons: _____

Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children? ☐ Yes, in all cases. ☐ Yes, in some cases. ☐ No.

If you do recommend poi,

At what age should the feeding of poi be started? _____ mos. old

How should it be fed: a. ☐ Every day, as part of a main meal.
☐ Every day, as a between-meal feeding, in a milk drink.
☐ Not daily, but in rotation with cereal foods.
b. ☐ Sweet. ☐ Sour. ☐ Leave choice to parents.

If you do not, in actual practice, recommend poi for all healthy babies and children, please state your reasons: _____

Part B—POI FOR THERAPEUTIC USES (Health Food)

Do you, in actual practice, recommend the use of poi to individuals with specific health problems? ☐ Yes. ☐ No. ☐ Sometimes.

If you do recommend it,

For what problems: ☐ Allergies to cereals ☐ Malnutrition ☐ Hyperacidity
☐ Gastric ulcers ☐ Prenatal ☐ Elderly persons with no teeth
☐ Convalescent, soft diet ☐ Nursing mothers
☐ Other (enumerate) _____

How should it be fed: ☐ Sweet. ☐ Sour. ☐ Leave choice to patient.

How many "at home" patients now under your care are on a poi-containing diet, at your recommendation? _____ persons. How many of them have cereal allergies? _____

If you do not, in actual practice, recommend poi for therapeutic use, please state your reasons: _____

How many children or adults have you ever known to be allergic to poi? _____

Part C—SUGGESTED IMPROVEMENTS IN POI

☐ Should be a uniform color _____ (preferred color _____)
☐ Texture should be changed _____ (preferred texture _____)
☐ Fortify with vitamins _____ (which vitamins? _____)
☐ Fortify with minerals _____ (which minerals? _____)
☐ Price should be lower. ☐ Processing should be more sanitary.
☐ Product is not now sufficiently sterile. ☐ Should dehydrate to powder form.

Preferred type of container: ☐ Glass. ☐ Tin. ☐ Cellophane bag.

Preferred size of container: For baby food, _____ oz. For health food, _____ oz.

Remarks: _____

Name _____ (Optional) Date _____

APPENDIX C

Tabulated Responses of Physicians

Table 5.—Number of practicing physicians in the Territory of Hawaii questioned in poi survey and number and percentage responding, by location and type of practice, spring 1951.*

Type of practice	Honolulu	Rural Oahu	Hilo, Hawaii	Rural Hawaii	Maui	Kauai	Molokai	Lanai	Territory
General									
Number questioned	137	17	20	7	12	9	2	—	204
Number replied	53	6	5	2	5	3	2	—	76
Percentage response	38.7	35.3	25.0	28.6	41.7	33.3	100.0	—	37.3
Plantation									
Number questioned	—	10	1	9	11	7	1	2	41
Number replied	—	5	1	6	8	5	1	2	28
Percentage response	—	50.0	100.0	66.7	72.7	71.4	100.0	100.0	68.3
Surgery									
Number questioned	27	—	1	—	—	—	—	—	28
Number replied	13	—	1	—	—	—	—	—	14
Percentage response	48.1	—	100.0	—	—	—	—	—	50.0
Obstetrics–gynecology									
Number questioned	21	—	2	—	—	—	—	—	23
Number replied	7	—	1	—	—	—	—	—	8
Percentage response	33.3	—	50.0	—	—	—	—	—	34.8
Internal medicine									
Number questioned	17	—	1	—	—	—	—	—	18
Number replied	10	—	1	—	—	—	—	—	11
Percentage response	58.8	—	100.0	—	—	—	—	—	61.1
Pediatrics									
Number questioned	17	—	—	—	—	—	—	—	17
Number replied	14	—	—	—	—	—	—	—	14
Percentage response	82.4	—	—	—	—	—	—	—	82.4
Dermatology–allergy									
Number questioned	8	—	—	—	—	—	2	—	10
Number replied	6	—	—	—	—	—	1	—	7
Percentage response	75.0	—	—	—	—	—	50.0	—	70.0
Bones									
Number questioned	6	—	—	—	—	—	—	—	6
Number replied	0	—	—	—	—	—	—	—	0
Percentage response	0.0	—	—	—	—	—	—	—	0.0
Tuberculosis									
Number questioned	2	—	1	—	1	—	—	—	4
Number replied	1	—	0	—	0	—	—	—	1
Percentage response	50.0	—	0.0	—	0.0	—	—	—	25.0
Total									
Number questioned	235	27	26	16	24	16	5	2	351
Number replied	104	11	9	8	13	8	4	2	159
Percentage response	44.3	40.7	34.6	50.0	54.2	50.0	80.0	100.0	45.3

* Type of practice based on information obtained from the Territorial Medical Society, Mabel Smyth Building, Honolulu; excludes territorial doctors now on the Mainland or in foreign countries, Board of Health officials, or doctors who are retired or for other reasons are not engaged in practicing; includes hospital residents and interns on Medical Society and Board of Health rosters.

Table 6.—Number and percentage of doctors responding, by professional classification, to the question: "Do you consider poi a good staple food for healthy infants and children?"

Replies	Pediatricians responding		Doctors other than pediatricians responding		Total doctors responding	
	number	percent	number	percent	number	percent
Yes	14	100.0	126*	86.9	140	88.1
No	0	0.0	5	3.4	5	3.1
Do not know	0	0.0	4	2.8	4	2.5
Did not answer	0	0.0	10†	6.9	10	6.3
Total	14	100.0	145	100.0	159	100.0

* One general practitioner remarked, "A staple food for young and old."
† Two obstetricians, one internist, one medical resident, three general practitioners, and three surgeons.

Table 7.—Number and percentage of doctors responding, by professional classification, to the question: "If you do, please state your reasons." (Do you consider poi a good staple food for healthy infants and children?)

Reasons	Pediatricians responding		Doctors other than pediatricians responding		Total doctors responding	
	number	percent	number	percent	number	percent
Nutritious, good source of carbohydrates or calories, or good substitute for cereal	8	57.1	47	37.3	55	39.3
Highly digestible	6	42.9	29	23.0	35	25.0
Mineral content	3	21.4	20	15.9	23	16.4
Well-tolerated or apparently not allergy producing	7	50.0	11	8.7	18	12.8
Vitamin content	1	7.1	14	11.1	15	10.7
Palatable or well-liked	5	35.7	8	6.3	13	9.3
Observation, experience, or tests show that children thrive on poi	—	—	10	7.9	10	7.1
Alkaline ash	1	7.1	5	4.0	6	4.3
Readily obtainable	1	7.1	4	3.2	5	3.6
Ease of preparation	1	7.1	3	2.4	4	2.8
Self sterilizing, contains yeast bacteria	—	—	3	2.4	3	2.1
Economical or relatively inexpensive	—	—	3	2.4	3	2.1
Aids in preventing, or at least is not conducive to, dental caries	—	—	2	1.6	2	1.4
Helps to regulate bowels	—	—	2	1.6	2	1.4
Easy to teach infants on the spoon	1	7.1	—	—	1	0.7
Good for child slow to gain	—	—	1	0.8	1	0.7
Fairly good source of protein	—	—	1	0.8	1	0.7
Total giving reasons*	12	85.7	86	68.3	98	70.0
No reasons given	2	14.3	40	31.7	42	30.0
Total doctors responding	14	100.0	126	100.0	140	100.0

* Columns do not add up to the figures shown because some doctors gave more than one reason.

Table 8.—Number and percentage of doctors responding, by professional classification, to the questions: "Do you consider poi a good staple food for healthy infants and children?" and "Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children?"

Replies	Pediatricians responding		Doctors other than pediatricians responding		Total doctors responding	
	number	percent	number	percent	number	percent
Consider poi a good staple food for healthy infants and children						
Recommend it in actual practice	14	100.0	108	74.5	122	76.7
Do not recommend it in actual practice	0	0.0	18	12.4	18	11.3
Do not consider poi a good staple food for healthy infants and children						
Recommend it in actual practice	—	—	2	1.4	2	1.3
Do not recommend it in actual practice	—	—	3	2.1	3	1.9
Do not know whether poi is a good staple food for healthy infants and children						
Recommend it in actual practice	—	—	1	0.7	1	0.6
Do not recommend it in actual practice	—	—	3	2.1	3	1.9
Did not answer whether consider poi a good staple food for healthy infants and children						
Recommend it in actual practice	—	—	1	0.7	1	0.6
Do not recommend it in actual practice	—	—	5	3.4	5	3.2
Did not answer	—	—	4	2.7	4	2.5
Total doctors responding	14	100.0	145	100.0	159	100.0

Table 9.—Number and percentage of doctors responding, by location, to the question: "Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children?"

Replies	Honolulu		Hilo		Rural*		Total	
	number	percent	number	percent	number	percent	number	percent
Yes	77	74	7	78	42	91	126	79
No	23	22	2	22	4	9	29	18
Did not answer	4	4	0	0	0	0	4	3
Total	104	100	9	100	46	100	159	100

* All areas on all islands other than Honolulu on Oahu and Hilo on Hawaii.

Table 10.—Number and percentage of doctors responding, by professional classification, to the question: "Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children?"

Replies	Pediatricians responding		Doctors other than pediatricians responding		Total doctors responding	
	number	percent	number	percent	number	percent
Yes	14	100.0	112	77.2	126	79.3
In all cases	6	42.9	52*	35.8	58	36.5
In some cases†	8	57.1	60	41.4	68	42.8
No	0	0.0	29	20.0	29	18.2
Do not see children in their practice	0	0.0	18	12.4	18	11.3
Other reasons given	0	0.0	10	6.9	10	6.3
No reason given	0	0.0	1	0.7	1	0.6
Did not answer	0	0.0	4	2.8	4	2.5
Total doctors responding	14	100.0	145	100.0	159	100.0

* One general practitioner said: "Unacceptable in certain families because it is cheap" [implying pride, not cost]. A plantation doctor said: "Home-made poi may be contaminated with germs in preparation."

† Eight doctors in this group checked both "yes, in all cases" and "yes, in some cases," but are not included in the "yes, in all cases" group. One doctor included in the "yes, in some cases" group checked also "yes, in all cases" and "no." One plantation doctor said: "From time to time have used it for infant feeding especially when we distributed feedings to homes."

Table 11.—Number and percentage of doctors responding to the question: "If you do not, in actual practice, recommend poi for all healthy babies and children, please state your reasons."

Reasons	Recommend in some cases, but not in all cases	Do not recommend in actual practice	Total respondent doctors	
	number	number	number	percent
Do not see children in their practice	—	18	18	18.5
Likes and dislikes of patient or family	6	—	6	6.2
Expensive	5	—	5	5.2
Not sterile enough, high bacterial count	2	3	5	5.2
Not always easily available	3	—	3	3.1
Processing not sufficiently sanitary	1	2	3	3.1
Do not know enough about the food value	1	2	3	3.1
Not a necessity	2	—	2	2.1
Inconvenience of preparation	2	—	2	2.1
Harmful results if eaten in excess	—	2	2	2.1
Does not keep well	1	—	1	1.0
Eaten fresh instead of sour, has caused gastro-enteritis	—	1	1	1.0
Poi sensitivity in children	1	—	1	1.0
Makes children have loose stools	1	—	1	1.0
Low iron content	1	—	1	1.0
Total giving reasons*	17	28	45	46.4
No reasons given	51	1	52	53.6
Total doctors responding	68	29	97	100.0

* Columns do not add up to the figures shown because some doctors gave more than one reason.

Table 12.—Number and percentage of doctors responding, by professional classification, to the question: "If you do recommend poi, at what age should the feeding of poi be started?" (Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children?)

Replies	Pediatricians responding		Doctors other than pediatricians responding		Total doctors responding	
	number	percent	number	percent	number	percent
Up to and including 2 months	4	28.6	14	12.5	18	14.3
From 2 up to and including 4 months	9*	64.3	61	54.5	70	55.6
From 4 up to and including 6 months	1	7.1	22	19.6	23	18.2
Over 6 months	0	0.0	9	8.0	9	7.1
Did not answer	0	0.0	6	5.4	6	4.8
Total doctors responding	14	100.0	112	100.0	126	100.0

* One said: "Because wheat is a very frequent cause of infantile eczema—I do not start infants on cereal until 7 months—also relatively low pancreatic amylase secreted to digest starches in infancy (Anderson's work). I prefer poi at 4 months—easier to digest."

Table 13.—Number and percentage of doctors responding, by professional classification, to the question: "If you do recommend poi, how should it be fed?" (Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children?)

Replies	Pediatricians responding		Doctors other than pediatricians responding		Total doctors responding	
	number	percent	number	percent	number	percent
"Every day, as part of a main meal"	3	21.4	28	25.0	31	24.6
"Every day, as a between-meal feeding, in a milk drink"	0	0.0	8	7.0	8	6.3
"Not daily, but in rotation with cereal foods"	6	42.9	59	52.7	65	51.6
Different combinations of these three answers	4	28.6	14	12.5	18	14.3
Did not answer	1	7.1	3	2.7	4	3.2
Total doctors responding	14	100.0	112	100.0	126	100.0

Table 14.—Number and percentage of doctors responding, by professional classification, to the question: "If you do recommend poi, how should it be fed?" (Do you, in actual practice, recommend to mothers that they include poi in the diet of healthy infants and children?)

Replies	Pediatricians responding		Doctors other than pediatricians responding		Total doctors responding	
	number	percent	number	percent	number	percent
Sweet	3	21.4	50	44.6	53	42.1
Sour	0	0.0	5	4.5	5	3.9
Leave choice to parents	6	42.9	48	42.9	54	42.9
Different combination of these three answers	3	21.4	1	0.9	4	3.2
Did not answer	2	14.3	8	7.1	10	7.9
Total doctors responding	14	100.0	112	100.0	126	100.0

Table 15.—Number and percentage of doctors responding, by location, to the question, "Do you, in actual practice, recommend the use of poi to individuals with specific health problems?"

Replies	Honolulu		Hilo		Rural*		Total	
	number	percent	number	percent	number	percent	number	percent
Yes or sometimes	75	70.8	7	77.8	31	70.4	113	71.1
No	29	27.3	2	22.2	12	27.3	43	27.0
Did not answer	2	1.9	0	0.0	1	2.3	3	1.9
Total doctors responding	106	100.0	9	100.0	44	100.0	159	100.0

* All areas on all islands other than Honolulu on Oahu and Hilo on Hawaii.

Table 16.—Number and percentage of doctors responding, by professional classification, to the question: "Do you, in actual practice, recommend the use of poi to individuals with specific health problems?"

Replies	General practitioners and plantation doctors		Pediatricians		Internists		All other specialists		Total	
	number	percent	number	percent	number	percent	number	percent	number	percent
Yes and sometimes*	73	70.2	10	71.4	10	90.9	20	66.7	113	71.1
No†	30	28.8	4	28.6	1	9.1	8	26.7	43	27.0
Did not answer	1	1.0	0	0.0	0	0.0	2	6.6	3	1.9
Total doctors responding	104	100.0	14	100.0	11	100.0	30	100.0	159	100.0

* Comments: "Many mainland Caucasians and Orientals cannot eat poi because of its looks and not accustomed to it"—general practitioner. "Good deal depends on nationalities and individual tastes"—plantation doctor. "Is a food and not a drug, a vitamin"—plantation doctor. "Think it is a good food but very few people seem to like it"—surgeon.

† Of this group, 27 recommend poi as a staple food for healthy infants and children: 13 general practitioners, 9 plantation doctors, 4 pediatricians, 1 surgeon.

Table 17.—Number and percentage of doctors responding, by professional classification, to the question: "If you do not, in actual practice, recommend poi for therapeutic uses, please state your reasons."

Reasons	General practitioners and plantation doctors		Pediatricians		Internists		All other specialists		Total	
	number	percent	number	percent	number	percent	number	percent	number	percent
No special indication for its use; or need has not arisen	7	23.3	2	50.0	—	—	4	50.0	13	30.2
Do not know enough about the food value of poi	4	13.3	—	—	1	100.0	1	12.5	6	14.0
Poi of no special therapeutic use; or other foods just as good	4	13.3	1	25.0	—	—	1	12.5	6	14.0
Product not sufficiently sterile; or processing should be more sanitary	5	16.7	—	—	—	—	—	—	5	11.6
Never thought of it	3	10.0	—	—	—	—	—	—	3	7.0
Total giving reasons	23	76.6	3	75.0	1	100.0	6	75.0	33	76.8
No reasons given*	7	23.4	1	25.0	—	—	2	25.0	10	23.2
Total doctors responding	30	100.0	4	100.0	1	100.0	8	100.0	43	100.0

* Comment of one general practitioner: "Not prescribing poi as yet—may eventually." All nine other doctors, who did not give reasons, recommend poi as a staple food for healthy infants and children.

Table 18.—Number and percentage of doctors responding, by professional classification, to the question: "If you do recommend it, for what problems?" (Do you, in actual practice, recommend the use of poi to individuals with specific health problems?)

Problems	General practitioners and plantation doctors		Pediatricians		Internists		All other specialists		Total	
	number	percent	number	percent	number	percent	number	percent	number	percent
Convalescent, soft diets	59	80.8	2	20.0	9	90.0	9	45.0	79	69.9
Malnutrition	47	64.4	8	80.0	7	70.0	6	30.0	67	59.3
Allergies to cereals	41	56.2	9	90.0	6	60.0	7	35.0	63	55.7
Elderly persons with no teeth	44	60.3	—	—	9	90.0	7	35.0	60	53.1
Gastric ulcers	26	35.6	—	—	4	40.0	5	25.0	35	31.0
Nursing mothers	16	21.9	1	10.0	3	30.0	1	5.0	21	18.6
Prenatal	16	21.9	—	—	—	—	2	10.0	20	17.7
Hyperacidity	10	13.7	—	—	4	40.0	1	5.0	15	13.3
Other problems	8	11.0	2	20.0	2	20.0	3	15.0	15	13.3
Total who checked problems*	71	97.3	10	100.0	10	100.0	19	95.0	110	97.3
Did not answer	2	2.7	—	—	—	—	1	5.0	3	2.7
Total doctors responding	73	100.0	10	100.0	10	100.0	20	100.0	113	100.0

* Columns do not add up to the figures shown because some doctors checked more than one problem.

Table 19.—Number and percentage of doctors responding, by professional classification, to the question: "If you do recommend it, how should it be fed?" (Do you, in actual practice, recommend the use of poi to individuals with specific health problems?)

Replies	General practitioners and plantation doctors		Pediatricians		Internists		All other specialists		Total	
	number	percent	number	percent	number	percent	number	percent	number	percent
Sweet	17	23.3	3	30.0	2	20.0	4	20.0	26	23.0
Sour	3	4.1	0	0.0	1	10.0	0	0.0	4	3.5
Leave choice to patient	47	64.4	6	60.0	7	70.0	15	75.0	75	66.4
Different ways in different cases	5	6.8	1	10.0	0	0.0	0	0.0	6	5.3
Did not answer	1	1.4	0	0.0	0	0.0	1	5.0	2	1.8
Total doctors responding	73	100.0	10	100.0	10	100.0	20	100.0	113	100.0

Table 20.—Number of doctors responding to the question: "How many 'at home' patients now under your care are on a poi-containing diet, at your recommendation?"

Professional classification	Have patients on poi-containing diet	Do not have patients on poi-containing diet	Did not answer	Total
General practitioners and plantation doctors*	32	12	30	74
Obstetrician–gynecologists	1	2	4	7
Internal medicine	2	1	7	10
Pediatricians	6	0	4	10
Dermatologists–allergists	3	1	2	6
Surgeons	0	2	4	6
Total doctors responding	44	18	51	113

* Includes one tuberculosis specialist.

Table 21.—Number of doctors responding, by professional classification, to the question: "How many children or adults have you ever known to be allergic to poi?"

Professional classification	Doctors who have known cases of poi allergy	Doctors who have never known cases of poi allergy	Did not answer	Total
General practitioners	3*	64	9	76
Plantation doctors	1**	24	3	28
Obstetrician–gynecologists	—	7	1	8
Internists	2†	8	1	11
Pediatricians	7††	6	1	14
Dermatologists–allergists	1§	6	—	7
Surgeons	—	10	4	14
Tuberculosis specialists	—	1	—	1
Total doctors responding	14	126	19	159
Percentage of total doctors responding	9	79	12	100

* Two replied, 1 case each; one replied, "exact number unknown."

** One replied, 1 case.

† One replied, 1; the other replied, "rare case."

†† Two replied, 1 case each; the others replied, "2," "2 to 6 a year," "5 or 6 a year," "a few," "5 or 6 suspected (2 certain)."

§ One replied, "1 percent roughly."

Table 22.—Number of patients and amounts of poi consumed in hospitals in the Territory of Hawaii, spring 1951.

Type of hospital	Patients in the hospital	Patients who eat poi (approximate)	Poi consumed per week (average)
			pounds
General hospitals			
Hospital 1	1,200	75	200
Hospital 2	425	135	20
Hospital 3	270	120	90
Hospital 4	160	50	20
Hospital 5	92	10	40
Hospital 6	85	1	4
Hospital 7	65	6	12
Hospital 8	38	8	4
Hospital 9	36	32	24
Hospital 10	36	0	*
Hospital 11	30	5	14
Hospital 12	24	3	8
Hospital 13	24	0	0
Hospital 14	20	0	*
Hospital 15	15	12	25
Hospital 16	4	1	*
Total	2,524	458	461
Plantation hospitals*			
Hospital 17	33	0	0
Hospital 18	27	2	5
Hospital 19	20	2	2
Hospital 20	14	0	0
Hospital 21	10	0	0
Hospital 22	5	0	0
Total	109	4	7
Tuberculosis hospitals			
Hospital 23	600	600	350
Hospital 24	169	87	425
Hospital 25	138	69	250
Hospital 26	87	20	87
Total	994	776	1,112
Leprosariums			
Hospital 27	260	260	1,100
Hospital 28	99	80	325
Total	359	340	1,425
Mental hospitals			
Hospital 29	1,100	†	134
Hospital 30	700	700	600
Total	1,800	†	734
Private hospitals			
Hospital 31	30	5	10
Hospital 32	18	2	5
Hospital 33	15	13	4
Hospital 34	6	0	0
Hospital 35	6	†	1
Hospital 36	4	†	1
Total	79	†	21
Children's hospitals			
Hospital 37	80	80	20
Hospital 38	28	28	10
Total	108	108	30
Maternity hospitals			
Hospital 39	75	3	5
Total, all hospitals	6,048	?	3,795
Plantation health center	250	250	240

* Given only when specifically requested by patient.
† Number not known.

APPENDIX D

Comments on the Use of Poi for Healthy Infants and Children

Reasons given by physicians for considering poi a good food for healthy infants and children, included in category "Observations, experience, or tests show that children thrive on poi"

Remarks by doctors who gave no other reason:

"Because it is"—general practitioner.

"Weight gain is good"—plantation doctor.

"Long use has demonstrated"—dermatologist.

"Though I do not know the actual nutritional value, I suspect it is good as the children do well on poi"—general practitioner.

"Clinical results and tests"—general practitioner.

"It has been proved at the Ewa Health Center." "Feeding children from 3 months to 6 years of age at Ewa Plantation Health Center for 20 years"—general practitioner.

Remarks additional to reasons listed in other categories:

". . . because my children like it and are healthy"—thoracic surgeon.

"Infants fed on poi appear healthy"—general practitioner.

". . . the Hawaiians seem to have done well on it"—plantation doctor.

Comments of physicians who recommend poi for healthy infants and children in actual practice, in some cases, but not in all cases

"Poi is expensive and has the disadvantage of not keeping like the dried precooked cereals such as Pablum, Pabena, Gerber oatmeal, etc."—pediatrician.

"Expensive (relatively) and sometimes not available"—general practitioner.

"High bacterial count"—general practitioner.

"It is inconvenient for some parents to acquire poi in small amounts"—general practitioner.

"Most Oriental families do not have available daily poi; do not believe poi so essential that I insist they buy poi daily just to feed infants"—general practitioner.

"Chinese and Japanese families do not eat poi regularly as do the Hawaiians"—general practitioner.

"Product not sufficiently sterile" and "processing should be more sanitary"—general practitioner.

"Likes and dislikes"—internist.

"It is too expensive for many parents; many commercial cereals are less expensive and about as good. It is also a lot of bother"—plantation doctor.

"No food should be prescribed to the exclusion of others. Many of my patients cannot tolerate poi because of sensitivity to it, even though it is mostly carbohydrate"—allergist.

"I recommend it for those families in which parents and other children already eat poi and like it and want it as a part of their diet from now on"—obstetrician-gynecologist.

"Not a necessity—cost is high for food value received"—general practitioner.

"Those that are accustomed to its use or would like to try it"—general practitioner.

"Nonavailability (at times in this district [Wahiawa]), low iron content"—plantation doctor.

"If the mother wants it. I do not know enough about the composition of poi to say one way or the other"—general practitioner.

Comments of physicians who do not, in actual practice, recommend poi for healthy infants and children

". . . frankly know very little about the food value of poi, so I have had nothing to do with it until now"—internist.

"Poi, so often eaten fresh instead of sour, has been the cause in some instances of severe gastroenteritis"—general practitioner.

"Not convinced it is being produced under sufficiently sterile conditions to recommend as infant and children's food"—general practitioner.

"Poi becomes contaminated easily although it is fairly safe to eat when sour. Acidity kills most bacteria"—general practitioner.

"Personally I do not think we know much about the food value of poi ourselves." "Certainly, I do not care to prescribe the crude poi for infant use"—general practitioner.

". . . because it is staple diet anyway among Hawaiians and they get it to excess, plus an excess of milk, leading frequently to a dietary anemia"—general practitioner.

"Too concentrated as source of carbohydrate—children eat too much—obesity is a disease"—surgeon.

"Not sufficiently sterile"—general practitioner.

"Any objection to poi is purely personal, caused largely by the caliber of poi factories in the Territory which are anything but a sanitary source of food production. If and when their standards are such as to equal at least those of a dairy or where pure food is processed, by at least mainland standards, then and then only will I prescribe poi more frequently. The Board of Health has done much to improve this situation" —general practitioner.

Remarks by doctors who do not advise on children

"No actual contact with pediatrics, but would recommend if I were . . ."—surgeon.

"I do not do this type of work, but if I did, I would certainly use it"—surgeon.

APPENDIX E
Comments on Poi for Therapeutic Uses

Comments of physicians who do not, in actual practice, recommend poi for therapeutic use

"There are other good and sometimes better foods for sick babies"—general practitioner.

"Using hypoallergic and other diets, other than poi"—general practitioner.

"Product is not now sufficiently sterile, and processing should be more sanitary"—general practitioner.

"People who eat poi continue to eat it. Others will not tolerate it"—general practitioner.

"Am not aware of any therapeutic value in poi"—plantation doctor.

"Have no real reason for its use"—general practitioner.

"Most of the patients for whom I might recommend it already use it, either regularly or occasionally"—plantation doctor.

"Have not come across problem for specific need"—pediatrician.

"Am not aware of any special advantages of poi for therapeutic use"—pediatrician.

"In pediatric practice we do not recommend any food as health foods, but if there are any allergies, poi would of course be considered just as we would also consider

other types of carbohydrates to replace the offending cereal or foods"—pediatrician.

"Only because I am a general surgeon instead of a pediatrician"—surgeon.

"Have never considered it"—plantation doctor.

"Ignorance of therapeutic value of poi"—general practitioner.

"I might use it more if I knew more of its properties"—plantation doctor.

"Being unfamiliar with it personally, it does not occur to me as a staple food"—surgeon.

APPENDIX F

Comments Regarding Suggested Improvements of Poi

Color

Preferred color, pink: "Purple poi is generally unappetizing"—dermatologist. Preferred color, red: "Kauai red"—general practitioner.

Preferred color (other than pink, red, or gray): "Lavender"—general practitioner; "Gray or pink"—plantation doctor; "Red-brown"—general practitioner; "Gray, pinkish gray"—general practitioner; "Yellowish or purplish"—general practitioner; "Lighter"—general practitioner; "Red, pink, blue-gray"—general practitioner; "Natural"—general practitioner; "White"—plantation doctor; "Butter-yellow"—general practitioner; "Purple"—pediatrician; "Softer"—general practitioner; "Darker brown"—internist; "Present color not appetizing to beginners"—general practitioner; "Could use only piele variety; too hard to control all sources"—internist.

Texture

Texture should be changed. Preferred texture: "Mixed thin and strained"; "finer"; "solid form would be better for new users"; "smooth and thin"; and "thin."

Texture should not be changed. "Doesn't matter"—general practitioner.

Remark not tabulated: "I should think improvement in taste would be the main problem as I know of only a few people from the Mainland who can eat it because of its unpleasant taste which may be in some part related to its texture."

Vitamins

Should fortify with vitamins. Suggested vitamins: "Thiamine, niacin, riboflavin, ascorbic acid"—internist; "B-complex group"—two general practitioners; "probably B complex"—internist; "B complex and C"—general practitioner; "B, C, and D"—two general practitioners; "Multiple vitamins"—two general practitioners; "C, B"—surgeon; "B group and C if possible"—plantation doctor; "many as possible"—tuberculosis specialist; "B group and C"—plantation doctor; "whatever is lacking"—plantation doctor.

Should not fortify with vitamins. "Buy separately"—internist.

Not necessary to fortify with vitamins. "Doesn't matter"; "questionable"; "fortification only when other diet has definite deficiency."

Minerals

Should fortify with minerals. Suggested minerals: "Calcium and iron" three general practitioners; "calcium and phosphorus"—two general practitioners; "iron"—two general practitioners and two plantation doctors; "iron and copper"—plantation doctor ("baby does not get enough iron early in diet"); "whatever is lacking"—plantation doctor.

Should not fortify with minerals. "Buy separately"—internist.

Price should be lower

"It would be used more if same cost as cereal"—pediatrician. Another pediatrician says price should be lower "if possible." "Especially bottled"—general practitioner.

Processing should be more sanitary

"For fresh poi"—pediatrician. Another pediatrician adds that he recommends fresh poi be sterilized for infants. "For sweet poi"—dermatologist. "Have no first-hand

knowledge of interiors of poi factories but outside appearances and locations of some suggest that improvement in sanitation is needed"—surgeon. "From stories I hear" —plantation doctor.

Product is not now sufficiently sterile

One pediatrician qualifies "Fresh product." One general practitioner qualifies that the product is not now "uniformly" sufficiently sterile.

Not tabulated: "Must be sterile to be sold in cans, the aciduric bacteria take care of pathogens"—internist. "Some brands of bottle poi very sterile now"—pediatrician.

Should dehydrate to powder form

"Would be useful for mainland use"—pediatrician. Another pediatrician says "Maybe." "Tarolactin is well liked and tolerated but too expensive"—pediatrician. "If could be precooked and palatable, I believe the dry form like Pabena, Pablum, Gerber oatmeal, etc., would definitely have great value"—pediatrician.

General practitioners: "Possibly." "Dehydrated in powder form would be the best marketing method." "For certain purposes."

Plantation doctors: "Might be more economical and easier to ship." "Think it would be preferable either in powder form or more diluted." "Tarolactin is very good."

Internist: "Would help." Dermatologist: "This would be ideal!" Surgeon: "Good idea. If in powder form, clean and easy to handle."

Comments of physicians regarding preferred type and size of container

Tin. "No glass!"—pediatrician.

Cellophane bag. "For everyday use"—general practitioner. "But smaller size"—general practitioner. "Have never used canned poi as bulk poi of good quality is always available"—plantation doctor. "Cheaper"—plantation doctor.

Glass or tin. "Tin for dehydrated poi"—general practitioner.

Glass or cellophane bags. "Container determines price or cost. Does not matter as long as bacterial count is low"—pediatrician. "Glass for infants, cellophane bag for children"—pediatrician. "Cellophane bag for local use"—general practitioner. "Glass for individuals who use small amounts of poi, cellophane bags for families who are accustomed to eating poi"—dermatologist.

Tin or cellophane bag. "Cellophane bag for local consumption only"—plantation doctor.

Miscellaneous. "Paper cartons"—general practitioner. "Tin, cellophane bag, and cardboard carton"—general practitioner. "I would say depends upon whether it is shipped far and upon the economical status of the people in various economical environments: for Hanalei type of rural people, cellophane bags; for Honolulu, glass or tin, etc."—plantation doctor and general practitioner.

APPENDIX G

Miscellaneous Comments

Suggestions which have not been tabulated

"There should be a greater supply"—internist.

"Taro cakes and pancakes, muffins, etc., are more palatable to most haoles"—general practitioner.

"Should be used for allergic children; other reasons not so good for Mainland since competition is too severe"—internist.

"Investigate quick-frozen; shredded or flaked like dry cereal. Chips were good but seldom available; also deep-fat fries, taro crunches with coconut"—general practitioner.

"I believe that unless the price can be greatly reduced it should be marketed as a food for allergic babies or adults. The mistake with Tarolactin was that milk products were mixed with the taro product, which, therefore, was of no value in most cases. It might well be marketed through some large industrial concern like Gerber, as they should be about ready for a new low-allergenic food"—pediatrician.

"Also consider taro for export—sliced or in chunks—for making patties or frying in slices (like potatoes)"—general practitioner.

"A more uniform source of supply"—plantation doctor.

"More people would eat poi if directions for preparation (i.e., mixing) were more available and if its beneficial effects were promulgated (e.g., yogurt, brewer's yeast, etc.)"—obstetrician.

"Poi is an excellent food for everybody, but at present it is not attractively marketed for the non-Hawaiian population"—general practitioner.

"Mainlanders as a rule do not like poi. There is not enough to supply the island demand"—general practitioner.

"An improvement could be made in the flavor as most people have to develop a taste for it as it is now"—physiologist.

"I do not feel that people not accustomed to the taste of poi would find it palatable enough for a health food"—plantation doctor.

Requests for information about poi on questionnaires received from doctors

"I would like to have the chemical analysis and the price of poi made known to the doctors. We would then have something to compare with other foods"—general practitioner.

"Please send me an analysis of poi"—plantation doctor.

"I should like any published data you have on poi"—plantation doctor.

"Would appreciate literature"—internist.

"I have been back in the Islands 6 months and, frankly, know very little about the food value of poi, so I have had nothing to do with it until now. Where can I get information on the subject?"—internist.

"Here poi is largely home-prepared. I am personally unacquainted with local commercial processing. Suggest that the Experiment Station could render a greater service in making food components of all island fruits and vegetables more widely known, especially to physicians"—internist.

"Do not know exact mineral and vitamin content; suggest testing all brands and circularizing results"—general practitioner.

"Let us have some scientific data on use"—surgeon.

Remarks on personal experience of respondents

"I am not a pediatrician, but I occasionally see babies and children for diabetes and heart disease. My own two children have been on poi since 2 months"—general practitioner.

"It is nutritious and a good wholesome food. Being Hawaiian, I was naturally raised on it and it continues as a main part of my diet. I have never known anyone who eats poi to suffer a deficiency disease"—dermatologist.

"I was brought up on poi with milk and poi with fish as an infant and during youth. Never had a very sick day until I was not able to eat it regularly"—industrial physician and surgeon.

"Don't like the stuff myself, so each individual to his own taste"—general practitioner.

"I consider it a good food for healthy infants and children because of its known caloric content, and because my own children like it and are healthy"—surgeon.

"Do no pediatrics. However, poi added to formula satisfied one of my own children at 3 to 4 months, when all (and I mean all!) other foods failed to satisfy his hunger. Method: evaporated milk formula thickened with poi; holes in nipple enlarged with red hot ice pick"—obstetrician.

"No actual contact with pediatrics, but would recommend poi if I were. My own children began eating it at 4 months; everyday, as part of main meal; sweet poi"—surgeon.

"I doubt if poi would ever have much appeal on the Mainland because of its taste; I feel you must learn to like it; I personally dislike it and don't recommend it unless others in family like it and it will always be available"—obstetrician-gynecologist.

Comments not noted elsewhere

"May I add an interesting commentary concerning poi. While I was training at the Children's Hospital of Harvard Medical School in Boston, a baby was brought in by his Army Officer father. He came to see me to learn where he could obtain poi for his child. The S. S. Pierce Company of Boston carried poi in stock!"—pediatrician.

"You can launch a good food like poi especially for infants but it will take a lot of money for advertising on a national scale"—pediatrician.

"This should be another industry for Hawaii to chalk up both for local and mainland markets"—plantation doctor, Hawaii.

"Poi powder is marketed on the Mainland by a Berkeley firm—Galen B Company—under a different name. It was extensively studied by the University of California Hospital. Poi is one item to make Hawaii industrially prosperous. I am in hearty approval of popularizing poi"—pediatrician.

Comments contained on unusable questionnaires

"Good source of thiamine, riboflavin, calcium, and phosphorus."

"Few allergies."

"Not too many calories and nonallergenic."

"Good source of calcium, phosphorus, and boron as well as easily digested carbohydrates, etc."

"Nutritious and forms bulk."

"Poi has more vitamins and minerals than polished rice. Poi can be used as a variety."

"Supplies needed calories in an easily digested form."

"Readily utilized by my own children on pediatrician's recommendation."

"We use poi at home principally because we like it."

"Children get poi in families using this staple. It is too expensive to be purchased especially for children in families not using this food for all members."

"We are receiving poi in large wooden barrels, which are unsanitary. Improvements along this line would help a great deal. Canned products on the markets have a peculiar floury taste"—hospital dietitians.

"Individualize all diet prescriptions whether for poi, potato, or other food stuffs."

"We have used poi as an alternate for cereal or potatoes and have been under the impression that few, if any, babies were allergic to the food."

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USE OF POI IN THE PREVENTION OF ALLERGIC DISEASE IN POTENTIALLY ALLERGIC INFANTS

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Reprinted from ANNALS OF ALLERGY, Volume 25, September, 1967

Poi appears to be well tolerated by babies. Its use may be considered in the potentially allergic infant, particularly when there is a family history of cereal allergy.

USE OF POI IN THE PREVENTION OF ALLERGIC DISEASE IN POTENTIALLY ALLERGIC INFANTS

ALEXANDER ROTH, M.D., ROBERT M. WORTH, Ph.D., and IRA J. LICHTON, Ph.D.

PREVENTION of disease has been an aim of medicine for many years. Attempts to prevent allergic disease, however, were not made until quite recently. Early in this century reports of unfavorable reactions to cow's milk began to appear. It was also noted that the introduction of egg, wheat, and orange juice into the diet of infants frequently caused trouble. Schloss and Worthen,[17] Ratner and Gruehl,[16] and others explained this by showing that proteins can pass unchanged through the intestinal wall into the circulation and set the stage for the production of antibodies. Applying this knowledge, it was found that many children could be relieved of their allergic symptoms by eliminating the offending foods from their diets. This left some patients in whom allergic symptoms, once started, continued unabated, in spite of the best possible management. Others, although their symptoms subsided, went on to develop other allergies. It seemed therefore desirable to avoid initial sensitization if at all possible. Glaser and Johnstone[4,5] suggested that this could be achieved by omitting the early feeding of allergenic foods to the potentially allergic child. They felt that this not only lessened the incidence of allergy in infancy, but somehow prevented or decreased the development of allergy in later life as well. Although their studies as well as the conclusions reached[4,5,9] have been criticized,[12,14] a later prospective study using a larger sample produced similar results.[11] The management of the potentially allergic child calls for avoidance of egg, cow's milk, and cereal during the first few months of life. From a practical point of view, egg avoidance is relatively simple. Several milk substitutes are now available to the mother who cannot nurse her baby. There remains only the problem of finding a good cereal substitute, since even rice may be allergenic,[8,10,19] and all cereals are closely related members of the grass family.

Fortunately, such a substitute exists in the form of poi made from the taro plant *(Colocasia esculenta)*. The plant is shown in Figure 1. It has been used for centuries by Hawaiians as food for infants and adults. Poi is made by mashing and straining the boiled or pressure-cooked underground stem (corm) of the plant. Poi may be con-

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TABLE I. COMPOSITION OF POI COMPARED WITH RICE

	Calories	Protein gm	Fat gm	CHO gm	Ca mg	P mg	Fe mg	Thiamine mcg	Riboflavin mcg	C mg
Poi, fresh (17% solids) 100 grams	67	0.6	0.1	16.0	11	22	0.4	42	15	5
Rice, white cooked (unenriched) 100 grams	120	2.5	0.1	26.2	8	8	0.3	12	9	0

sidered as mainly a carbohydrate food. Its composition has been analyzed[3,13,15] and is given in Table I, which also shows the composition of rice for comparison.

The first suggestion that poi be used as a cereal substitute in allergic persons was made by Alvarez in 1939.[1] Glaser[9] became interested in its use for infants in 1963 and found it to be well tolerated. The present study was undertaken to test his experience on a larger scale.

Methods

Physicians in five Honolulu group practices cooperated in a study to test the use of poi in potentially allergic infants. A potentially allergic infant is defined as one who has a parent or sibling with major allergy. Mothers who agreed to participate in this study

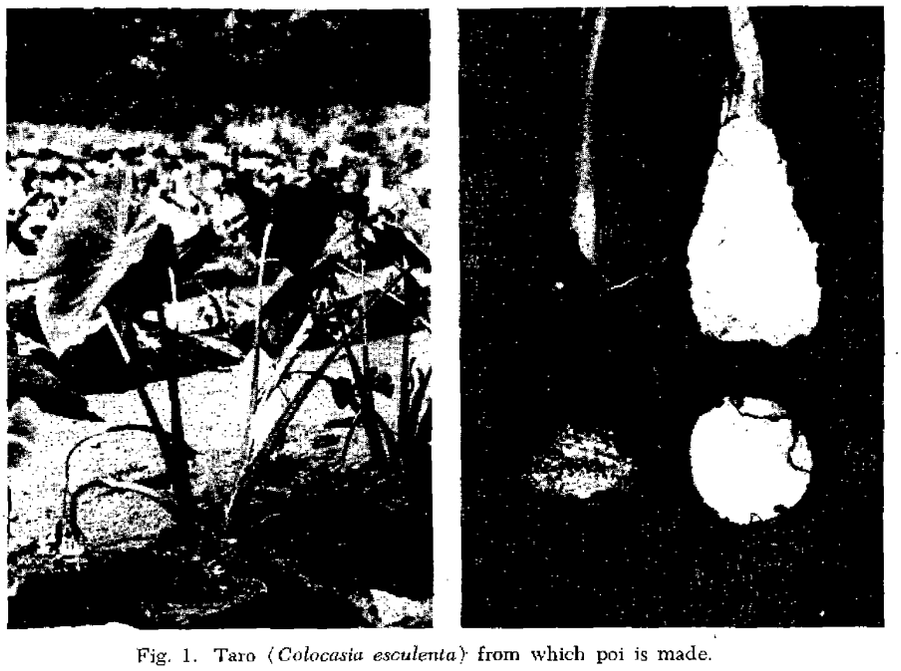

Fig. 1. Taro (*Colocasia esculenta*) from which poi is made.

were asked to start their infants on breast or soy bean milk. Babies were alternately assigned to one of two groups, one receiving poi, the other rice cereal, beginning at about six weeks. The mothers were advised not to add other foods during the first four months of life. Babies who received forbidden foods were dropped from the study. Table II shows the four hypo-allergenic regimens and the composition of each group.

Surveillance was carried out by transcribing dietary and clinical data from each infant's record for each clinic visit. Table III lists the items from the clinical record used in determining presence of allergic disease. It should be stressed that these symptoms, particularly those involving the gastrointestinal tract, may also occur in the nonallergic baby.

An infant was considered to be adequately observed if he was seen at least three times during the first four months of life. At the end of this period, the clinical record for each infant was entered onto a new card bearing only a code number without dietary or other identifying data. These cards were then presented to two pediatricians who judged independently if allergic disease was present. Three choices were permitted: "Yes," "No," and "Not sure." If there was any disagreement between the two judges, or if they were both "Not sure," the card was submitted for a third independent judgment, along with some cards on which there was no disagreement.

TABLE II. NUMBER OF INFANTS ASSIGNED TO EACH OF FOUR HYPO-ALLERGENIC REGIMENS

	Soy Milk	Breast Milk
Rice Cereal	30	25
Poi	49	28

TABLE III. LIST OF ENTRIES ON CLINICAL RECORD USED IN DETERMINING PRESENCE OF ALLERGIC DISEASE IN INFANTS

Colic	Excessive crying
Gas	Nasal stuffiness
Vomiting	Mucus in chest
Diarrhea	Wheezing (bronchospasm)
Constipation	Eczema

TABLE IV. DISTRIBUTION OF 132 HONOLULU INFANTS BY DIETARY REGIMEN, RACE, AND SEX

		Soy Milk		Breast Milk		Breast→Soy		
		Male	Female	Male	Female	Male	Female	Total
Rice Cereal	Caucasian	7	4	1	0	4	0	16
	Japanese	5	4	0	0	1	3	13
	Hawaiian Part-H.	1	5	1	2	4	1	14
	Chinese	0	1	1	0	0	2	4
	Other	2	1	0	1	1	3	8
Poi	Caucasian	4	11	3	0	2	1	21
	Japanese	11	10	0	1	0	3	25
	Hawaiian Part-H.	3	4	0	1	3	2	13
	Chinese	0	0	1	1	1	0	3
	Other	0	2	0	1	4	4	11
Poi→ Rice Cereal	Caucasian	0	0					
	Japanese	0	0					
	Hawaiian Part-H.	0	1					1
	Chinese	1	0					1
	Other	1	1					2
	Totals	35	44	7	7	20	19	132

TABLE V. DISTRIBUTION OF 132 HONOLULU INFANTS AMONG TWO JUDGES AND ONE REFEREE AS TO PRESENCE OR ABSENCE OF ALLERGIC SYMPTOMS

Response of Judges	Yes-Yes	Yes-No	Yes-?	?-?	No-?	No-No	Total
No. of Infants	6	5	7	4	25	85	132
No. Submitted to Referee	3	5	7	4	25	2	

Response of Referee	Yes	Yes	?	No	Yes	?	No	Yes	?	No	Yes	?	No	No
	3	0	3	2	3	3	1	0	2	2	3	4	18	2
Final Allocation of Cases	Yes		?	No	Yes	?			?			?	No	No
	6		3	2	3	4			4			7	18	85
Totals	Yes	?			No									
	9	18			105									132

TABLE VI. DISTRIBUTION OF INFANTS WITH DEFINITE OR POSSIBLE ALLERGIC DISEASE BY ORGAN SYSTEM INVOLVED

Organ system involved	Definitely allergic	Questionably allergic
Respiratory only	2	16
Respiratory and skin	3	1
Respiratory and GI	2	1
Respiratory, skin, and GI	1	0
GI and skin	1	0
Totals	9 (6.8%)	18 (13.6%)

Results

Of 191 infants who started in the study, 59 were dropped for the following reasons:

- Seen less than three times during follow-up period—25 infants
- Added other foods or otherwise broke regimen—25 infants
- Seriously ill—in the hospital frequently—one infant
- Severe, definite gastro-intestinal intolerance of soy milk (before poi or cereals started)—eight infants

Table IV shows the distribution of the remaining 132 infants by dietary regimen, sex, and race, with the infants who were shifted from one regimen to another listed separately. The racial distribution corresponds closely to that found in the general population on the island of Oahu (Caucasian 29 per cent, Japanese 29 per cent, Hawaiian and part-Hawaiian 18 per cent, Chinese 6 per cent, other 18 per cent).[2] It is unfortunate that the number of infants breast-fed throughout the first four months was too small for useful analysis.

The diagnosis of allergy in early infancy tends to be difficult and subjective. It is therefore instructive to see the evaluations of the two judges and the one referee (summarized in Table V).

Table VI shows the distribution of children with definite or suspected allergies by symptoms. The low incidence of atopic dermatitis and the preponderance of respiratory involvement is of interest. It is encouraging that only 7 per cent of these high-risk infants developed allergies during the four months observation period. As might be expected, the breast-fed babies fared best and all remained symptom free. Of those receiving cow's milk substitutes, four out of 55 given rice, and five out of 73 fed poi showed signs of allergy.

TABLE VII. DISTRIBUTION OF 132 HONOLULU INFANTS BY DIETARY REGIMEN AS TO PRESENCE OF ALLERGY DURING THE FIRST FOUR MONTHS OF LIFE

	Soy			Breast			Breast→Soy			Combined			Totals
	Yes	?	No	Yes	?	No	Yes	?	No	Yes	?	No	
Rice	0	7	23	0	0	6	4	4	11	4 7.3%	11 20.0%	40 73%	55
Poi	3	4	38	0	1	7	2	2	16	5 6.8%	7 9.6%	61 84%	73
Poi→Rice	0	0	4*							9	18	101	128

$\chi^2 = 2.885$ (2df)
$p \doteq 0.25$

*Excluded from χ^2 analysis.

Conclusions

1. Seven per cent of 132 potentially allergic children developed definite symptoms of allergy during their first four months of life while on a hypoallergenic diet.

2. Infants fed rice cereal and those fed poi (taro) had a similar risk of developing allergies.

3. Poi was well tolerated by babies. Its use may be considered in the potentially allergic infant, particularly when there is a family history of cereal allergy.

Acknowledgements

The authors acknowledge the help of Mrs. Shirley R. McDermott, B.S., R.N. and the participation of Drs. Gene J. Ahern, Andrew R. Biles, Jr., Robert Long, William F. Moore, Joseph Oren, and Donald R. Pfeifer. This study was aided by gifts of soy bean milk from Linda Foods Company and Mead Johnson Laboratories, and was supported by grants from the Health Committee, Honolulu Chamber of Commerce and the Department of Planning and Economic Development, State of Hawaii. The encouragement and support of Mr. Richard A. Cooke, Jr. was also essential in getting financial support for this study.

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Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 867.

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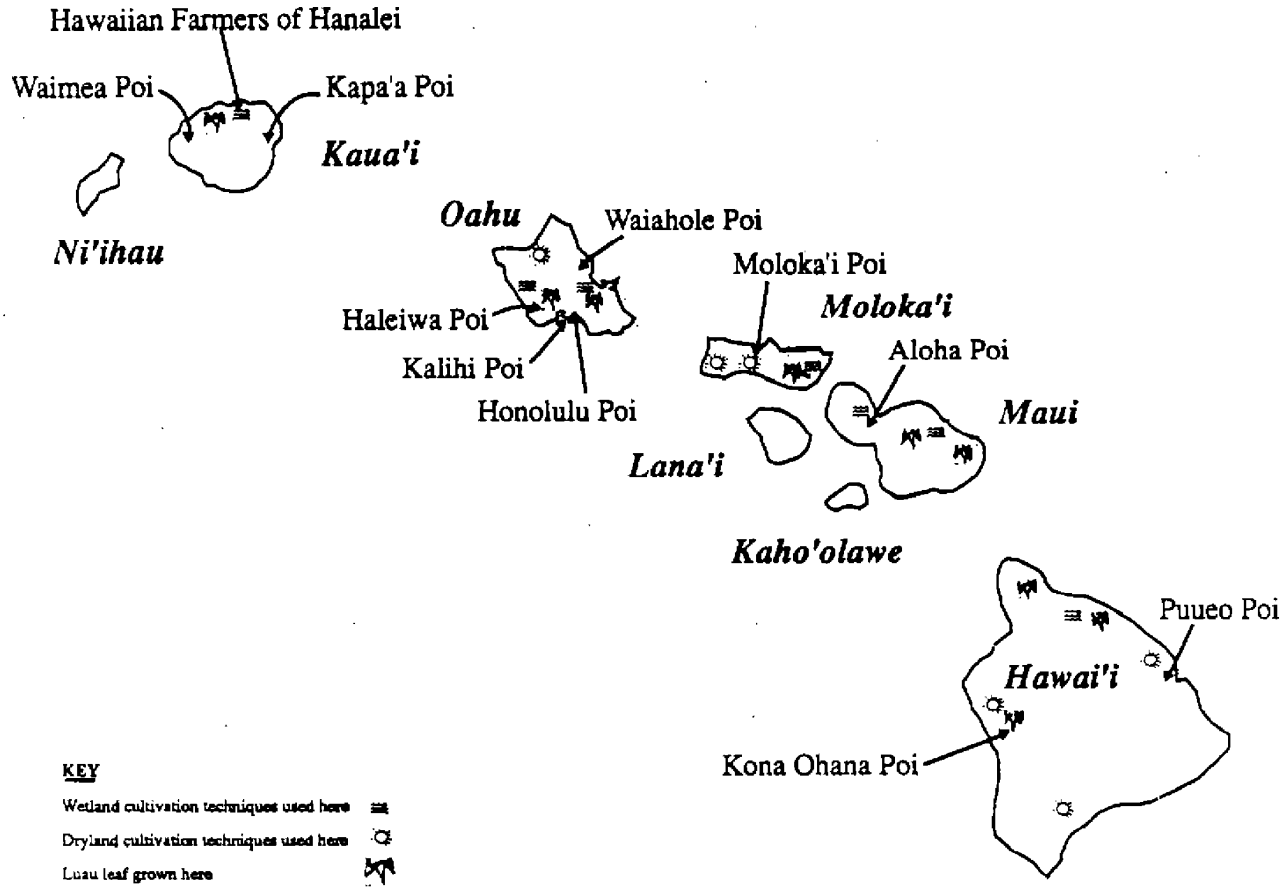
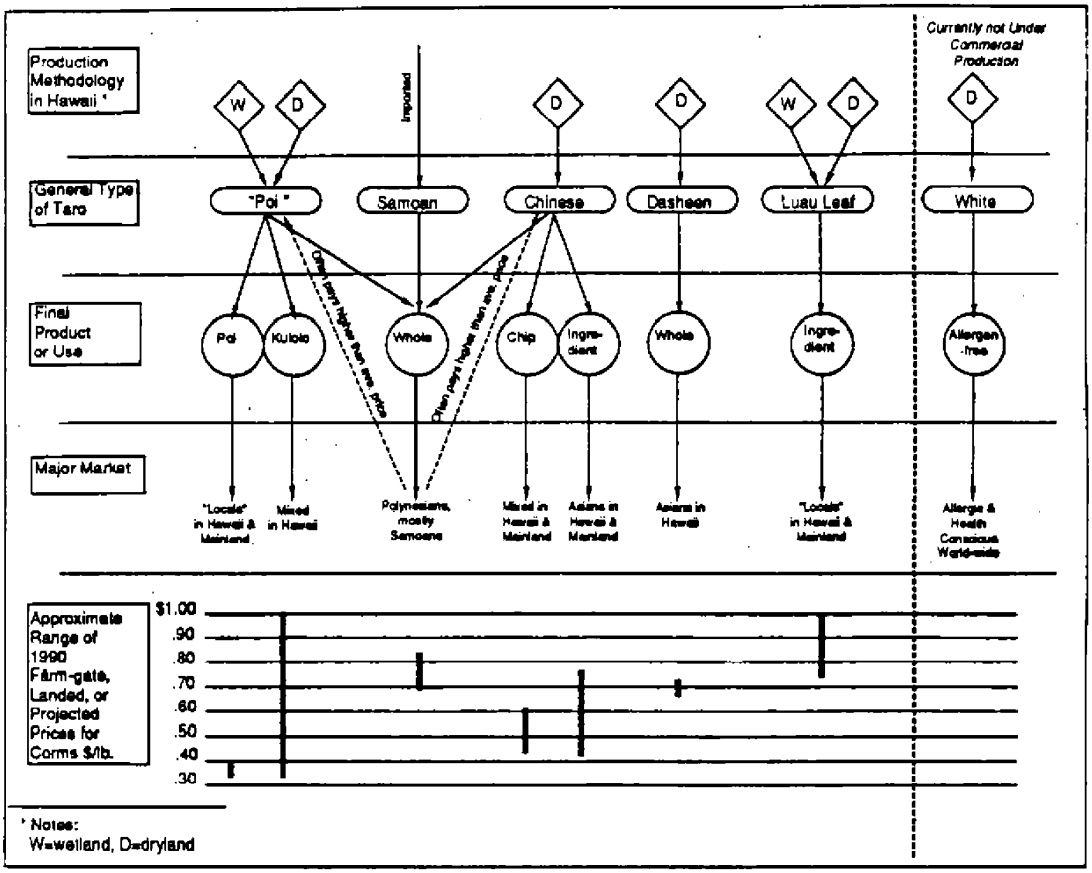
HAWAI'I

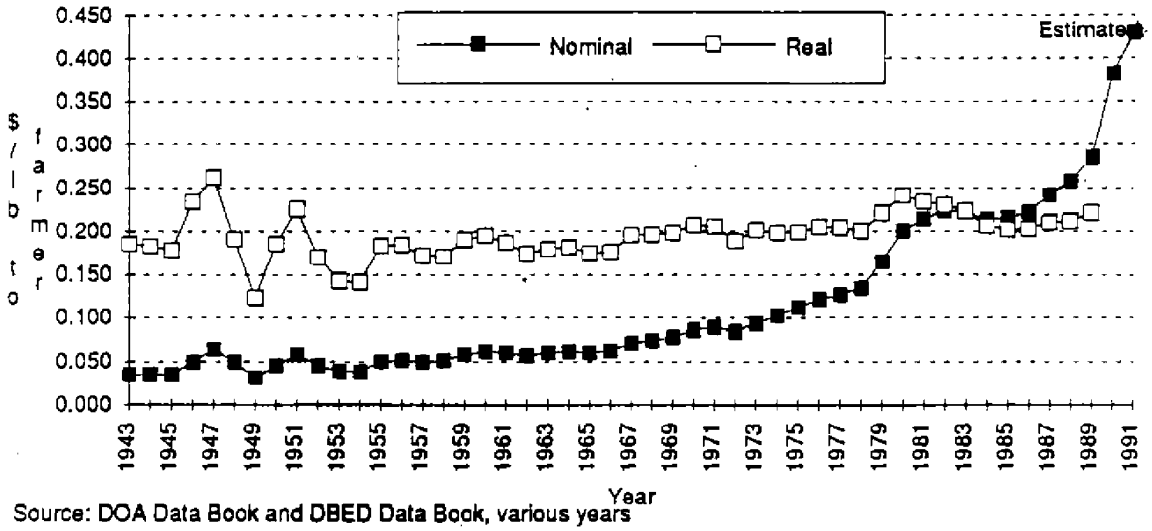
Existing Commercial Cultivation and Techniques Used for Corm and Leaf Production and Poi Mills 1991



Market Interaction and Range of Farm-gate Prices for Taro 1990



FARM GATE OR NOMINAL AND REAL VALUE OF POI TARO IN HAWAII 1943-1991



Source: DOA Data Book and DBED Data Book, various years

THE REALITIES IN THE PRICE OF POI

Cost of Production Inputs	-Labor (lots of other cleaner, better paying jobs)--you can't tell people what job they must have, or how much money they can make...when is the last time you turned down a raise?? Not so may kids around, they are off getting educated and the like. -Land -Fertilizer (tied to the price of oil) -Transportation costs -Equipment costs -Lots of others
Costs of Processing	-Labor (have to pay going wage) -Electricity -Transportation -Equipment -Land
All Other Goods and Services	-Prices up
All Other Foods in the Waianae Diet	-Fish (was about as "free" as the cost of poi in old time Hawaii.) -Fruits -Greens -Starchy Vegetables

SOLUTIONS??

HAWAII ECONOMIC REVIEW

STATE OF HAWAII—DEPARTMENT OF PLANNING AND ECONOMIC DEVELOPMENT SUMMER 1965

One-year-old Rodney Loo enjoys eating poi for his lunch, according to his mother, Mrs. Paul C. T. Loo. *Tom Fujise photo.*

POI HAS POTENTIALITIES

By CLARENCE L. HODGE

Poi—"staff of life" for the Polynesians and a mainstay in the diet of old Hawaiians—was given a boost toward a come-back at the first State Taro Conference held in Honolulu last March.

Major objectives of the conference were to: (1) evaluate medical research done on taro as a baby and health food; (2) analyze the national market potential of taro; and (3) determine if Hawaii can grow taro to meet this market.

The conference was attended by some 150 businessmen, pediatricians, nutritionists, and governmental officials. Key research officials and executives from the Carnation Company, Ralston Purina Company, Foremost Dairies, Inc., and Love's Biscuit & Bread Company attended.

The conference was sponsored by the Chamber of Commerce of Honolulu, the Hawaii State Department of Planning and Economic Development, and the Kauai Economic Development Commission.

Chairman and conference moderator was Richard A. Cooke, Jr., director, land utilization department, C. Brewer & Co.

Ten speakers were heard at the conference. The major highlight was a report given by Dr. Jerome Glaser, professor of pediatrics at the University of Rochester, on his study: "Poi—Its Use as a Food for Normal, Allergic and Potentially Allergic Infants."

Glaser said: "Poi, as a substitute food for patients allergic to cereals and as a prophylaxis (preventive treatment) for allergy to cereal in infants and children, offers a tremendous potential market for Hawaii."

Twenty per cent of the children 10 to 12 years of age are potentially allergic, an indication of the vast market potential, he said.

As for the price competition of cereals, Dr. Glaser said that in his judgment, poi might be able to hold its own. He suggested mixing poi with fruit, just as other baby foods are. This would bring the cost to about the same as for cereals, he added.

Cow's milk, milk products, eggs, and cereals, are the principal foods to which babies are allergic. No adequate carbohydrates food to substitute for cereals had been found until poi was suggested. Allergy to poi does exist, but it is very rare, according to Glaser's findings.

Dr. Glaser stressed the important role that poi could play in the treatment of allergic diseases such as asthma, eczema, diarrhea, and gastro-intestinal diseases. He further suggested that a study be made on the use of poi in the treatment of ulcers.

Among other suggestions he made were the following:

1. A local study should be made by Honolulu physicians to verify his findings.

DR. GLASER

2. A study should be made as to what are the best features to develop in a cereal substitute.

3. Recipes for poi should be developed which should not contain egg, milk, or true cereals.

4. Poi in colors other than gray should be developed.

5. Further experiments in the uses of frozen poi should be encouraged.

6. Poi should be a uniform color, consistency, and composition.

7. Experiments with the dehydration of poi should be encouraged as well as efforts to make palatable cookies with poi—similar to studies now going on at the University of Hawaii.

Co-authors in the study with Dr. Glaser were Drs. Ruth A. Lawrence, Anne Harrison, and M. Richard Ball.

The study was made possible by a grant from the House Policy Committee of the Hawaii State Legislature to the University of Hawaii, upon recommendation by the Kauai Economic Development Commission. It was sub-let by contract to the University of Rochester's School of Medicine and Dentistry.

Other major highlights brought out at the conference:

1. Taro is a declining industry. Acreage dropped from 1,010 acres in 1948 to 470 acres in 1964, or about 53 per cent. It was the consensus of the conference that its future depends largely on reduction of production costs and developing new markets.

2. The gross value of taro at the present time is about $575,000; however, processed taro for poi is valued at about $3 million. This is a sizeable crop in Hawaii's agricultural economy.

3. Land is available. It is estimated there are about 10,000 acres of valley bottom land suitable for dryland taro production, plus several thousand acres of uplands.

4. Labor costs are steadily increasing and there is a decline in the kind of labor needed for growing wetland taro. This labor market has to be filled.

5. Dryland growing of taro is probably the answer to the problem—plus mechanization. It was suggested that the industry adopt some of the modern methods of production currently being used by beet, tobacco, and strawberry producers.

6. Dryland taro will require selection of the best varieties for highest production together with fertilization, weed control, and irrigation.

7. The growing of dryland taro is feasible, according to experiments conducted by the University of Hawaii's branch experiment station at Wailua, Kauai. A party of 25 conference participants made an inspection trip of both dry and wetland taro fields on Kauai following the conference.

A full report on the findings of the conference will be published by the Cooperative Extension Service of the University of Hawaii.

Immediately following the conference, Chairman Cooke appointed a six-man committee to develop an action program to implement the findings and recommendations emerging from the conference. The committee agreed that the conference definitely revealed taro as a crop of considerable promise. It likewise revealed the major problems to be resolved before taro can become a major crop.

The committee adopted the following five-point program:

1. Request the State Government to establish a grant-in-aid, preferably with pediatric allergists in Hawaii, to confirm Dr. Glaser's contentions on the value of taro as a clinical food. (It was further recommended by Dr. Glaser that a local physician be given a grant-in-aid to study the use of taro in the treatment of gastro-intestinal disorders.)

2. Request the Hawaii Agricultural Experiment Station to operate a demonstration dryland farm using mechanized operations. Such a demonstration should prove the practicability of these mechanical methods as well as indicate costs of operation.

3. Establish a State pesticide residue laboratory in Hawaii to expedite the clearance of herbicides and fungicides that are used in modern agricultural practices.

4. Initiate a project with the Food Science and Technology Laboratory at the University of Hawaii to develop ways of enhancing the acceptability of taro and its products.

5. Plan and execute a marketing test program in Hawaii to determine consumer reaction to taro and its products.

The committee set a target deadline for completion of this program at July 1, 1967.

The author is Deputy Director, DPED.

Research Center

Ling-Temco-Vought, Dallas, Texas-based aerospace organization and one of the nation's leading defense contractors, has established a research center in the 50th State.

The LTV Research Center-Hawaii Division, at 1130 University Avenue, will work closely with the University of Hawaii on various areas of scientific research. The Hawaii Division is under the direction of Dr. Felix Fenter, assistant director of LTV's Dallas research center. Its work will emphasize but will not necessarily be limited to oceanic systems, according to Fenter.

Members of the Hawaii Division staff include James Morrow, one of LTV's leading technical men in anti-submarine warfare and oceanic systems; George Curtis, a physicist with extensive experience in anti-submarine warfare systems and acoustics, and Dr. Eugene Wilkins, specialist in meteorology and oceanography. The Center plans to augment its staff with graduate students from the University of Hawaii who will work for the company on a part-time basis.

Ling-Temco-Vought also operates a Hawaii-based electronics subsidiary, Kentron-Hawaii.

* * *

Military Population

The number of members of the armed forces and their dependents in Hawaii dropped sharply during the first three months of 1965, according to statistics compiled by the State Department of Planning and Economic Development from local commanding officers. The April 1, 1965 total was 126,792, compared with 135,648 on January 1, 1965 and 112,938 on April 1, 1960.

The new total includes 50,330 officers and enlisted men (11,063 stationed ashore and 12,273 aboard ships homeported in Hawaii) and 70,456 dependents domiciled in Hawaii. The number of military families was 22,339.

All branches of the armed forces were represented. Air Force personnel and dependents numbered 26,038; Army, 38,811; Coast Guard, 3,369; Marine Corps, 12,341; and Navy, 16,233. The only branch to report a major change during the preceding months was the Marine Corps, which had numbered 21,368 personnel and dependents as of January 1.

HAWAII ECONOMIC REVIEW

Volume II No. 4

Publication of the Hawaii State Department of Planning & Economic Development, 426 Queen St. Honolulu, Hawaii 96813.

SHELLEY M. MARK, PH.D. *Director*

EDWARD J. GREANEY *Editor*

Poi Keeps Ohio Child, 3, Alive

AKRON, Ohio (AP) — The Summit County Welfare Department said it is purchasing dehydrated poi from Hawaii for a 3-year-old girl unable to eat anything but poi and rabbit.

"It's a life or death situation," a social worker said. The little girl weighs about 23 pounds, suffers from cerebral palsy and is allergic to every other food according to social worker Sally Crist.

"The doctors discovered some time ago that poi was quite agreeable, and we were using a canned poi," Mrs. Crist said. "But now the doctor pops up and says we need a powdered poi."

She said she located a firm in Hawaii that agreed to ship 15 pounds of freeze-dried poi, about a three-month supply to Akron. Mrs. Crist said the poi costs $1.25 a pound.

"It's really a small money matter compared to the other medical expenses the child has," Mrs. Crist said. She is fed through a gastric tube.

The girl's mother receives Aid to Dependent Children and purchases the rabbit herself with food stamps, Mrs. Crist said.

Star Bulletin - Oct. 16 '73

TB: TARO

Poi Flown To Akron To Save Girl's Life

Akron Beacon Journal

By J. CURTIS BROWN
Beacon Journal Staff Writer

Poi is being shipped in from Hawaii by the Summit County Welfare Department for a 3-year-old girl unable to eat anything but poi and rabbit.

"It's a life-or-death situation," said social worker Sally Crist, who coordinated the poi shipment. The first 15 pounds of freeze-dried poi arrived by air freight Saturday.

Robert McDonald, assistant welfare director, authorized the air freight transport of the poi.

THE GIRL, who weighs only 23 pounds, suffers from cerebral palsy and is allergic to every other kind of food, the Welfare Department said.

Mrs. Crist said, "The doctors discovered some time ago that poi was quite agreeable, and we were using a canned poi" (a Hawaiian food made from the taro root which is mashed and allowed to ferment).

Doctors said, however, that the little girl needed a powdered poi. Mrs. Crist discovered the Hawaiian firm that agreed to ship 15 pounds of the freeze-dried poi, about a three-month supply, for about $1.25 a pound.

The child is fed through a gastric tube and requires medical equipment at her bedside. The girl's mother receives Aid to Dependent Children and purchases the rabbit herself with food stamps.

Rittman Press 10-23-73

We read about the little child in Akron who is a cerebral palsy victim and can only eat rabbit and "poi", which is grown only in Hawaii. Tom Hughes, from Rittman, and originally of Hawaii, inadvertently became the middle man in the shipment of the "poi" the other night, when his sister, Mrs. Claire Ho, of Hawaii, called him long distance to say that she had the shipment ready for the trip, but could not contact the right person in Akron. Mrs. Ho is the Assistant State Nutritionist in Hawaii, and had the assignment of shipping the poi to Akron. Tom contacted the authorities in Akron and arranged for the shipment of the vital food to keep the child alive.

OCT 2 5 1978

SUMMIT COUNTY WELFARE DEPT.

695 S. Main St.
762-0681
AKRON, OHIO 44311

FRANK BIRKEL
DIRECTOR

Mrs. Claire Ho
State of Hawaii
Department of Health
Nutrition Branch
P. O. Box 3378
Honolulu, HI 96801

Dear Mrs. Ho:

On behalf of our client and ourselves, we wish to express our deep appreciation for your fast and hard work in locating the freeze-dried poi.

The poi arrived in Akron the very next day and now the little girl is using it.

The articles which you sent us were very informing. I will be xeroxing these to send to the physician involved and also our local Children's Hospital of Akron.

Again we thank you so much. If we can ever be of service to you please don't hesitate in contacting us.

Very truly yours,

SUMMIT COUNTY WELFARE DEPARTMENT

Sally Crisp

(Mrs.) Sally Crisp
Comprehensive Family Service

Approved by:

Francis J. Birkel

Francis J. Birkel
Director

Fleeta Bodosi

(Mrs.) Fleeta Bodosi
Supervisor

SC:mem

October 12, 1973

Miss Sally Crisp
Summit County Welfare Department
Akron, Ohio 44311

Dear Sally:

I have xeroxed three articles for your information. The list of references in the Roth article will give the pediatricians some background reading if they are interested.

The "starchy aroids" article provides information on the entire taro family. Taro is cooked and then mashed into poi. Hawaii's poi comes from wet-land variety of taro. The shape of Hawaii taro is more pear-shaped as shown in the Roth article. Because land values in Hawaii are high, the taro farmers are fewer in number. The retiring farmers are not being replaced by younger men. So poi is quite expensive and is a luxury item for many families.

Hope things work out well with the Honolulu Poi Company.

Sincerely yours,

(Mrs.) Claire Ho
P. H. Nutritionist
Nutrition Branch

CH:dh
enclosures

SOME FACTS ABOUT TARO

HISTORY

Taro is one of the oldest of cultivated crops. Chinese books make mention of it as early as 100 B.C. and it was grown in Egypt before the time of Pliny (23-79 A.D.) for he mentions it as one of the established food plants of the country. The earliest European navigators saw it cultivated in Japan and as far south as New Zealand.

Taro (Colocasia esculenta (L) Schotl.) was truly the "staff of life" of the old Hawaiians and it was an important source of carbohydrate in the more southerly Pacific Islands where it continues to be extensively used.

In Hawaii and other areas, it is natural that varieties best suited to the uses in the area would be selected out of any varieties available and thus have given rise to types peculiar to the area and not necessarily found in other locations.

Taro was used for many purposes besides the staple food, poi, in Hawaii. Varieties were selected as being particularly suited as offerings to the Gods and other varieties for the making of puddings. Some were used for medicinal purposes but just how they were used is not clear. The royal taros, producing a pinkish or purplish poi, were reserved exclusively for the use of royalty and high chiefs. The gray or white taros were the staple food of the commoner.

The varieties of Hawaiian taros which have been studied may be grouped into four general classes as to corm color--red, yellow, light gray or white, and dark gray. "The yellow varieties are of interest in that the pigment is carotenoid in nature. A calorimetric analysis showed approximately 13 ppm of carotene in dried taro. This compares with less than 1 ppm found in white and red varieties. Due to the close relationship between carotenoid pigments and vitamin A the potentialities of the yellow taros as a source of this vitamin are indicated."

CULTURE

The cultivation of the taro crops was developed into a fine art in old Hawaii with variations of management to fit the peculiar ecological environment of soil, rainfall and nutrition.

The crop was grown in paddies under submerged culture, whose size varied from as small as 20 square feet to areas of a third of an acre or more. Extensive and intricate irrigation systems were constructed to insure continued and adequate control of water flow through the paddies and permitted isolation for drying any single paddy or sections for fallowing. In areas of fairly uniform and high rainfall, the crop was grown "dry land" or non-submerged, and great care was taken to conserve moisture with mulches to carry the crop through dry periods. Here again, field management of selected varieties and time of planting provided a system permitting continuous harvest.

As would be expected, yields varied considerably as harvesting and planting were conducted on a continuous basis. The good grower could predict within fairly narrow limits the yield and time of harvest for each patch or paddy, and timed his plantings accordingly. The varieties used also provided a basic variant in cropping time as some varieties could be matured in an eight-month period while others required 18 or more months. The longer growing types produced the higher per-acre tonnages. It is reported that tonnages up to 65 T.P.A. were obtained on favored areas where fertility, sunlight, water and disease were not limiting factors.

The taro industry today produces tonnages of 10 to 25 T.P.A. on 500 acres and the average crop time is about 14 months according to the last crop census. This supplies the present local taro needs with some export to the mainland as a canned or bottled product.

The increased use of commercial fertilizers in taro production has been a mixed blessing as it has increased the continuous use of the paddies with a possible increase of imbalance of the nutritional elements and a more rapid build-up of pathogens of root and corm rots. Pythium sp. is the most severe of the root and corm rots, and a "hard rot," locally called "guava seed," is suspected to be a physiological microdeficiency possibly compounded by an imbalance in nutritional levels. Losses from both of these diseases vary from 1 or 2% to as much as 100% in rare cases.

A debilitating leaf spot disease of wet-land taro is caused by Phytophthora colocasiae, one of the downy mildews, closely allied to the late blight of potatoes. Recent tests have shown a close relationship between leaf spot incidence, high humidity, low temperature and little or no air movement. Currently fungicidal agents are being evaluated which appear to show promise of effective control of the disease.

Losses from the disease vary greatly, depending upon the degree of damage to the leaf surfaces. When leaf surface and even the petioles are damaged, then crop loss is very high.

Another foliar disease, Phyllosticta calocasiophila leaf spot, occurs exclusively in the upland taro, occasionally becoming very serious. Mechanical wind damage provides entrance of the organism and the disease is considered quite significant in wet weather when the spores are splashed from one leaf to another and under such conditions may result in serious loss of yield.

Nutritive Value

The following table of retention values of thiamine, riboflavin and niacin in home cooked taro was taken from a station publication by Carey D. Miller, et al. entitled "Taro is a source of thiamine, riboflavin and niacin."

Taro corms cooked	Moisture	Thiamine			Riboflavin			Niacin		
		As assayed mg/100 gms	Dry wt. mg/100 gms	Retention %	As assayed mg/100 gms	Dry wt. mg/100 gms	Retention %	As assayed mg/100 gms	Dry wt. mg/100 gms	Retention %
Piko keo	74.3	0.111	0.432	77	0.030	(0.117)		0.47	1.83	(112)
Bun Long	59.6	0.100	0.248	59	0.025	0.062	98	0.58	1.44	91
Dasheen	74.9	0.073	0.291	89	0.015	0.060	97	0.60	2.39	96

The following table is from Pacific Subsistence Crops and was drawn from several food composition tables based upon 100 grams of edible material:

Water	- 72.5 gm	Iron	- 1 mgm
Proteins	- 1.9 gm	Vitamin A	- 30 I.U.
Fats	- 0.2 gm	Thiamine	- 0.04 mgm
Carbohydrates	- 24.0 gm	Riboflavin	- 0.03 mgm
Fibre	- 0.8 gm	Niacin	- 0.4 mgm
Ash	- 1.3 gm	Ascorbic Acid	- 10 mgm
Calcium	- 30 mgm	Calories	- 100
Phosphorus	- 80 mgm		

Another table from the same publication compares different carbohydrate sources and their weights in gms to provide 100 calories.

	Wt. giving 100 calories gms	Thiamine mcg	Riboflavin mcg	Niacin mcg	Calcium mg
White flour	26	20	8	226	5.4
Polished rice	28	25	8	560	2.5
(Polished, washed and cooked rice)	28	5	-	390	2.5
Sweet potatoes	80	80	48	559	24.0
Breadfruit	70	96	59	720	14.7
Taro	70	149	25	424	16.0

It must be noted that there are discrepancies in the figures from the various tables for the same material. The tables were taken from different publications and the analyses presumably were done with materials grown under divergent conditions. Under these conditions, complete agreement could not be expected.

Poi has been used in Hawaii as an infant's first solid food, initially as an admixture in the bottle with milk and later as a cereal substitute. The starch grains being of small size and readily digested, provide a starch easily assimilated and without the occasional allergy difficulties found with some of the other starches. A substantial part of the fresh and canned or bottled poi is being used in infant feeding.

An estimate of the acreage at one time devoted to taro culture would probably be considerably in excess of 10,000 acres. Much of this acreage is now being utilized as house lots or pasture for the culture of other crops or forest land. There still remains several of the larger valleys with adequate water sources which could be returned to the culture of taro should the need arise.

The areas of high rainfall below 2,500-ft. elevation unsuited for sugar growing could also be converted to taro culture with the possibility of mechanization to a greater extent than possible in wet paddies under the present system. A possible modification of the paddy system could increase mechanization in this area also.

It is difficult to estimate the extent to which an increase in taro acreage could be expanded as the factors of land rental, labor and the other farm operations all enter the picture as well as the value of the crop to the processor. Conservatively, two to four thousand acres are now available. It is visualized that there are about 10,000 acres of valley bottoms suitable for taro culture plus several thousand acres of high rainfall uplands suitable for "dryland" taro production.

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F. A. I. Bowers
March 1965

Francis Bowers worked with the Ag Dept at the UH (? extension?) Son Mike graduated + taught @ Punahou!

Reprinted from JOURNAL OF THE AMERICAN DIETETIC ASSOCIATION
Vol. 16, No. 6, June-July, 1940

TARO (COLOCASIA ESCULENTA) AS A FOOD[1]

MARTHA POTGIETER

Hawaii Agricultural Experiment Station, Honolulu

TARO (*Colocasia esculenta* (L.) Schott.) for many centuries has been a common food crop in the islands of the mid-Pacific, in sections of southern Asia, in countries bordering on the Mediterranean, and in parts of South and Central America. Varieties known as dasheens[2] have been grown in Florida and other southeastern states for more than a quarter of a century. Several varieties are sold in the San Francisco Chinese markets, where they are purchased by Caucasians as well as Chinese.

The edible starchy *corm* (an enlarged subterranean stem) of the taro plant is somewhat similar in size and composition to Irish and sweet potatoes. The young leaves and the thick, succulent stems of the plant are also eaten. Taro seldom blooms, but the flowers when cooked are considered a rare delicacy.

Taro as a crop is one of the greatest food producers per acre in the world. It is easily grown (by both primitive and modern agricultural methods) and the great number of varieties makes production adaptable to many conditions of soil and moisture. The yield per acre is in some cases two to four times that of potatoes. In Hawaii an acre of taro yields, on the average, 5 to 10 per cent more calories in one year than an acre of rice. The time required for the crop to mature ranges from about 6 to 18 months, depending on variety, climate, and method of cultivation.

[1] This and two succeeding papers on taro to be published in subsequent issues of this Journal, were presented in condensed form as one paper before the General Session, American Dietetic Association, Los Angeles, August 29, 1939. Published with the approval of the director, Hawaii Agricultural Experiment Station, as Technical Paper No. 61.

[2] The name dasheen is believed to be a corruption of the French "de Chine" (from China). This term was probably introduced from the West Indies, where the vegetable was originally called "taro de Chine" (Chinese taro).

USE OF TARO IN HAWAII

The culture of taro probably reached its highest development in the Hawaiian Islands (4). A recent study of taro varieties at this station showed that out of more than 80 distinct forms, 69 were native to Hawaii (26). In these islands taro is usually eaten in the form of a soft paste called *poi*. The taro corms are steamed or boiled, peeled, then pounded or ground, with the addition of a little water, into a thick paste called *paiai* (containing about 30 per cent solids). In this form it keeps for several weeks without refrigeration, the resulting fermentation being considered a desirable quality. To prepare it for eating, paiai is mixed with water to make a slightly thinner paste and strained through a coarse cloth. This mixture is the well-known poi of the Hawaiians. The organisms of fermentation include yeasts and lactic acid bacteria. Allen and Allen (1) found the souring of poi to be similar to the souring of milk; namely, a production of organic acids (chiefly lactic) through the action of lactobacilli on the carbohydrates present. Bilger and Young (5) noted a decrease in sugars

and Miller (21) reported a decrease in the starch content of poi from 10.5 to 9.9 per cent during fermentation.

Taro, and the poi made from it, constituted the staff of life of the Hawaiian people at the time of the discovery of these islands by Captain Cook in 1778 (9, 10). The estimated 300,000 people in the islands at that time lived chiefly on poi, sweet potatoes, fish, *limu* (seaweeds), and a few greens and fruits (10). They had no milk other than human milk. The good physique and excellent teeth of the ancient Hawaiians (7, 16) testify to a diet adequate in bone- and tooth-building material. Taro, though relatively low in calcium, was eaten to such an extent, at least by adults, that it could have furnished the greater part or all of the daily requirement for this mineral. No doubt this one food furnished the early Hawaiians a large part of the calcium required to produce their strong skeletons and good teeth. The many hours of sunshine and the custom of wearing but little clothing no doubt afforded ample vitamin D to aid in the efficient utilization of the calcium and phosphorus in the diet.

Since the advent of the Caucasians the production and consumption of taro have greatly fallen off in Hawaii. Imported "civilized" foods (refined grain products and sugar) have been for some time replacing taro in the diet of the Polynesians, both in Hawaii and in Samoa. This change in diet is accompanied by an increase in dental caries (11, 23, 24).

COMPOSITION

The composition of steamed taro corms was given by Miller (21) in 1927 as follows:

	Per cent
Water	64.0
Protein	1.18
Ether extract	0.17
Starch (acid hydrolysis)	29.31
Sucrose	1.40
Reducing sugars	0.39
Ash	0.59
Calcium	0.026
Phosphorus	0.061

Composition data for the dasheen, given by Young (29), are similar to these figures. Chung and Ripperton (8) reported a range of 0.0015 to 0.0017 per cent iron in peeled taro corms. Hammond (12) found the iodine content of poi made from taro corms grown in Hawaii to be 300–400 parts per billion. The excess alkalinity of the ash of 100 gm. of air-dried taro corms was recently found, in this laboratory, to be equivalent to 18.1 cc. of normal alkali.

Miller (21) reported the corms to be rich in vitamin B (B complex) and to contain appreciable amounts of vitamin A, but to be poor in vitamin C. Recent tests in the nutrition department of this station show taro corms to contain about three-fourths as much vitamin B_1 (on the dry weight basis) as whole wheat flour. Preliminary tests show taro corms to be a good source of vitamin G (flavin).

Both the corms and the leaves of most varieties of raw taro have an acrid quality which causes a stinging sensation in the mouth and throat. This is due to the presence in the plant of microscopic raphides of calcium oxalate (6). These crystals and the acrid quality are destroyed by thorough cooking. Though raphides are visible in the corms under the microscope, the amount of oxalate present is so small that it cannot be de-

tected by chemical methods satisfactory for determining one part in 5000.[3]

NUTRITIVE VALUE OF TARO

Taro was considered by the early Hawaiians to be a very healthful food, easily digested, "most soothing to the stomach and highly beneficial to an invalid" (28).

Langworthy and Deuel (19) found the digestibility of taro starch, even when eaten in comparatively large quantities, to be 98.8 per cent. Langworthy and Holmes (20) found the starch of cooked dasheens to be 97.6 per cent digestible.

In olden days the Hawaiians commonly fed poi along with breast milk to infants, and this custom is continued even today. Plantation physicians in Hawaii have recently fed poi to a large group of young infants of Oriental ancestry with good results (13, 14). Taro flour and other taro products are being successfully used in infants' formulas in several hospitals in the mainland of the United States (15).

Kirkpatrick (17) reports that the Melanesians on the Island of Manus, northwest of New Guinea, who live chiefly on taro, have better-developed dental arches and less Vincent's gingivitis than do others of the group whose carbohydrate food is largely sago. He ascribes this to the higher vitamin content of taro (over that of sago). Larsen and others (18) found a high incidence of dental caries in a group of infants and young children in Hawaii, of Oriental ancestry, who received rice as their main source of carbohydrate. In children of the same ancestry fed an adequate diet in which poi replaced rice, only a small percentage showed evidence of dental caries.

[3] Unpublished data from the taro processing division of this station.

Due to its ready digestibility and its bland nature, taro is a satisfactory food for many individuals with digestive difficulties. Its high calcium and vitamin B_1 content make it preferable to refined grain products in restricted diets.

Since taro is so different botanically from any foods commonly used in the mainland of the United States, it has been suggested as a possible substitute for the frequently allergenic wheat and other cereal foods (2). For patients allergic to wheat, the dietary department of a California hospital has devised some recipes in which taro flour takes the place of wheat. None of the patients was found to be sensitive to taro (15).

TARO PRODUCTS

Various products have been prepared from taro corms from time to time during the past 60 years in Hawaii, both for local use and for distribution elsewhere. At present a taro flour is being manufactured by steaming, drying, and grinding the corms (3, 15). Taro flour has been used successfully to replace 15 to 20 per cent of the white flour in bread. In other products, such as cookies, doughnuts, cakes, waffles and muffins, as much as 50 to 100 per cent of the wheat flour may be replaced by taro flour. Due to its hygroscopic nature, the taro flour causes the baked products to retain moisture for a longer period than do the same products without the taro flour. Since refined wheat flour contains little vitamin B_1, the substitution of taro flour for part of the wheat flour improves the vitamin B_1 content of these products. Recently a division of the United States Army stationed in Hawaii found taro bread to be palatable and generally as well liked as regular issue bread. Pre-

liminary experiments in the nutrition laboratory of this station showed a taro bread to contain approximately 30 I. U. vitamin B_1 per 100 gm.—a value equal to that of one sample of whole wheat bread tested at the same time.

An infant food for use in formulas, and a beverage powder, both prepared from taro corms, are also on the market (15).

Taro corms are not suitable for starch manufacture because of the extremely small size of the starch granules and the mucilaginous nature of the juice.

INCREASED USE OF TARO ADVOCATED

The increased use of taro, in preference to other and less nutritious carbohydrate foods, is being urged in many localities. In the Dutch East Indies it is recommended as preferable to cassava, a common food in some sections there at present (25). In the island of Cyprus (27) the increased production and use of taro are advocated as a means of improving the nutrition of the people. Young (29) urges the growing of more dasheen (taro) in southern United States for human consumption and mentions its possibilities as a stock feed. He also lists recipes for the preparation of various dishes from this vegetable. Increased production and use of taro are being encouraged in various islands in the Pacific.

More extensive use of taro is being urged in Hawaii because of its capacity for correcting specific local dietary deficiencies (3). Published data (22) and unpublished studies in progress at this station among some of the various racial groups in Hawaii show many family dietaries to be deficient in calcium and in vitamin B_1. Additional indication of calcium deficiency, in a land where sunshine is abundant, is the occasional occurrence of mild rickets in infants; and a further evidence of a dietary shortage of vitamin B_1 is the recorded annual beriberi death rate in the Territory ranging from 5 to 36 per 100,000 during the past ten years. Increased production and use of taro would tend to decrease the amount of imported refined foods used and increase the calcium and vitamin B_1 contents of the deficient diets. Greater taro production would also aid in making these islands nutritionally self-sustaining (instead of being dependent on outside sources for over half of the food consumed) in time of possible maritime strike or war and consequent isolation from the mainland of the United States and other countries.

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Samoa – Niué ulaula

New Zealand – Red + White Dasheen
Easter Island – Kuku Angamea tahi

Timor – unnamed (dasheen)

Claire Hughes

DESCRIPTIONS OF CLASSIFIED VARIETIES

DESCRIPTIONS OF CLASSIFIED VARIETIES

Japanese Varieties

The Japanese taros are probably of Asiatic origin, having been introduced, presumably during the latter part of the last century, by early immigrants from Japan. They are characterized by symmetrically ovoid corms which produce as many as 20 or more cormels, or *oha*. The *oha* begin to develop early in the life of the mother plant, several generations having developed by the time the plant is mature. Except for a few of the oldest ones, the cormels remain dormant, and these dormant cormels are marketed.

The Japanese taros differ markedly from the Polynesian taros, more closely resembling the dasheens. They are generally more hardy and disease-resistant, earlier maturing, and heavier yielding; yields of 15 to 20 tons per acre of salable cormels in 6 to 10 months are not unusual. They have better keeping qualities, remaining in excellent condition after 2 or more months of storage. Japanese taros are grown almost entirely under nonsubmerged culture, but they are usually irrigated. The dormant *oha* are used for planting material whereas with the Polynesian varieties the *huli* are used almost exclusively.

The Japanese varieties are not adapted to poi making but are used almost entirely as table taro. The plant is usually less acrid[1] than the Polynesian taros, and the petioles of the young leaves are often cooked as a vegetable.

There are three Japanese varieties in the Territory.

1. Tsurunoko

(Araimo)

General characteristics: Short, spreading, moderately stocky, often maturing within 6 months, producing as many as 40 *oha*, mostly dormant; distinguished by light green petioles and divergent petiole sinus.

Petiole: 55 to 80 cm. long, light green with slight light brown flecking near base, white to greenish-white at base, reddish-purple at apex, with inconspicuous reddish edge; sinus widely divergent.

Leaf blade: 35 to 50 cm. long, 25 to 40 cm. wide, 30 to 45 cm. from tip to base of sinus, narrowly ovate, firm-chartaceous, light green with bluish cast; margins finely undulate, the marginal veins often purplish; *piko* yellowish to light purple; lobes obtuse to slightly acute with shallow, wide sinus.

[1] All parts of the taro plant contain small needle-like crystals of calcium oxalate which cause irritation of the throat unless thoroughly cooked. They occur to a marked degree in some varieties but to only a negligible extent in others.

Corm: Flesh white with yellowish fibers; skin white; cormels about 3 to 5 cm. in diameter.

Origin, and derivation of name: Probably native of Japan; *Tsurunoko* refers to the prolific production of *oha*.

Distribution: Most important Japanese variety in Hawaii, grown throughout the islands, almost exclusively under upland culture by Japanese gardeners, usually under irrigation alongside other vegetable crops.

Use: Mainly as table taro; to a certain extent for taro sprouts.

Remarks: Parent corms are discarded because of their pronounced acridity. The *oha* are much smaller than those of the other Japanese varieties and are the only ones which cause irritation. They are pared under water to prevent itching hands. If the cormels develop top growth, they become acrid and are discarded. The popularity of this variety is due primarily to the excellent keeping quality.

2. Akado

(Ekaeka)

General characteristics: Medium in height to tall, stiffly erect, stocky, maturing within 10 months, producing more than 20 *oha* which remain dormant for several weeks; outstanding among the Japanese taros because of the vivid petiole coloring.

Petiole: 60 to 90 cm. long, greenish-bronze shading into dark reddish-purple at base and apex, indistinctly edged, curved abruptly at apex so that blade hangs more or less vertically.

Leaf blade: 40 to 55 cm. long, 30 to 40 cm. wide, 35 to 45 cm. from tip to base of sinus, broadly ovate, firm-chartaceous, dark green with bluish cast, often tinged with purple on lower surface when young, with conspicuous purple veins on lower surface; *piko* prominent, purple; lobes acute with shallow, wide sinus.

Corm: Flesh white with yellowish fibers; skin purple; *oha* usually 4 to 6 cm. in diameter.

Origin, and derivation of name: Probably native of Japan; called *Akado* because of coloring of petioles. *Ekaeka*, meaning "dirty reddish," is the name given by the Hawaiians, probably also referring to the petiole coloring.

Distribution: Grown sparingly, almost entirely by Japanese gardeners in small patches, usually under upland culture.

Use: *Oha* used principally as table taro; petiole stalks sometimes sold as greens; sprouts from small *oha* grown in darkness sold in limited amount.

Remarks: The parent corms are edible but an aversion to them exists because of their extreme acridity. This variety is highly resistant to disease. It has the largest *oha* of the Japanese taros and probably has the best quality but is grown only to a limited extent because of its comparatively poor keeping quality.

3. Miyako

General characteristics: Short to medium in height, stiffly erect, moderately stocky, maturing in less than 10 months, producing more than 20 *oha*

6. Aweu

(*Aweo, Aweoweo, Aweuweu, Mamauweo, Maauweo*)

General characteristics: Medium in height to tall, moderately spreading, maturing within 9 to 12 months, producing from 10 to 15 long, slender rhizomes; distinguished by length of rhizomes.

Petiole: 70 to 105 cm. long, light green often inconspicuously flecked with dark green near base, white at base, with narrow, light purplish to indistinct edge, curved sharply at apex so that blade hangs vertically.

Leaf blade: 40 to 65 cm. long, 25 to 45 cm. wide, 35 to 55 cm. from tip to base of sinus, narrowly ovate, thin in texture, light green; margins slightly undulate; *piko* greenish to faintly purple; lobes acute with shallow, narrow sinus.

Corm: Flesh white with yellowish fibers; skin cream-colored, usually with pink or purple along leaf-scar rings, the outer skin shaggy and fibrous.

Origin, and derivation of name: Native variety; derives its name from shaggy outer skin of corm.

Distribution: Formerly widely distributed in wild state, now scattered along streams and in forests in the mountains.

Use: Good as poi, but not used at present because the corms are usually small; the leaves are used for *luau*.

Remarks: This variety was used by the old Hawaiians for poi only when other food was scarce. The corms are too acrid to be used as table taro unless cooked for a long time. *Aweu* is often called wild taro because of its frequent occurrence in the wild state. The rhizomes, sometimes as long as 70 cm., come so close to the surface that they appear like creeping stolons.

7. Kakakura-ula

(*Kakakura*)

General characteristics: Medium in height to tall, moderately spreading, maturing within 9 to 12 months, producing very early from 6 to 12 short, thick rhizomes; distinguishable by brilliant reddish-purple coloration overlying light and dark green striping on petioles.

Petiole: 75 to 95 cm. long, dark and light green-striped with strong tinge of reddish-purple almost obscuring stripes, indistinctly edged, white at base, curved at apex so that blade hangs almost vertically.

Leaf blade: 45 to 60 cm. long, 30 to 35 cm. wide, 35 to 50 cm. from tip to base of sinus, sagittate, firm-chartaceous, dark green with bluish cast; veins reddish on lower surface; *piko* purple; lobes acute with shallow, wide sinus.

Corm: Flesh white with yellowish fibers; skin cream-colored to white.

Inflorescence: Peduncle striped pink and light brown; spathe 24 to 32 cm. long, the lower tubular portion 4 to 5 cm. long, whitish, flecked or indistinctly striped with pink and light brown, with reddish-purple margins, the upper portion orange with reddish margins, abruptly acute at apex but loosely convolute below, sometimes open near constriction at

maturity; spadix 9 to 11 cm. long, the sterile appendage 7 to 13 mm. long, noticeably constricted, conspicuously acute.

Origin, and derivation of name: Introduced from South Seas; since four varieties were received under the name *Kakakura*, the descriptive suffix "*ula*" has been added to indicate a red *Kakakura*.

Distribution: Limited; the variety has done well at Pensacola Street Station under upland culture.

Use: Primarily as table taro.

Remarks: This variety is one of the most beautiful of all the taros. The predominating impression given by the plant is of the brilliant dark pinkish-red color; on closer examination almost every color of the rainbow may be found on the petiole. This taro might well be propagated as an ornamental plant.

Group Mana

The word *mana* means "branching" and refers to the habit of division of the parent corm, which is characteristic of this group. A single parent corm of *Mana Uliuli* may produce seven or more *mana*, or branches; the usual number for the other *Mana* is two or three. Branching takes place with most varieties only when the corms are fairly well matured; under some conditions of growth only a small percentage of the plants produce branches. Probably because of the branching habit, *oha* are produced sparingly and much later than in other taros.

The petioles of the *Mana* are curved sharply at the apex, causing the blade to hang almost vertically. The blades are very narrow, and the primary veins are oblique, giving the impression that they are much more numerous than in the other groups although actually the number is practically the same in all taros. The coloring of the *piko* is also rather unusual in that color splotching extends along the midrib and the main veins of the basal lobes, forming a more or less distinct Y. The *Mana* are usually quite upright in growth, with rather stiffly erect petioles.

The corms of the *Mana* taros have a somewhat dry, mealy, flaky texture when cooked. They are excellent as table taro but usually make very poor poi. The shape of the corms is irregular because of the branching. Most varieties are fairly heavy producers and mature comparatively early, in from 7 to 12 months.

The *Mana* are usually planted under upland culture. They are grown fairly extensively on the island of Hawaii, especially in Kona, Puna, and Kau. *Mana Keokeo* and *Mana Ulu* are the two most popular varieties in this group.

Origin, and derivation of name: Introduced from South Seas under the name "Yellow," which referred to the color of the corm flesh; it has since been classified as a *Mana* taro and given the descriptive name *Uliuli* because of the dark olive-green petioles.

Distribution: Limited; grown primarily under upland culture.

Use: Makes good poi of distinctly yellow color.

Remarks: Because of excessive branching, the shape of the corms is very irregular. This is probably the only South Sea introduction desirable for poi. The corms are similar to those of the *Kai* group, being tough and rubbery when cooked.

12. Mana Ulaula

(*Mana Ha Ulaula*)

General characteristics: Medium in height to tall, slender, erect, maturing within 9 to 12 months, producing two or three branches; readily identified by purplish-red flecking along the entire petiole, with almost complete absence of green coloration.

Petiole: 70 to 90 cm. tall, slender, slightly curved at apex, flecked with purplish-red, almost lacking in green, with narrow reddish edge, a dark reddish-purple ring at base with lilac-pink for about 3 cm. above.

Leaf blade: 40 to 50 cm. long, 30 to 35 cm. wide, 35 to 45 cm. from tip to base of sinus, ovate, thin in texture, light green; margins slightly undulate; *piko* small, purple; veins purplish on lower surface of lobes; lobes acute with narrow sinus.

Corm: Flesh white tinged with pink, especially near apex, with yellowish fibers; skin dark lilac-pink.

Inflorescence: Peduncle light purplish flecked with dark reddish-purple areas at base and above constriction; spathe 14 to 17 cm. long, the lower tubular portion about 3 cm. long, light purplish flecked with dark reddish-purple at base and at constriction, the upper portion yellow, tightly rolled; spadix 4 to 5 cm. long, slender, the sterile appendage 5 to 6 mm. long.

Origin and derivation of name: Native variety; *Ulaula* refers to purplish-red-flecked petioles.

Distribution: Comparatively rare; planted in a few scattered localities on Hawaii and Maui, nearly always under upland culture.

Use: Mainly as table taro for home use.

13. Mana Lauloa

General characteristics: Medium in height to tall, stiffly erect, maturing within 9 to 12 months, producing two or three branches; characterized by large, somewhat ovate leaf blades and dark green petioles with dark brownish-purple on lower portion.

Petiole: 80 to 90 cm. long, dark green tinged with brownish-purple, dark brownish-purple on basal third, fairly broadly edged with pink to whitish, a dark reddish-purple ring at base with lilac-pink-flecked area for 1 to 3 cm. above.

Leaf blade: 45 to 50 cm. long, 35 to 40 cm. wide, 35 to 45 cm. from tip to base of sinus, ovate, thin in texture, medium green; margins undulate; *piko* purplish; lobes obtuse, sometimes overlapping, with narrow sinus.

Corm: Flesh white with pink apex and yellowish fibers; skin pinkish-lilac to purple.

Origin, and derivation of name: Native variety; *Lauloa* refers to large leaves.

Distribution: Limited; grown primarily under upland culture.

Use: Chiefly as table taro.

14. Mana Keokeo

(*Mana Kea*)

General characteristics: Medium in height, erect, maturing within 7 to 12 months, producing two or three branches; characterized by dark green petioles with distinct pinkish-red edges.

Petiole: 60 to 85 cm. long, dark green, distinctly pinkish-red at edge, white at base.

Leaf blade: 40 to 55 cm. long, 20 to 40 cm. wide, 30 to 40 cm. from tip to base of sinus, ovate, thin in texture, medium green; margins undulate; *piko* small, yellowish; lobes obtuse, often overlapping, with narrow sinus.

Corm: Flesh chalky white with yellowish fibers; skin white, light lilac-pink to purple at leaf scars.

Origin, and derivation of name: Native variety; *Keokeo* refers to white corm flesh and white color at base of petiole.

Distribution: Grown extensively at Kona, Hawaii, almost exclusively under upland culture.

Use: Mainly as table taro; one of the favorite varieties for making *kulolo*.

Remarks: This is probably the most popular of the *Mana*, due to its large corms and ability to produce good yields even under adverse conditions.

15. Mana Kukuluhema

(*Manua*)

General characteristics: Short to medium in height, moderately spreading, maturing within 9 to 12 months, producing two or three branches; differentiated from *Mana Keokeo* by lighter petioles and whitish rather than light lilac-pink or purple leaf-scar rings of corms.

Petiole: 50 to 70 cm. long, pale green, often with light brownish fleckings near base and along margins, pink at edge, purplish at apex, white at base.

Leaf blade: 40 to 45 cm. long, 30 to 35 cm. wide, 30 to 35 cm. from tip to base of sinus, ovate, firm-chartaceous, medium green; margins slightly revolute; *piko* yellowish to light purple; lobes acute with narrow sinus.

Corm: Flesh chalky white with conspicuous yellow fibers; skin white.

Inflorescence: Peduncle whitish; spathe 21 to 24 cm. long, the lower tubular portion 3 to 4 cm. long, light green, the upper portion yellow, tightly rolled; spadix 7 to 8 cm. long, the sterile appendage 4 to 5 mm. long.

Origin, and derivation of name: Introduced from Samoa under the name *Manua*. Because of the close similarity between *Mana* and *Manua*, the Hawaiian *Kukuluhema*, meaning "south," has been substituted for *Manua*.

Distribution: Very little known.

Use: A fair table taro.

4.—Top: A general view of commercial taro grown under wetland culture (note the embankments used for flooding the petioles); middle: *Hinana*, a variety of taro with unusually large leaf blades and corms which, although the best yielder, is seldom grown because it cannot be made into poi; lower left: *Lauloa Palakea-eleele*, with large, long leaf blades with a few large undulations and the tall, erect petioles characteristic of the group *Lauloa*; lower right: *Apuwai*, characterized by short, stocky growth and more or

Distribution: Widely planted on all the islands, almost exclusively in wetland patches; although grown extensively in the lowlands, it appears to thrive better up toward the mountains where the water is cooler.

Use: A very important poi taro, particularly on Oahu.

Remarks: The corms have fairly firm texture and will absorb more water, in the preparation of *paiai*,[1] than most varieties. The poi is light bluish-grey in color and of very good quality.

19. Piko Keokeo

(Hachae Keokeo, Uaua Keokeo)

General characteristics: Closely resembles *Piko Kea*, but maturing within 12 to 15 months; differs in having white petiole base and chalky white corm flesh.

Petiole: 60 to 95 cm. long, light green, pinkish red at edge, usually with adjacent dark green blotches especially near base, white at base.

Leaf blade: 30 to 45 cm. long, 25 to 35 cm. wide, 20 to 35 cm. from tip to base of sinus, ovate, pendant, light to dark green; *piko* whitish; lobes narrow and obtuse with narrow sinus.

Corm: Flesh chalky white with light yellow fibers; skin cream-colored.

Origin, and derivation of name: Native variety; *Keokeo*, meaning light or white, refers to the corm flesh.

Distribution: Mainly as a mixture among other *Piko* varieties.

Use: Makes fairly good poi.

20. Piko Uaua

(Uaua Piko)

General characteristics: Medium in height, erect, moderately stocky, maturing in 12 to 15 months, producing from 5 to 10 *oha;* distinguished from other *Piko* by dark green petioles and pinkish base.

Petiole: 65 to 100 cm. long, dark green, usually edged narrowly with dark pink or red, light pink at base with pink ring.

Leaf blade: 30 to 45 cm. long, 25 to 35 cm. wide, 20 to 35 cm. from tip to base of sinus, ovate, nearly horizontal, chartaceous, light to dark green; *piko* whitish; lobes obtuse with narrow sinus.

Corm: Flesh white with slight pinkish tinge near apex and yellowish fibers; skin cream-colored.

Origin, and derivation of name: Native variety; the descriptive name *Uaua*, meaning "tough," indicates that the extensive root system makes this variety difficult to pull under wetland culture.

Distribution: Throughout the islands under both upland and wetland cultures; grown most extensively in Waipio Valley, Hawaii, under wetland culture.

Use: Makes poi of good quality.

Remarks: This is one of the hardiest of the *Piko* taros, and probably the only one grown to any extent under upland culture.

[1] In the production of *paiai*, the cooked corms are ground and water is added to bring the mass to a certain consistency. Tough, rubbery, cooked taro, while difficult to pound under the older methods of preparation, is regarded as desirable because of the good quality of the resulting poi. The yields of *paiai* and of poi, which is simply a diluted form of *paiai*, depend upon the amount of water the taro will absorb during grinding and that added later.

white at base, the apex whitish on outer surface and reddish-purple on inner.

Leaf blade: 40 to 50 cm. long, 25 to 35 cm. wide, 30 to 40 cm. from tip to base of sinus, sagittate, fairly concave, conspicuously mottled with green and dark purple especially on lower surface; margins quite undulate; *piko* purple; veins light reddish-purple on lower surface of lobes; lobes obtuse to slightly acute with deep, narrow sinus.

Corm: Flesh white with yellowish fibers; skin white with pink or light to dark purple leaf-scar rings.

Inflorescence: Peduncle lilac-purple with occasional dark purple streaks; spathe 18 to 24 cm. long, the lower tubular portion 3 to 4 cm. long, green with lilac-purple flecks and a few purple streaks, the upper portion yellow, tightly rolled or sometimes open near constriction; spadix 6 cm. long, the sterile appendage 6 mm. long.

Origin, and derivation of name: Native variety; called *Uahiapele*, or "smoke of *Pele*" because of smoky appearance of purplish- and green-mottled leaves and smoky gray poi made from the corms.

Distribution: Formerly grown to some extent at Ewa, Oahu, under wetland culture, but at present found most commonly on Hawaii and occasionally on Kauai, under upland culture.

Use: Makes a high-quality smoky-gray poi; formerly highly prized for medicinal purposes and as an offering to the gods.

Remarks: This variety has many of the characteristics of the *Kai* group, in particular the tough, rubbery consistency of the cooked corm.

25. Manapiko

General characteristics: Medium in height, erect, stocky, maturing within 12 to 15 months, producing from 2 to 5 *oha;* recognized by purplish blotching on *piko* extending along midrib and on primary veins of the lobes, forming a more or less distinct Y.

Petiole: 65 to 80 cm. long, dark green, conspicuously whitish at edge, dark reddish-purple at apex, white for 3 to 4 cm. above base, abruptly curved at apex.

Leaf blade: 35 to 50 cm. long, 25 to 35 cm. wide, 25 to 40 cm. from tip to base of sinus, sagittate, vertical, dark green with bluish cast, a dark purple streak on lower surface running from base of sinus to *piko;* margins slightly undulate; *piko* conspicuously dark purple, blotched, the color extending along midrib and veins of lobes; lobes acute with narrow sinus.

Corm: Flesh white with yellowish fibers; skin cream-colored, occasionally faintly pink along leaf-scar rings.

Origin, and derivation of name: Native variety; the name *Manapiko* refers to the branching coloration of the *piko*.

Distribution: Rare variety.

Use: Fair table taro.

Remarks: This variety does not belong to either the *Mana* or the *Piko* group as the name might imply.

26. Tahitian

General characteristics: Medium in height, moderately spreading, stocky, maturing within 9 to 12 months, producing from 2 to 5 *oha;* similar to *Manapiko* but with much lighter petioles and leaf blades.

Petiole: 70 to 85 cm. long, rigid, light yellowish-green, indistinctly pale pinkish to whitish at edge, light reddish-purple at apex, white for 3 to 4 cm. above base, abruptly curved at apex.

Leaf blade: 45 to 55 cm. long, 30 to 35 cm. wide, 35 to 40 cm. from tip to base of sinus, sagittate, vertical, light green; margins slightly undulate; *piko* conspicuously blotched with dark purple, running into veins; veins reddish on lower surface of lobes; lobes acute with deep, wide sinus.

Corm: Flesh white with yellowish fibers; skin cream-colored.

Inflorescence: Peduncle light green; spathe about 30 cm. long, the lower tubular portion about 5 cm. long, light green with purplish area at base, the upper portion yellow, rather widely open at base upon maturity.

Origin, and derivation of name: Introduced by Wilder from Tahiti; no name has been found for this variety so it has merely been called "Tahitian."

Distribution: Little-known variety of limited distribution.

Use: Mainly as a table taro.

Group Kai

This group, comprising three varieties, is distinguished by the concave, pendant blades with distinct, finely undulating margins, and by the tough rubbery texture of the cooked corms. The time of cooking is often twice as long as for other varieties. A fragrant odor (*ala*) is usually emitted when the corms are cooked: hence the name *Ala* is sometimes used, instead of *Kai*, for this group. It is difficult to make poi from the *Kai* taros by the old Hawaiian method of hand pounding the cooked corms on a poi board, and even in the commercial poi factories, where machines are used for grinding the corms, the *Kai* taros generally must be run through the machine twice before the poi is satisfactory. However, they give a high yield of *paiai*.

The *Kai*, the *Piko*, and the *Lehua* are the three most important groups of commercial taros. They are used almost exclusively for poi making, and are almost invariably grown under wetland culture. The *Kai* are very popular on Kauai and are planted in several localities on Oahu. Observations seem to indicate that they are more tolerant of alkaline conditions than any other group, and of stagnant water. They are also tolerant of deep or soft patches whereas most varieties require a firm, relatively shallow soil, and there is evidence that *Kai* are more resistant to soft rot.

30. Apuwai

General characteristics: Short, moderately spreading, very stocky, maturing within 6 to 9 months, producing from 5 to 10 *oha;* readily identified by the cup-shaped, definitely crinkled blades and light self-green petioles.

Petiole: 35 to 50 cm. long, broad at base, thick and rigid, light green with white for 3 to 5 cm. above base.

Leaf blade: 35 to 40 cm. long, 25 to 35 cm. wide, 25 to 30 cm. from tip to base of sinus, horizontal, very crinkled and conspicuously cupped, medium green; *piko* and veins light green; lobes obtuse, distinctly overlapping, with deep, narrow sinus.

Corm: Flesh white with indistinct, yellowish fibers; skin cream-colored.

Inflorescence: Peduncle light green; spathe usually loosely enclosing spadix to base of plant, light green on lower tubular portion, the upper portion 20 to 25 cm. long, light yellow, usually open and ordinarily rolled only at the tip; spadix usually 17 to 20 cm. long, a spongy naked base with the ovulate portion extending along about 8 to 9 cm. and ovaries sparsely arranged on the lower part, the sterile appendage about 1 cm. long.

Origin, and derivation of name: Native variety; it derives its name from the fact that its leaves are shaped like a cup (*apu*) and hold water (*wai*) in the form of dew and rain.

Distribution: Essentially a wetland taro although it is found in a few scattered localities in Kona under upland culture. Formerly it was widely planted, especially in Kohala, Hawaii. It is now sometimes found growing wild in wet places near the woods.

Use: This variety is now grown mainly for its leaves which are highly prized for *luau*. The corm makes good poi of very light color, soft in consistency, and easy to pound and prepare, and also serves as a good table taro.

31. Apu

(*Oapu*)

General characteristics: Short, moderately spreading, stocky, maturing within 6 to 9 months, producing from 10 to 15 *oha;* resembles *Apuwai* very closely, the latter having a more crinkled leaf blade and a deeper-set *piko*.

Petiole: 40 to 60 cm. long, rigid, light green with inconspicuous greenish edge, white at base.

Leaf blade: 45 to 55 cm. long, 35 to 40 cm. wide, 35 to 40 cm. from tip to base of sinus, horizontal, ovate, somewhat cupped, light green; *piko* light green; lobes obtuse, frequently overlapping, with deep, narrow sinus.

Corm: Flesh chalky white with inconspicuous yellowish fibers; skin cream-colored.

Origin, and derivation of name: Native variety; it derives its name from the fact that the leaves are somewhat cup-shaped.

Distribution: A little-known taro at the present time; the only planting found was on Maui.

Use: Sparingly as a table taro.

32. Piialii

(*Ahapii, Moiula, Mokohe*)

General characteristics: Short, erect, stocky, maturing within 8 to 12 months, producing from 2 to 5 *oha;* easily distinguished by broad, crinkly blades and short, stocky, dark green petioles tinged with pink.

Petiole: 45 to 65 cm. long, fairly thick and rigid, dark green with pinkish tinge and conspicuous narrow red edge, a reddish-purple ring at base with lilac-pink for 3 to 4 cm. above.

Leaf blade: 45 to 55 cm. long, 30 to 35 cm. wide, 40 to 45 cm. from tip to base of sinus, horizontal, ovate, slightly cupped, crinkled, dark green with light pinkish cast on lower surface; *piko* small, light pinkish to greenish; marginal veins often tinged with red; lobes obtuse with shallow, wide sinus.

Corm: Flesh lilac-purple with darker purple fibers; skin brilliant reddish-purple.

Inflorescence: Peduncle yellowish-green; spathe 26 to 33 cm. long, the lower tubular portion usually 4.5 to 6 cm. or sometimes as much as 9 cm. long, yellowish-green, often tinged with red, the upper portion yellow, usually rather open or loosely rolled; spadix 9 to 12 cm. long, the sterile appendage 1.2 to 2 cm. long.

Origin, and derivation of name: Native variety; the name *Piialii* means "ascending from the *alii*," and refers to the high esteem in which it was held by the chiefs.

Distribution: Essentially a wetland taro although grown to some extent under upland culture in Kona, where it goes under the name *Moiula*. This variety is one of the most important of the wetland poi taros, and is planted extensively on the windward side of Oahu.

Use: Makes a red poi that is highly prized for flavor and quality.

Remarks: This is one of the oldest varieties grown in the islands, known in the early days of Hawaiian history as one of the royal taros. It was considered particularly desirable as an offering to the gods. The Chinese generally harvest this taro at 12 to 14 months, the Hawaiian growers at 8 to 10 months when the quality is considered better although the total yield is not so great.

33. Paakai

(*Launui Paakai*)

General characteristics: Short, moderately spreading, stocky, maturing within 9 to 12 months, producing from 5 to 10 *oha;* distinguished by short, stocky growth and dark green petioles with distinct, narrow reddish edges.

Petiole: 45 to 60 cm. long, very dark green with a distinct, narrow reddish edge, white at base.

Leaf blade: 35 to 45 cm. long, 25 to 30 cm. wide, 25 to 35 cm. from tip to base of sinus, narrowly ovate, slightly concave, fairly crinkled, dark green; *piko* light yellowish; lobes acute with wide sinus.

Corm: Flesh white with yellowish fibers; skin cream-colored, sometimes reddish-purple along the leaf-scar rings.

Inflorescence: Peduncle purplish-black; spathe 30 to 35 cm. long, usually curved and drooping, the lower tubular portion 5.5 to 6 cm. long, dark reddish-purple, the upper portion orange with reddish-purple margins, usually tightly rolled but sometimes slightly open near constriction.

Origin, and derivation of name: Native variety; the descriptive name *Eleele* refers to the purplish-black color of the petioles and the suffix *omao* to the light green edges.

Distribution: Planted fairly extensively in the uplands throughout the islands but especially so in Kona, Hawaii.

Use: Mainly as a table taro.

Remarks: This variety resembles *Lauloa Eleele-ula* so closely that at times it is practically impossible to distinguish the two. Although the outward appearance is almost identical, the quality of poi made from *Lauloa Eleele-ula* is far superior to that from this variety. The two varieties may be differentiated by the greenish edge and continuance of the petiole color into the leaf veins of *Lauloa Eleele-omao* in contrast to the more pinkish edge and the changing of the dark petiole color to a yellow green just below the apex of *Lauloa Eleele-ula*.

37. Lauloa Eleele-ula

(*Eleele Lauloa*)

General characteristics: Tall, erect, stocky, maturing within 9 to 12 months, producing from 2 to 5 *oha;* recognized by purplish-black petioles with pinkish edges.

Petiole: 100 to 140 cm. long, purplish-black with pinkish edge, light green at apex, a dark red ring at base with pink for 1 to 2 cm. above.

Leaf blade: 40 to 60 cm. long, 30 to 40 cm. wide, 35 to 45 cm. from tip to base of sinus, sagittate, slightly concave, dark green; margins with a few large undulations, the marginal veins purple; *piko* small, purplish; lobes obtuse with narrow sinus.

Corm: Flesh white tinged with pink, especially near the apex, with yellowish fibers; skin light to brilliant dark pink and occasionally purple along leaf-scar rings.

Origin, and derivation of name: Native variety; the suffix *ula* refers to the pinkish color of the edges.

Distribution: Planted somewhat extensively in the uplands throughout the islands, particularly in Kona.

Use: Grown mainly for home use as poi taro.

Remarks: Although in vegetative characters this variety is very similar to the other *Lauloa*, and it has occurred as a mutant form, in corm texture and quality of poi it is more closely related to the *Eleele* group.

38. Lauloa Palakea-eleele

(*Palakea; Lauloa Palakea*)

General characteristics: Tall, erect, stocky, maturing within 8 to 12 months, producing from 5 to 10 *oha;* the conspicuous black edge is a distinguishing feature.

Petiole: 100 to 140 cm. long, dark green heavily suffused with dark reddish-purple especially on upper half, dark purplish at apex, white at base, conspicuously blackish at edge.

Leaf blade: 45 to 65 cm. long, 30 to 40 cm. wide, 35 to 50 cm. from tip to base of sinus, sagittate, slightly concave, dark green; margins with a few large undulations; *piko* purplish; veins dark purplish on lower surface of lobes; lobes obtuse with narrow sinus.

Corm: Flesh chalky white with yellowish fibers; skin white or yellowish.

Inflorescence: Peduncle yellowish-green with faint brownish tinge, often reddish-purple at apex; spathe 32 to 37 cm. long, the lower tubular portion 5 to 6 cm. long, reddish-purple, the upper portion dark yellow with reddish-purple margins, bent and drooping, usually tightly folded but sometimes slightly open near constriction; spadix about 11 cm. long, the sterile appendage conspicuous, about 13 mm. long.

Origin, and derivation of name: Native variety; four members of the Lauloa group have the descriptive name *Palakea*, which refers to the soft, white consistency of the cooked corm. The distinguishing suffix, *eleele*, indicates the black edge of this form of *Lauloa Palakea*.

Distribution: Grown quite extensively in Kona, Hawaii, almost exclusively as upland taro.

Use: Used primarily as a table taro, being considered superior to both *Lauloa Palakea-keokeo* and *Lauloa Palakea-ula* although the poi is considered inferior to that of any of the standard poi taros; highly favored as a medicinal taro by the early Hawaiians.

Remarks: This variety is one of the hardiest of the taros, withstanding adverse weather conditions under which other varieties will not survive. Under favorable conditions it yields well and is comparatively early maturing. It is less acrid than most taros; hence its popularity for medicinal purposes.

39. Lauloa Palakea-ula

General characteristics: Tall, erect, maturing within 9 to 12 months, producing from 5 to 10 *oha;* characterized by pinkish edge and white base of petiole.

Petiole: 100 to 140 cm. long, dark green heavily suffused with dark reddish-purple especially on upper half, purplish at apex, white at base, with distinct reddish-pink to almost whitish edge.

Leaf blade: 45 to 65 cm. long, 30 to 40 cm. wide, 35 to 50 cm. from tip to base of sinus, sagittate, slightly concave, dark green; margins with a few large undulations; *piko* purplish; veins dark purplish on lower surface of lobes; lobes obtuse with narrow sinus.

Corm: Flesh chalky white with light yellowish fibers; skin yellowish.

Origin, and derivation of name: Native variety of comparatively recent origin, probably arising through somatic mutation from *Lauloa Palakea-eleele;* given the suffix *ula* because of the distinguishing pink edge.

Distribution: Found occasionally among plantings of *Lauloa Palakea-eleele*. It is considered inferior in quality and is usually rogued out.

Use: Primarily as a table taro.

mature usually within 8 months and are fairly high producers. The corms must be harvested soon after maturity as they begin to rot very quickly. Even the *huli* deteriorate if held over for any length of time after harvesting. They are grown primarily under upland culture and are especially popular in Kona where they are made into red poi of excellent quality.

43. Eleele Makoko

(Nohu, Makoko)

General characteristics: Medium in height, well spreading, maturing within 8 to 12 months, producing from 5 to 10 *oha;* characterized by light purplish-black petioles shading into yellowish-green at apex and light lilac-purple corm flesh.

Petiole: 60 to 85 cm. long, drooping, light purplish-black on lower part shading into yellowish-green at apex, with an inconspicuous, narrow reddish edge, a dark reddish-purple ring at base with dark lilac-purple for 3 to 4 cm. above.

Leaf blade: 35 to 45 cm. long, 25 to 35 cm. wide, 25 to 35 cm. from tip to base of sinus, sagittate, medium green; margins undulate; *piko* light brownish; lobes acute with medium-cut sinus.

Corm: Flesh light lilac-purple; skin light reddish-purple.

Inflorescence: Peduncle blackish; spathe 22 to 25 cm. long, the lower tubular portion 3.5 to 4.5 cm. long, yellowish-green tinged with brown, with purplish areas at base and at constriction, the upper portion yellowish, slightly open at maturity; spadix 7 to 9 cm. long, the sterile appendage 6 to 7 mm. long.

Origin, and derivation of name: Native variety; *makoko* is a reddish fish.

Distribution: Not planted as widely as *Eleele Naioea* but its distribution is quite general; chiefly under upland culture.

Use: Makes light red poi of good quality; although not important commercially, it is grown fairly extensively for home use.

44. Eleele Naioea

(Naioea, Eleele)

General characteristics: Medium in height, well spreading, maturing within 8 to 12 months, producing from 5 to 10 *oha;* characterized by blackish petioles, similar to those of *Kumu-eleele, Lauloa Eleele-omao,* and *Lauloa Eleele-ula,* and by dark purplish-lilac corm flesh.

Petiole: 65 to 90 cm. long, blackish with inconspicuous narrow brownish to greenish edge, yellowish-green at apex, a dark reddish-purple ring at base with dark lilac-purple for 3 to 4 cm. above.

Leaf blade: 40 to 50 cm. long, 25 to 35 cm. wide, 30 to 40 cm. from tip to base of sinus, sagittate, drooping, slightly undulate, dark green, often with pinkish cast when young; *piko* inconspicuous, light reddish-brown; lobes acute with wide sinus.

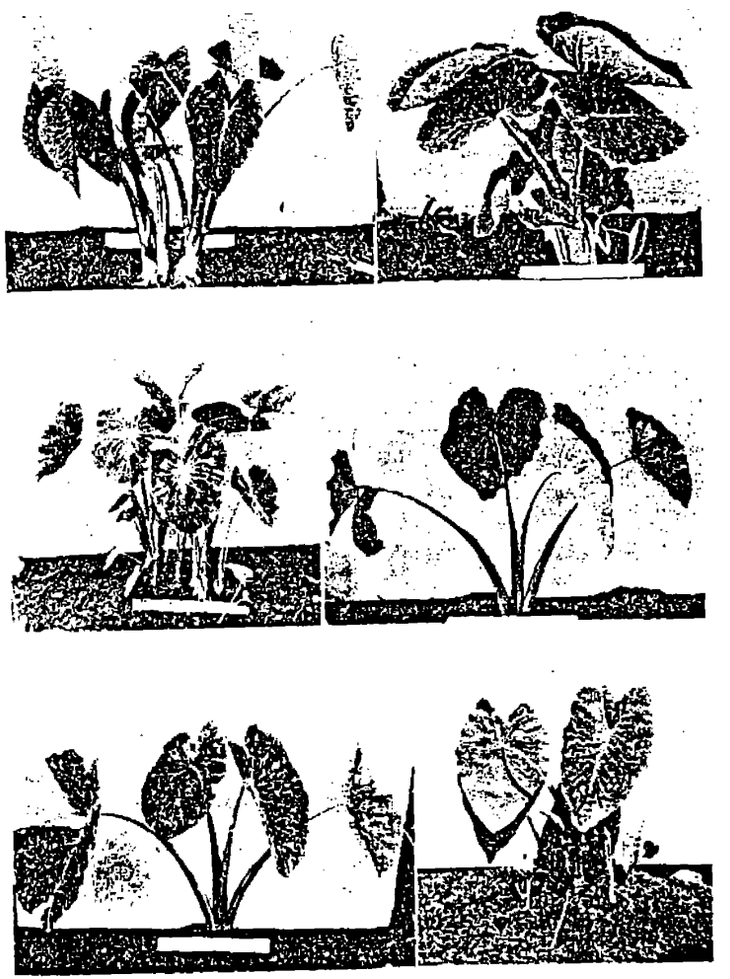

Fig. 5.—Upper right: *Mana Uliuli,* characterized by branching parent corm and pendant leaf blades; upper left: *Moana,* with short, stocky growth and slightly crinkled, horizontal leaf blades; middle left: *Piko Uliuli,* one of the leading wetland varieties, with sinus cut to point of attachment with the petiole; middle right: *Manini Toretore,* with striped petioles; lower left: *Elepaio,* a picturesque variety with mottled green and white leaf blades; lower right: *Awea,* one of the few varieties of taro producing rhizomes. Note the slender rhizomes on the foreground.

48. Ulaula Kumu

(*Kumu*)

General characteristics: Medium in height to tall, moderately spreading, maturing within 8 to 12 months, producing from 5 to 10 *oha;* identified by the brilliant light red petioles.

Petiole: 75 to 100 cm. long, brilliant light red occasionally faintly diffused with yellowish-green, indistinctly dark reddish at edge, a dark red ring at base with dark pink for 3 to 5 cm. above.

Leaf blade: 35 to 45 cm. long, 25 to 35 cm. wide, 25 to 35 cm. from tip to base of sinus, ovate, dark glossy green with bluish cast; *piko* conspicuous, purple; veins reddish on lower surface; lobes obtuse, undulate on margins, with narrow sinus.

Corm: Flesh white with pinkish tinge, especially near apex, the fibers yellowish; skin pinkish-lilac.

Inflorescence: Peduncle light red; spathe 21 to 23 cm. long, the lower tubular portion 3 to 4 cm. long, dark reddish-purple, tightly rolled, the upper portion dark yellow with tinge of red throughout, dark red with dark red streaks at margins, light red inside, partially open near constriction at maturity; spadix about 7 cm. long, the sterile appendage 4 to 5 mm. long, not clearly differentiated from staminate portion.

Origin, and derivation of name: Native variety; named after the brilliant red Hawaiian fish, *kumu,* because of the brilliant reddish color of the petioles.

Distribution: Found scattered throughout the islands in small patches under both wetland and upland cultures.

Use: Both as poi and as table taro, principally for home consumption; formerly this variety was used as an offering to the gods.

Remarks: This is one of the most brilliantly colored of the taros.

49. Ulaula Poni

(*Poni Ulaula*)

General characteristics: Medium in height to tall, moderately spreading, maturing within 8 to 10 months, producing from 5 to 10 *oha;* recognized by the dark reddish-purple petioles, inconspicuously striped with lighter color, with bright reddish edges.

Petiole: 75 to 100 cm. long, dark reddish-purple shading to purplish-lilac on upper third, inconspicuously striped with lighter color, distinctly bright reddish at edge, a purple ring at base with narrow, bright red area for 2 to 4 cm. above.

Leaf blade: 35 to 45 cm. long, 25 to 35 cm. wide, 25 to 35 cm. from tip to base of sinus, ovate, dark glossy green with bluish cast; *piko* conspicuous, purple; veins bright reddish on lower surface; lobes obtuse, undulate on margins, with narrow sinus.

Corm: Flesh white with pinkish apex, the fibers yellowish; skin brilliant lilac-pink, often dark purple along leaf-scar rings.

Origin, and derivation of name: Native variety; *poni,* meaning "purple," refers to the petiole coloring.

Distribution: Often found associated with the other *Ulaula,* usually in the uplands.

Use: Occasionally as a table taro; in early times a purple pigment was extracted from the petioles and used by the natives for dyeing tapa, straw hats, etc.

50. Ulaula Moano

(*Ieie, Iaia*)

General characteristics: Medium in height, moderately spreading, maturing within 8 to 10 months, producing from 5 to 10 *oha;* characterized by reddish-purple petioles with inconspicuous yellowish-green stripes.

Petiole: 70 to 95 cm. long, red near base shading to reddish-purple above, with inconspicuous yellowish-green stripes especially on midsection, indistinctly dark reddish at edge, a dark red ring at base with dark pink for 3 to 5 cm. above.

Leaf blade: 35 to 45 cm. long, 25 to 35 cm. wide, 25 to 35 cm. from tip to base of sinus, ovate, dark glossy green with bluish cast; *piko* large, distinct, purple; primary and marginal veins reddish on lower surface; lobes obtuse with narrow sinus.

Corm: Flesh white with pinkish tinge, especially near apex, the fibers yellowish; skin pinkish-lilac.

Origin, and derivation of name: Native variety; named after the Hawaiian fish, *moano,* which is reddish to reddish-purple with brownish markings.

Distribution: Planted in a few scattered localities throughout the islands, usually under upland culture.

Use: Both for poi and as table taro, principally for home consumption.

51. Niue-ulaula

(*Niue*)

General characteristics: Medium in height, well spreading, stocky, maturing within 9 to 12 months, producing from 5 to 10 *oha;* distinguished by its deep reddish-brown petioles and white base.

Petiole: 65 to 80 cm. long, deep reddish-brown slightly diffused with green, purplish-red at apex, white at base, with a narrow, dark pinkish edge.

Leaf blade: 40 to 55 cm. long, 25 to 35 cm. wide, 30 to 45 cm. from tip to base of sinus, sagittate, dark green with bluish cast; *piko* large, conspicuous, purple; veins distinctly purplish-red on lower surface, usually purplish on upper; lobes acute with narrow sinus.

Corm: Flesh chalky white with yellow fibers; skin white to cream-colored.

Origin, and derivation of name: Introduced from South Seas by Wilder as one of two distinct forms named *Niue;* the suffix *ulaula* has been added to designate the reddish hue of the petioles.

Distribution: Limited; grown primarily under upland culture.

Use: Principally as a table taro.

Remarks: According to Christophersen (*2*), *Niue* is apparently the name for a group comprising at least three varieties; the writers have not, how-

Leaf blade: 40 to 55 cm. long, 35 to 45 cm. wide, 30 to 40 cm. from tip to base of sinus, ovate, inconspicuously mottled dark and light green with bluish cast; *piko* large, prominent, purple; veins reddish-purple at margins and on lower surfaces of lobes; lobes acute with deep, narrow sinus.

Corm: Flesh chalky white with conspicuous yellow fibers; skin cream-colored.

Inflorescence: Peduncle striped dark purple and light green; spathe about 28 cm. long, the lower tubular portion striped like peduncle with deep purple at constriction, the upper portion yellow; spadix about 9 cm. long, the staminate portion yellow, the sterile appendage orange, about 8 mm. long.

Origin, and derivation of name: Introduced from South Seas; *Toretore* is the name under which it was introduced but it has been classified under the *Manini* group.

Distribution: Little-known variety of limited distribution.

Use: A fair table taro.

56. Papakolea-koae

(Papakolea)

General characteristics: Short to medium in height, moderately spreading, stocky, maturing within 9 to 12 months, producing from 5 to 10 *oha;* the brilliantly red-streaked apex of the petiole is distinctive.

Petiole: 60 to 80 cm. long, dark green brilliantly streaked with red at apex, especially when young, a brilliant deep pink ring at base, the area above red with a few broad green stripes, indistinctly pinkish at edge.

Leaf blade: 40 to 55 cm. long, 30 to 35 cm. wide, 30 to 40 cm. from tip to base of sinus, slightly concave, thin in texture, medium green; margins slightly undulate; *piko* light green or tinged with red; veins brilliantly reddish on lower surfaces of lobes; lobes acute with wide sinus.

Corm: Flesh white with pinkish tinge, especially near apex, and yellowish fibers; skin a brilliant pink, purple at leaf-scar rings.

Origin, and derivation of name: Native variety; *Papakolea*, being the name of a land district, and *koae*, meaning "the food of," probably indicates that this variety was the common food of the district.

Distribution: Planted exclusively under upland culture in a few scattered localities, chiefly in Kona and Puna, Hawaii.

Use: Primarily as a table taro.

Remarks: The red coloration near the base of the petioles is often so narrow that it may not be noticed.

57. Ula

General characteristics: Short to medium in height, moderately spreading, stocky, maturing within 9 to 12 months, producing from 2 to 5 *oha;* distinguished by a few narrow green stripes on the brilliant pink basal portion of the petioles.

Petiole: 60 to 80 cm. long, rather rigid, nearly solid pink at base with narrow green stripes, the upper half green, distinctly reddish-pink at edge, a white ring at base.

Leaf blade: 40 to 55 cm. long, 30 to 40 cm. wide, 30 to 40 cm. from tip to base of sinus, ovate, thin in texture, medium green; margins slightly undulate; *piko* yellowish-green to light green; lobes acute with narrow sinus.

Corm: Flesh chalky white with large, conspicuous, yellow fibers; skin white to cream-colored.

Origin and derivation of name: Introduced from Samoa by Wilder, *ula* means "red" in Samoan and probably refers to the brilliant pinkish-red coloration of the petiole bases.

Distribution: Upland taro of limited distribution.

Use: A good table taro.

Remarks: The similarity between this variety and *Papakolea-koae* is rather striking, further indicating the close relationship between certain Hawaiian and South Sea forms.

58. Nihopuu

General characteristics: Medium in height to tall, moderately spreading, maturing within 12 months, producing from 5 to 10 *oha;* identified by light and dark green-striped petioles and distinct purplish-black edges.

Petiole: 75 to 90 cm. long, light and dark green-striped, the light green predominating, conspicuously purplish-black at edge, white to greenish-white at base.

Leaf blade: 45 to 50 cm. long, 30 to 35 cm. wide, 35 to 40 cm. from tip to base of sinus, sagittate, indistinctly light and dark green-mottled; *piko* purple; lobes acute with deep, narrow sinus.

Corm: Flesh white with yellowish fibers; skin white.

Origin, and derivation of name: Native variety, collected at Ewa, Oahu; the derivation of the name is unknown.

Distribution: Rare; formerly grown to considerable extent in valleys near Schofield Barracks.

Use: Makes a light-colored poi of good quality.

Remarks: This variety is said to be susceptible to soft rot soon after maturity, necessitating early harvesting.

59. Manini-opelu

General characteristics: Medium in height, well spreading, maturing within 9 to 12 months, producing from 5 to 10 *oha;* distinguished by profuse light and dark green striping of the petiole, with reddish tinge on upper third.

Petiole: 65 to 90 cm. long, distinctly and profusely dark and light green-striped, strongly tinged with reddish-purple on upper third, white at base, light pinkish at edge, curved slightly at apex.

Leaf blade: 45 to 55 cm. long, 30 to 40 cm. wide, 40 to 45 cm. from tip to base of sinus, sagittate, thin in texture, drooping, inconspicuously light and dark green-mottled; margins undulate; *piko* purple; veins reddish-purple on lower surface; lobes acute with narrow sinus.

Corm: Flesh white with yellow fibers; skin white to cream-colored.

Inflorescence: Peduncle green- and white-striped with diffusion of reddish-purple; spathe 28 to 32 cm. long, the lower tubular portion 4 to 5 cm.

63. Lehua Maoli

(Lehua)

General characteristics: Medium in height, well spreading, slender, maturing within 8 to 12 months, producing from 5 to 10 *oha;* identified by yellowish-green, widely spreading petioles and light purplish-lilac corm flesh.

Petiole: 65 to 80 cm. long, yellowish-green with pinkish cast, slightly tinged with brownish-purple at apex, pinkish-lilac at edge, a dark reddish-purple ring at base with light purplish-lilac for 3 to 5 cm. above.

Leaf blade: 40 to 55 cm. long, 30 to 40 cm. wide, 35 to 45 cm. from tip to base of sinus, sagittate, very smooth in outline, thin in texture, drooping, medium green, often with pinkish tinge when young; *piko* small, light pinkish; lobes acute with narrow sinus.

Corm: Flesh light purplish-lilac with darker purplish fibers; skin dark pinkish-lilac.

Inflorescence: Peduncle pale green with pinkish flush; spathe 14 to 20 cm. long, the lower tubular portion 2.5 to 3 cm. long, olive green with pinkish tinge, the upper portion deep yellow, open near constriction only upon maturity; spadix 6 to 7 cm. long, the sterile appendage 6 to 8 mm. long.

Origin, and derivation of name: Native variety; *maoli* means "the more common" or "ordinary." This variety is commonly known simply as *"Lehua."*

Distribution: A favorite variety of the Hawaiians, grown throughout the islands under both upland and wetland cultures. It is the most widely distributed of the upland poi taros and is planted extensively in Kona, Hawaii.

Use: The widely advertised *"Lehua* red poi," which often commands a premium in price, usually comes from this variety.

64. Lehua Keokeo

(Waiakea)

General characteristics: Medium in height, well spreading, maturing within 8 to 12 months, producing from 5 to 10 *oha;* identified by pale green petioles with broad, purplish-black edges.

Petiole: 70 to 90 cm. long, pale green often tinged with reddish-brown at apex, pinkish at base with a reddish-purple ring, the edge conspicuous, broad, purplish-black with adjacent dark green blotches.

Leaf blade: 40 to 55 cm. long, 35 to 45 cm. wide, 35 to 45 cm. from tip to base of sinus, broadly sagittate, drooping, medium green with pinkish cast when young; margins slightly undulate; *piko* pinkish; veins reddish on lower surface; lobes acute with medium-cut sinus.

Corm: Flesh pale pinkish with purplish fibers; skin dark pinkish.

Origin, and derivation of name: An old native variety; the descriptive name *Keokeo* is derived from the pale coloring of the petiole.

Distribution: Grown in a few scattered localities, primarily under upland culture.

Use: Makes red poi of good quality.

Remarks: This variety is reputed to make very luxuriant growth in certain sections, rivaling the *Lauloa* group.

65. Lehua Eleele

(Wailana)

General characteristics: Medium in height to tall, slender, erect, maturing within 8 to 12 months, producing from 2 to 5 *oha;* distinguished by the dark green petioles which are shaded with purple, especially near base and along margins.

Petiole: 75 to 100 cm. long, dark green with purplish shading especially near base and along margins, purple at apex, with a narrow dark reddish to purplish-black edge, a dark reddish-purple ring at base with lighter reddish-purple for 3 to 5 cm. above.

Leaf blade: 45 to 55 cm. long, 30 to 35 cm. wide, 35 to 45 cm. from tip to base of sinus, sagittate, drooping, dark green; *piko* small, dark purplish; lobes acute with deep, narrow sinus.

Corm: Flesh lilac-purple with darker reddish-purple fibers; skin brilliant reddish-purple; roots light reddish-purple.

Orgin, and derivation of name: Native variety; the name *Eleele* is probably given to this variety because it has much darker colored petioles than other *Lehua* varieties, although the petioles are far from being blackish. This variety is known as *Wailana* in Kona, Hawaii.

Distribution: Planted quite extensively in Kona, Hawaii, usually under upland culture, but practically none is grown elsewhere.

Use: Makes a very good red poi.

Remarks: This is an early-maturing taro of high yielding capacity. It must be harvested as soon as it is mature as it rots readily if held in the field for any length of time.

66. Lehua Palaii

(Palaii)

General characteristics: Short to medium in height, stiffly erect, slender, maturing within 12 to 18 months, producing from 5 to 10 *oha;* distinguished by lilac-purple corm flesh and dark green petioles.

Petiole: 60 to 75 cm. long, dark green slightly tinged with reddish-brown at apex, a dark purple ring at base with light purplish-lilac for 3 to 4 cm. above, with a narrow, indistinct, reddish to whitish edge.

Leaf blade: 40 to 50 cm. long, 25 to 35 cm. wide, 30 to 40 cm. from tip to base of sinus, sagittate, drooping, dark green with faint pinkish cast; margins slightly undulate; *piko* light green to faint brownish; lobes acute with fairly deep, wide sinus.

Corm: Flesh lilac-purple with darker purplish fibers; skin light pink.

Inflorescence: Peduncle dark green; spathe 18 to 23 cm. long, the lower tubular portion 3 to 4 cm. long, dark green, the upper portion clear, deep yellow, open near constriction only upon maturity; spadix 7 to 8 cm. long, the sterile appendage 5 to 8 mm. long.

Petiole: 65 to 80 cm. long, dark green with dark brown flecked shading on lower portion, yellowish at apex, white at base, a narrow reddish edge usually with adjacent yellowish-green blotches, especially near base.

Leaf blade: 40 to 50 cm. long, 35 to 40 cm. wide, 30 to 40 cm. from tip to base of sinus, ovate, slightly crinkled, dark green; *piko* light green to yellowish; veins conspicuous; lobes obtuse to slightly acute with wide sinus.

Corm: Flesh white with yellowish fibers; skin cream-colored.

Inflorescence: Peduncle green; spathe 15 to 17 cm. long, the lower tubular portion 2.5 to 3 cm. long, green, the upper portion yellow; spadix 6 to 7 cm. long, the sterile appendage 8 to 11 mm. long.

Origin, and derivation of name: Native variety; *leo*, meaning "influence arising from station, character, or reputation," indicates that this may have been an important variety in the old days.

Distribution: Little is grown except for some plantings in Puna, Hawaii, usually under upland culture.

Use: Primarily as a table taro.

72. Maea

General characteristics: Medium in height, well spreading, maturing within 9 to 12 months, producing from 5 to 10 *oha;* characterized by dark green petioles, whitish at base with reddish-brown flecks immediately above, and conspicuous broad whitish edges.

Petiole: 60 to 80 cm. long, drooping, dark green flecked with reddish-brown, the flecking most pronounced near base, with a conspicuous, broad whitish edge, often tinged with reddish-purple adjacent to the edge, white at base.

Leaf blade: 35 to 45 cm. long, 25 to 30 cm. wide, 30 to 40 cm. from tip to base of sinus, narrowly sagittate, dark green; *piko* yellowish; lobes acute with wide sinus.

Corm: Flesh white with yellowish fibers; skin cream-colored, usually with dark purple along leaf-scar rings.

Origin, and derivation of name: Native variety; *maea* means "strong smelling" or "pungent" in Hawaiian, and probably refers to the odor of the cooked corms.

Distribution: Little-known variety, found occasionally under upland culture in Puna, Hawaii.

Use: Mainly as a table taro.

73. Haokea

(*Haakea, Haawikea, Ahakea*)

General characteristics: Medium in height, erect, stocky, maturing within 9 to 12 months, producing from 10 to 15 *oha;* distinguished by the light self-green petioles and narrowly ovate leaf blades.

Petiole: 65 to 90 cm. long, light green with indistinct greenish edge, white at base.

Leaf blade: 45 to 60 cm. long, 35 to 50 cm. wide, 35 to 45 cm. from tip to base of sinus, narrowly ovate, medium green; *piko* light yellowish-green; veins rather conspicuous; lobes obtuse with wide sinus.

Corm: Flesh white with yellowish fibers; skin white; roots conspicuously white.

Inflorescence: Peduncle light green; spathe 26 to 37 cm. long, the lower tubular portion 4 to 5 cm. long, light green with faint tinge of purple at base, rather loosely rolled, the upper portion deep yellow, open near constriction and loosely rolled above; spadix 8 to 11 cm. long, the sterile appendage 9 to 14 mm. long, clearly constricted from staminate portion.

Origin, and derivation of name: Native variety; the name is probably derived from the firm white corm flesh.

Distribution: Quite common throughout the islands, under both wetland and upland cultures.

Use: A commercial poi taro in certain areas on Oahu, making a good quality poi of grayish color. The young leaves are comparatively nonacrid and are used extensively for *luau*. Formerly, this taro was used as offerings to the gods, the *luau* being highly prized by the *kahuna*. It was also used quite widely for medicinal purposes.

74. Kalalau

General characteristics: Short to medium in height, well spreading, maturing within 9 to 12 months, producing from 5 to 10 *oha;* identified by the light self-green spreading petioles and sagittate leaf blades.

Petiole: 55 to 70 cm. tall, light green, inconspicuously greenish at edge, white at base.

Leaf blade: 35 to 50 cm. long, 25 to 35 cm. wide, 30 to 40 cm. from tip to base of sinus, sagittate, medium green; margins slightly undulate; *piko* yellowish; lobes acute with wide sinus.

Corm: Flesh chalky white with yellowish fibers; skin whitish.

Origin, and derivation of name: Native variety; possibly named after Kalalau, a tableland on Mt. Waialeale, Kauai.

Distribution: Planted quite extensively on Maui, Molokai, and Kauai.

Use: Not very important commercially as it is inclined to rot readily under slightly adverse conditions. The *luau* is relatively nonacrid. Poi of good quality may be made from this variety.

Leaf blade: 45 to 65 cm. long, 30 to 40 cm. wide, 35 to 50 cm. from tip to base of sinus, sagittate, slightly concave, dark green; margins with a few large undulations; *piko* small, light purplish; lobes obtuse with narrow sinus.

Corm: Flesh white with pinkish tinge, especially near apex, and yellowish fibers; skin light pink, occasionally purple along leaf-scar rings.

Origin, and derivation of name: Native variety; the descriptive name *Uliuli* refers to the dark green petioles with brownish tinge.

Distribution: Found occasionally among other *Lauloa*.

Use: Mainly as table taro.

78. Lihilihimolina

General characteristics: Short to medium in height, well spreading, producing a few *oha;* easily identified by the unusual coloring of the corm flesh—lilac-purple in the center, surrounded by white. This is the only taro having bicolored corm flesh.

Petiole: 55 to 70 cm. long, rather drooping, yellowish-green flecked with reddish-brown near base, a faint, pale pink ring at base with white for 3 to 5 cm. above.

Leaf blade: 35 to 45 cm. long, 25 to 35 cm. wide, 30 to 35 cm. from tip to base of sinus, sagittate, thin in texture, smooth and regular in outline; lobes acute with wide sinus.

Corm: Conspicuously lilac-purple at center and white outside; skin white with purple along leaf-scar rings.

Origin, and derivation of name: Native variety; the derivation of the name is unknown.

Distribution: Found only occasionally under upland culture on the island of Hawaii.

Use: Primarily as a table taro.

79. Mana Eleele

(Poni Mana)

General characteristics: Medium in height, erect, maturing within 9 to 12 months, producing two or three branches; readily distinguished from other *Mana* by blackish petioles.

Petiole: 55 to 85 cm. long, purplish-black, pink to whitish at edge, a dark reddish-purple ring at base with lilac pink for 3 to 4 cm. above.

Leaf blade: 35 to 50 cm. long, 25 to 40 cm. wide, 30 to 40 cm. from tip to base of sinus, ovate, dark green; veins purplish on lower surface; lobes acute with shallow sinus.

Corm: Flesh white tinged with lilac near apex, with yellowish fibers; skin dark purple.

Origin, and derivation of name: Native variety; the descriptive name *Eleele* refers to the color of petioles.

Distribution: Limited, confined chiefly to the island of Hawaii; planted almost exclusively under upland culture.

Use: Mainly as table taro for home consumption.

Remarks: This variety is said to be the most drought-resistant of the Hawaiian taros.

80. Mana Okoa

General characteristics: Resembles *Mana Keokeo* except that petioles are decidedly lighter green and leaf blades are sagittate rather than ovate.

Petiole: 60 to 85 cm. long, light green, pinkish-red at edge, white at base.

Leaf blade: 45 to 55 cm. long, 30 to 35 cm. wide, 35 to 40 cm. from tip to base of sinus, sagittate, medium green; margins undulate; *piko* light greenish; lobes acute with narrow sinus.

Corm: Flesh white with yellowish fibers; skin whitish.

Origin, and derivation of name: Probably native of Hawaii; as no name could be ascertained it has been given the descriptive name of *Okoa,* meaning "another."

Distribution: Limited; occurs as a mixture in large plantings of *Mana Keokeo.*

Use: Fair table taro.

81. Moi

(Neenee)

General characteristics: Medium in height, well spreading, maturing within 9 to 12 months, producing from 5 to 10 *oha;* characterized by its light green petioles with pinkish base.

Petiole: 60 to 85 cm. long, slender, drooping, light green, indistinctly whitish-green at edge, a pink ring at base with lighter pink for 3 to 5 cm. above.

Leaf blade: 40 to 55 cm. long, 30 to 45 cm. wide, 30 to 45 cm. from tip to base of sinus, narrowly ovate, thin in texture, medium green; *piko* whitish; veins conspicuous, light green; lobes acute with shallow, wide sinus.

Corm: Flesh white with light pinkish tinge, especially near apex, the fibers yellow; skin pale pink.

Origin, and derivation of name: Native variety; probably named after the whitish Hawaiian fish, *moi.*

Distribution: At the present time this variety is one of the lesser-known taros but it is quite popular in certain districts, especially on Maui, Molokai, and in Puna, Hawaii; grown principally under upland culture but also does well under wetland culture.

Use: Good poi and table taro.

82. Oene

(Owene Ulaula, Owene)

General characteristics: Short to medium in height, moderately spreading, maturing within 9 to 12 months, producing from 6 to 15 *oha;* distinguished by the lilac-purple flecked petioles which are almost lacking in green and fairly numerous *oha.*

Petiole: 60 to 75 cm. long, light lilac-purple flecked, almost lacking in green, a dark pink ring at base with lighter pink for 3 to 5 cm. above.

Leaf blade: 35 to 45 cm. long, 25 to 30 cm. wide, 25 to 35 cm. from tip to base of sinus, ovate, dark green; *piko* purple; lobes obtuse with wide sinus.

Corm: Flesh white with light pinkish tinge, especially near apex; skin dark pink.

APPENDIX

Finding Lists

Petiole Coloring

Primarily Red

Akado
Hapuu
Kai Uliuli
Kakakura-ula[1]
Niue-ulaula
Niue-uliuli
Oene
Pololu
Uahiapele[1]
Ulaula Kumu
Ulaula Moano
Ulaula Poni

Primarily Black

Eleele Makoko
Eleele Naioea
Kumu-eleele
Laaloa
Lauloa Eleele-omao
Lauloa Eleele-ula
Lauloa Palakea-eleele
Lauloa Palakea-papamu
Lauloa Palakea-ula
Lehua Eleele
Mana Eleele
Manini-owali[2]
Nawao
Piko Eleele

Striped

Akuugawai
Elepaio
Hinupuaa
Kakakura-ula[1]
Manini Kea
Manini-opelu
Manini-owali[2]
Manini Toretore
Manini Uliuli
Nihopuu
Oopukai
Papakolea-koae
Uahiapele[2]
Ula
Ulaula Moano[3]
Ulaula Poni[3]

Primarily Light to Medium Green

Apu
Apuwai
Aweu
Haokea
Iliuaua
Kai Ala
Kai Kea[3]
Kalalau
Lauloa Keokeo[3]
Lauloa Palakea-keokeo
Lehua Keokeo
Lehua Maoli[3]
Lihilihimolina[3]
Mana Kukuluhema[3]
Mana Okoa
Mana Opelu[3]
Mana Ulu[3]
Moi
Moana
Obe[3]
Piko Kea
Piko Keokeo
Piko Lehua-apei
Tahitian
Tsurunoko[3]

[1] Double-keyed.
[2] Suffused with other colors.
[3] Flecked with other colors.

Primarily Dark Green

Apowale[2]
Bun-long[2]
Kuoho
Lauloa Uliuli
Lehua Palaii[2]
Leo[3]
Maea[2]
Mana Keokeo
Mana Lauloa
Mana Uliuli[2]
Mana Weo
Manapiko
Miyako[2]
Paakai
Papapueo
Piialii[2]
Pikoele
Piko Uaua
Piko Ulaula[3]
Piko Uliuli
Wehiwa[2]

Corm Coloring

Flesh Purple at Center, White Outside

Lihilihimolina

Flesh White with Purple Fibers

Bun-long

Flesh Yellow

Mana Opelu
Mana Uliuli
Mana Ulu
Mana Weo

Flesh Purple

Eleele Makoko
Eleele Naioea
Lehua Eleele
Lehua Keokeo
Lehua Maoli
Lehua Palaii
Oopukai
Piialii
Piko Lehua-apei
Piko Ulaula

Flesh White with Yellow Fibers: Skin White to Cream-Colored
(Makes a gray poi unless otherwise indicated)

Akuugawai
Apu
Apuwai[4]
Aweu
Elepaio
Haokea[4]
Hinupuaa
Kai Ala
Kakakura-ula
Kalalau
Laaloa
Lauloa Palakea-eleele
Lauloa Palakea-ula
Leo
Maea
Mana Keokeo
Mana Kukuluhema
Mana Okoa
Manapiko
Manini Kea
Manini-opelu
Manini Toretore
Manini Uliuli
Miyako
Moana
Nihopuu
Niue-ulaula
Paakai
Piko Keokeo
Piko Uaua
Piko Uliuli
Pikoele
Pololu
Tahitian
Tsurunoko
Uahiapele
Ula

[2] Suffused with other colors.
[3] Flecked with other colors.
[4] Makes a silvery poi.

Grown Under Both Upland and Wetland Cultures

Bun-long	Lehua Palaii	Piko Uaua
Haokea	Manini Kea	Piko Ulaula
Hapuu	Manini-owali	Uahiapele
Lehua Eleele	Manini Uliuli	Ulaula Kumu
Lehua Keokeo	Moi	
Lehua Maoli	Piko Eleele	

Usage of Varieties

Poi Taros

Apowale	Lauloa Eleele-ula	Piko Eleele
Apuwai[1]	Lehua Eleele	Piko Kea[1]
Eleele Makoko	Lehua Keokeo	Piko Keokeo
Eleele Naioea[1]	Lehua Maoli[1]	Piko Lehua-apei
Elepaio	Lehua Palaii[1]	Piko Uaua[1]
Haokea[1]	Manini Kea	Piko Ulaula
Hapuu	Moi	Piko Uliuli[1]
Kai Ala[1]	Nihopuu	Pololu
Kai Kea[1]	Ohe[1]	Uahiapele
Kai Uliuli[1]	Paakai	Ulaula Kumu
Kalalau	Papapueo	Ulaula Moano
Kuoho	Piialii[1]	Wehiwa

Luau Taros

Apuwai[1]	Kalalau	Oopukai
Aweu	Lauloa group	Piko Eleele
Bun-long[1]	Lauloa Palakea-eleele[1]	Piko Lehua-apei
Haokea	Mana group	Wehiwa
Hapuu	Mana Keokeo[1]	

Kulolo Taros

Lauloa group	Mana group	Mana Keokeo[1]

Sprouts Used as Greens

Akado	Haokea	Miyako
Apuwai	Lauloa group	Tsurunoko

Important Table Taros[2]

Apuwai	Mana Keokeo	Piko Uliuli
Bun-long	Mana Ulu	Tsurunoko
Lauloa Keokeo	Piko Eleele	
Lauloa Palakea-eleele	Piko Kea	

[1] Indicates the most important varieties.
[2] All varieties may be used as table taros.

Early- or Late- Maturing Varieties

Early-maturing

Akado	Kai Ala	Lehua Maoli
Apu	Kai Kea	Miyako
Apuwai	Kakakura-ula	Oopukai
Eleele Makoko	Lehua Eleele	Piialii
Eleele Naioea	Lehua Keokeo	Tsurunoko

Late-maturing

Hinupuaa	Piko Eleele	Piko Uaua
Ohe	Piko Kea	Piko Ulaula
Palaii	Piko Keokeo	Piko Uliuli

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maea. Strong or bad smelling.
makoko. A reddish fish.
makua. Parent or older one; i.e., *kalo-makua* or parent corm.
mana. Branching; also the name of a group of taro varieties characterized by branching of the parent corm at the apex.
manini. A striped fish living in the coral reefs.
maoli. Native; genuine.
moana. Broad.
moano. A fish.
moi. A fish.
nawao. Wild taro; bad.
oha. Primary lateral cormlets or suckers produced from the parent corm.
ohe. Hawaiian bamboo.
okoa. Different; another.
omao. Green.
oopukai. A fish.
opelu. A fish (mackerel).
owali. Weak.
owene. The first crop of taro.
paiai. (*Pai*, a bundle, and *ai*, food.) A round bundle of pounded taro done up in ti leaves (*Cordyline terminalis*).
pake. Chinese.
pala. Soft; ripe, as fruit; mellow; cooked soft.
papa. Old; ancient.
pele. Goddess of the volcano.
piko. Navel; the upper surface of a leaf blade at the point of junction with the petiole. Also the name of a group of taro varieties.
poi. Pasty mass made by pounding or grinding cooked taro corms, with sufficient water added after thorough pounding to obtain the proper consistency, and allowed to ferment for a shorter or longer time before it is consumed.
pololu. Spear; a valley on Hawaii.
poni. Royal; purple.
puu. Secondary cormlets, too small to cook and not yet producing leaves.
uaua. Tough, elastic, viscid, glutinous, not easily separated.
ula. Shortened or condensed form of ulaula.
ulaula. Red, rosy, reddish.
uli. Shortened or condensed form of uliuli.
uliuli. A dark or dusky hue.
ulu. Breadfruit.
wai. Water.

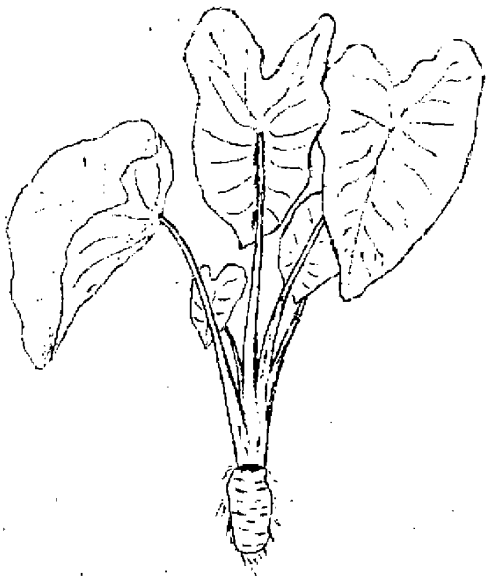
TB: TARO

Agricultural Economics Report No. 13

Honolulu, Hawaii
December 1952

A Preliminary Study

MAINLAND MARKET FOR TARO PRODUCTS



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This study was conducted with funds allotted to project 7x by the Industrial Research Advisory Council, authorized by the Territorial Legislature Act 122, 1949, and Act 217, 1951, and with Research and Marketing funds allotted to Hawaii Agricultural Experiment Station project 355 under the Research and Marketing Act of 1946.

SUMMARY

At present, the largest mainland demand for poi is from former residents of Hawaii and tourists who have been to Hawaii. This volume could be increased to some extent by improving and standardizing the quality of the delivered product.

Canned, ready-to-serve poi as a baby food has limited possibilities. It would add variety to the carbohydrate foods now being packed by the baby-food industry but, on the whole, would have severe competition. The market is already supplied by a large number of established products; prices and profit margins in the baby-food industry are low, and no significant expansion in sales volume is expected for this decade.

The best opportunity for expanding the market for taro products is in the field of dietary foods. If the total of hypertension, allergy, and gastrointestinal uses could be developed together, they would provide a substantial sales volume for poi or taro flour in any of the large metropolitan areas.

Several conditions must be fulfilled before the dietary market can be developed: (1) There must be a series of clinical tests in mainland clinics to provide the medical profession with authentic information on the value of poi in various diets. (2) Processing, packaging, and storage difficulties must be solved so that a standard quality in easily usable form will reach mainland users. (3) The labels and descriptive material that accompany the product must be improved and also must conform to regulations of the Federal Food and Drug Administration. Clearance with the American Medical Association would accelerate acceptance by the medical profession. (4) The supply situation requires careful organization, not only in the production phase in the Territory but in making the product available in mainland markets at all times. In recent years, the frequent maritime freight interruptions have discouraged mainland stores who have attempted to handle taro products. Physicians are reluctant to start patients on a diet unless they are sure it can be continued.

INTRODUCTION

Poi is a product of the taro root. Taro (*Colocasia esculenta*) has long been a staple in the diet of Polynesians. The taro tuber is usually cooked and ground into a viscous paste (poi) that ferments with the addition of water. High heat or freezing will halt the fermentation process. The consistency and viscosity of poi depend on the amount of liquid that is added. It is most frequently eaten as "ready-mixed" poi containing about 18 percent solids; the balance is usually water. Poi can be dehydrated and converted to flour which is referred to in this report as taro flour, although it has been marketed under many commercial names. Also, poi can be frozen solid and later reconverted by placing it in hot water.

A recent survey of Hawaii's physicians and dietitians in hospitals and allied institutions indicated that poi is recommended and used by them for many therapeutic and dietary purposes (5).[1] Local physicians almost unanimously recommend poi for children and healthy infants. Poi is also recommended by physicians for infants exhibiting allergies to cereals and for malnutrition. Infants and adults with certain digestive disturbances and convalescents requiring an easily digestible food are frequently given poi. Poi is especially recommended because of its high calcium-

[1] Numbers in parentheses refer to bibliographical references found on page 15.

phosphorus content and the beneficial effect of these minerals on teeth and bone formation. The dietary usage of poi by physicians and dietitians in Hawaii has developed over the years from observing the responses of selected patients to poi and from laboratory studies, rather than from exhaustive clinical tests. Nutritional studies have established the fact that poi is a good, healthful carbohydrate food and is superior to the grains and potatoes in vitamin and mineral content.

Because of its known nutritional values and dietary usage made of poi in Hawaii, a reconnaissance survey of the possible mainland market for the product was conducted in January and February of 1952. The investigation followed up the leads uncovered in the Territorial physicians' survey and in the scanty literature on the subject. The discussion and conclusions on the market potential for poi are limited, by necessity, to broad observations and opinions of mainland doctors, "health food" distributors, nutritionists, and other interested individuals.

EXPORT HISTORY

Taro flour was promoted and marketed on the Mainland as a baby and allergy food prior to World War II. Frozen and chilled poi has been shipped to the Mainland for more than 20 years. Canned, ready-mixed poi (18 percent solids) has been exported to the states only since World War II. Standard poi (30 percent solids) cannot be canned satisfactorily at present.

Early records show that taro flour was manufactured in Hawaii as early as 1874, and that King Kalakaua signed a legislative bill in 1886 authorizing the payment of a subsidy for the manufacture and export of taro flour (16). The flour was marketed under the trade names of Taroena and Taro Mano.

In the mid-1930's, Hawaiian Taro Products, Ltd., was formed. It manufactured for export a taro flour and also such products as Taro-Lactin, a taro flour with milk solids added for infant feeding, and Taroco, a taro powder to which other ingredients were added to make it palatable in liquid form. This firm spent considerable time and money promoting its products on the local and mainland markets as "health" foods, for infant feeding, and for making bread and pastries (10). The f.o.b. Honolulu prices for taro flour were $6.30 per 5-pound tin and 16 cents per pound in 100-pound bags.[2] The Hawaiian Taro Products could not make its operations pay and sold its equipment to another firm that occasionally manufactures Taro-Lactin and Taroco on a limited scale for the local market.

In 1939, the Galen Company of Berkeley, California (not now in business under this original name) imported Hawaiian taro flour and marketed it as Poy-o-Meal for allergy purposes, and Poy-o-Lin, a taro flour base with solids added, as an infant food. It also made a product called Poy-o-Malt which was sold to dairies. The company contracted for about 100,000 pounds of flour a month. The Galen Company spent 3 years in developing these products and about $25,000 in promoting them chiefly among the physicians throughout the United States. (A market for the products was also developed in Venezuela.) Poy-o-Lin retailed for $1.00 a pound in 1939-40 and Poy-o-Meal for $1.25 per 1½ pounds. At that time Hawaiian growers were receiving $1.00 to $1.50 per hundredweight for taro. World War II cut off the taro flour supplies, and the business was not revived after the war.

The Galen Company sold all the poi products it manufactured. Poy-o-Lin sold better at first, but Poy-o-Meal outlasted it in preference. Even today inquiries for Poy-o-Meal are being received by the successor company

[2] Information from Hawaiian Taro Products, Ltd., given to the Lowe Corporation, Chicago, Illinois, April 8, 1938.

from medical men throughout the country.[3] The promotional efforts of these companies have left their imprints on the mainland markets. A number of doctors interviewed on the Mainland had used the taro flour prior to World War II, principally in allergy work, and still enthusiastically endorse it.[4]

In 1951, exports of fresh poi from Hawaii to the Mainland amounted to 16,000 pounds and of canned, ready-mixed poi, 9,000 pounds. Little, if any, taro flour is being exported at present. Some taro is shipped to the Mainland for use as a vegetable.

TARO PRODUCTS FOR SPECIALTY FOOD STORES

Poi has little chance of becoming a staple food on the Mainland. Rice and potatoes are well-established staple foods; furthermore, most adults dislike the viscosity and flat taste of poi. On the Pacific Coast, where most of Hawaii's tourists originate, poi has an unsavory reputation that extends substantially beyond those who have actually tasted it. This unfavorable public reaction creates a formidable barrier to the sale of poi as a staple, whether fresh, sour, or artificially flavored.

At present there is a specialty market for fresh, standard poi,[5] mostly frozen, in a few fish and meat markets and restaurants in California's coastal cities where the Portuguese, Hawaiians, and other migrants from Hawaii have settled. The migrants still like their poi to the extent of paying 49 to 50 cents a pound for the frozen poi that, when thawed and reconverted, bears little resemblance to the fresh product in taste or appearance.

Most of the fresh poi is shipped in the 2- and 4-pound pliofilm bags in which it is marketed locally. Some of the poi is merely chilled in transit while some shippers have it frozen en route. The chilled poi continues to ferment slowly so that it is more sour on arrival than poi that is frozen. A shrinkage of about 12 percent in weight occurs during the 6-day trip from Honolulu to the Pacific Coast. Poi shippers have found that they must pack more poi in the bags if the 2- and 4-pound net weights, as stated on the label, are to be maintained on arrival. Many of the Hawaii people on the Mainland would prefer to buy the canned, ready-mixed form in place of the frozen poi, which requires considerable time and labor to reconvert to a usable form. Some poi eaters object to the frozen poi because it is impossible to tell the degree of sourness when they buy it. Sales could be stimulated if shippers indicated the age of poi on the label at the time of freezing.

Some canned, ready-mixed poi is sold along the Pacific Coast in fancy food stores and delicatessens for cocktail, snack, hors d'oeuvre, and luau purposes. These markets are the principal sources of supply for tourists and others who have been to the Islands and who wish to serve Hawaiian foods on special occasions (see table 1 for number of delicatessens on the Pacific Coast). Fancy food stores provide a limited market for canned, ready-mixed poi, but of the 2,000 meat markets and 300 fish markets on the Pacific Coast, not more than a dozen stores now carry the product. Not all of these stores would have customers for fresh or frozen poi, but with a little promotional work, canned, ready-mixed poi in small containers could be sold to this trade.

Several inquiries were received from fancy-food distributors during the survey for taro chips as a cocktail item and canned taro as a fancy food delicacy. These are not being processed in the Islands at present but were packed on a limited scale prior to World War II. The "taro investigations," conducted by the Hawaii Agricultural Experiment Station from 1936 through 1941, explored the methods of processing these and many bakery products from taro (8).

[3] Information from W. Worswick, formerly sales manager of the Galen Company, Berkeley, California, February 26, 1952.

[4] Information from Dr. J. M. Frawley, Fresno, California, April 24, 1952, and from Dr. Jerome Glaser, Rochester, New York, May 3, 1952.

[5] Standard poi, by Territorial law, must contain at least 30 percent solids.

of fact and intrusions into professional practice. Nevertheless, the food faddists have made Americans 'health' food conscious.

Even though foods and diets are receiving greater attention, a recent analysis of the number and kinds of treatments given new patients in medical clinics in the United States shows that only 7.3 percent are given a dietary treatment while 57.4 percent of the new patients are treated with drugs. The dietary treatments are principally for digestive disorders (27.9 percent) and cardiovascular ailments (13.4 percent) (12).

The increasing importance of the dietetic uses of food is evidenced by the growth of the dietetic canned food business. In 1949, the National Canners Association surveyed the field and found 17 packers processing 33 products. In 1951, a repeat survey registered 85 canners and 53 products (3).

Poi for Allergies

Many diseases and disorders formerly attributed to other causes are now traceable to allergies, and the study of the causes and cures of food allergies is one of the rapidly developing phases of medical research. Poi and taro flour have been used from time to time in treating allergies, principally as a cereal substitute, and, if clinical tests of poi are favorable, there may be a large potential market for poi. The actual size of this market cannot be determined from the many different medical estimates and opinions on the incidence of allergies.

A handicap to the development of this market is the strong objection most adults have to the taste of ready-mixed poi and the inconvenience of preparation. A few mainland physicians have attempted to place adults on a poi diet by masking the objectionable taste with flavoring. Physicians who know about the nutritional and allergenic value of taro flour and poi feel that perhaps the flour is the better product for adult use. Taro flour can be made into gruel or used as the principal ingredient for specialty bakery products such as cookies, breads, and crackers. Bakery products made from taro or poi are more acceptable and palatable than is ready-mixed poi.

The greatest mainland market for poi would result from the physicians' recommendations for its use in diets for babies with allergies. Most babies take to poi readily, and poi is not likely to cause an allergy.

Poi for Gastrointestinal Disorders

Some 15 million people in the United States suffer from ulcers at one time or another during their lifetime. More than a half million ulcer patients receive medical treatment or are hospitalized for at least 1 month during the year. Practitioners of internal medicine in Hawaii indicate that poi has great value in alleviating gastrointestinal difficulties (9).

One mainland physician reports good results with poi in a limited number of ulcer and other gastrointestinal cases.[6] The following is a quotation from the physician's letter:

> *"I feel that it [poi] is a very valuable carbohydrate supplement for infant diets and I also have used it extensively for adults who have gastrointestinal disfunction. We have found it very valuable in the treatment of peptic ulcers, during convalescence, following acute illness, in the postoperative state, and also in the aged individual who so frequently has digestive disturbances."*

The physician stated that one major advantage of using poi was that it left no secondary effects such as constipation, occationally encountered when using pharmaceutical treatments. In addition, poi has a food value that is lacking in most medical treatments. The trial feedings, however, were on too limited a scale to be considered conclusive. The digestibility of poi, its "softness" on the gastrointestinal linings, and its alkaline residual effects seem to be the properties that make poi valuable for alleviating many gastrointestinal disturbances.

[6] Information from Dr. Rachael Jenkins, Lomita, California, given to Thomas T. Tateishi Company, Honolulu, Hawaii, October 18, 1951.

The ease of digestibility gives it promise in other fields, too. Elderly people, people with no teeth, and postoperatives are prospective clients for soft foods. Being a carbohydrate food and relatively high in caloric content, poi provides an easily obtainable source of energy for convalescents and a nutritious food for those who might be suffering from malnutrition. Also, the ready utilization of the calcium and phosphorus in poi is of importance to the nutritional and physical well-being of elderly people as well as of youngsters. The number of aged in the population of the United States is steadily increasing. Today, some 12 million people are 65 years old or older, and by 1980 the number is expected to rise to 24 million (11).

Poi in Low-Sodium Diets

Another possible but unexplored use of poi in diet therapy is in the field of feeding hypertension patients. A diet low in salt, fluid, and protein but relatively high in carbohydrates is prescribed for persons suffering from a chronic heart disease with edema. The rice diet, low in sodium, is perhaps the most widely used hypertension diet, but it has been observed that the rice diet is generally unpopular among patients (especially ambulatory patients), and many medical researchers believe that a more palatable substitute diet is needed. Future investigations are planned to test diets that are more palatable and that would provide a higher carbohydrate content than does the rice diet (14).

Poi has a low-sodium content. Chemical analyses show a sodium range of from .0020 to .0076 percent in air-dried, cooked taro (16). This sodium content is low enough for taro and poi to be used in low-sodium diets. Patients already on a salt-free or "severely restricted" diet are generally accustomed to eating bland foods so poi should be acceptable to most adults on this type of diet. The greatest drawback to those persons on a "moderately restricted" salt diet would be itslack of palatability.

A prominent mainland nutritionist reports that the potential market for low-sodium foods is thought to be about as large as the present baby-food market of some 123 million dozen cans annually (2).

PROBLEMS OF MARKETING POI ON THE MAINLAND

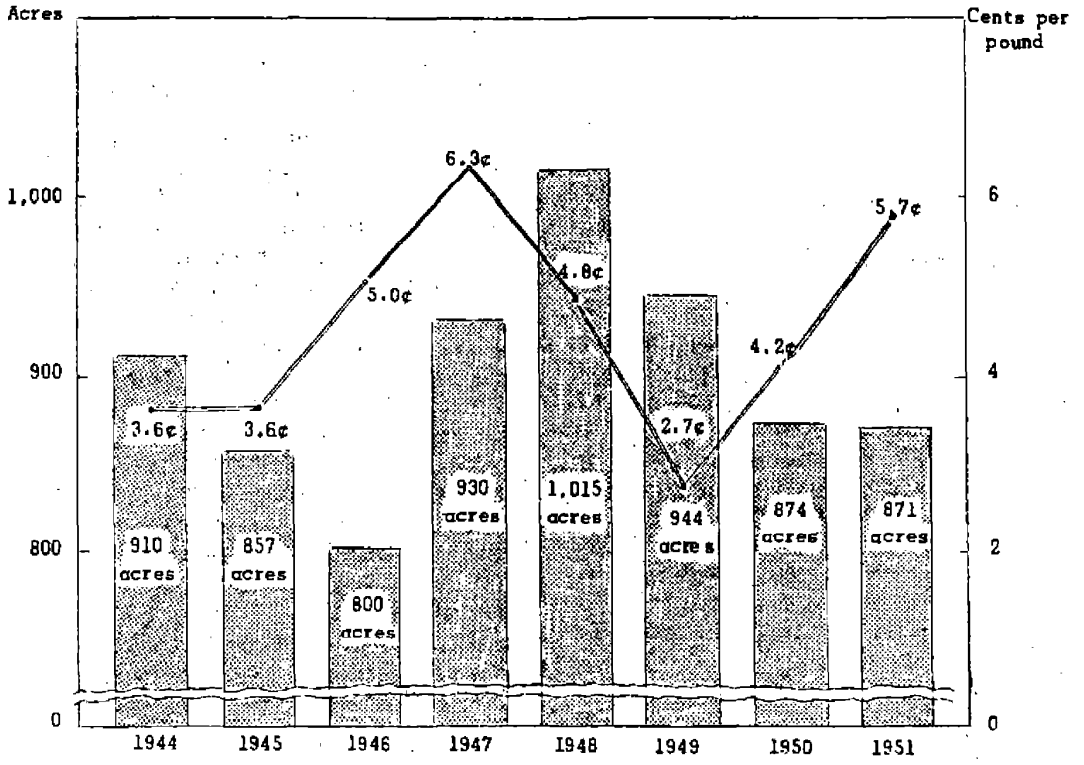
Promotional and Educational Problems

If the mainland market for poi as a dietary food is to be developed and firmly established, considerable promotional effort will have to be expended to accomplish the task.

It is difficult at best to acquire new consumers when selling an unknown product. Food habits change slowly, and usually there must be a strong motive for a person to change his eating habits or to buy an unknown food. The two principal motives for changing dietary habits are fashion and health (18). The "health" aspects are important when selling poi as a special dietary food, while the "fashion" aspects are more important for selling poi through fancy food stores and delicatessens.

Some basic work was done more than a decade ago with taro flour products among the medical profession, but the effects of the initial promotional efforts have been largely dissipated. The least expensive and most effective means of establishing a dietary market would be clinical research work conducted by reputable medical men. Most new dietary products are introduced to the medical profession and then to the public in this manner. The clinical work should be done on the Mainland to establish the special dietary usefulness of poi under mainland conditions. If the results were favorable, as anticipated, their dissemination through medical journals would be highly effective in introducing the product nationally. Physicians must be sold on a new product before the consumer market can be developed. A little support from the doctors, and the market for poi could be expanded.

Chart. Territorial taro acreage and annual average prices of taro, 1944-51[1]



[1]F.o.b. roadside price to millers. Prices are weighted for grade and seasonal volume.
Source: *Statistics of Diversified Agriculture* (annual), Hawaii Univ. Agr. Ext. Serv.

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MAY 10 1990

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MEMORANDUM

May 10, 1990

TO: All UH Taro researchers and other interested faculty

FROM: Jim Hollyer, The Taro Project

VIA: Dr. Ken Rohrbach

RE: Update on taro happenings

This note is to bring you up to date on a number of issues.

1) Please find attached the latest list on all funded taro research. Congratulations to all of you who worked so hard getting the proposals assembled.

2) The taro bibliographic database is on line and should be up to date, through April 1990, in the next few weeks. It is very complete with some 3,400 citations and abstracts (from Biosis, Agricola, Food Technology, Agris and CAB, and covering *Colocasia, Xanthosoma, Cyrtosperma and Alocasia*). We encourage everyone to use it as opposed to spending their own research funds. However, if you have the need, it would be best to coordinate the search with Scott Campbell, Pete Rotar or myself so that we can get the data on disk and thus be efficient. Please make an appointment for your research assistants or yourself to use this tool with Scott Campbell (948-6971).

3) The Fourth Taro Industry Analysis will be on Friday, June 15 in Hilo from 1 to 5 pm, with Dr. Rohrbach heading up the meeting. We will be sending out the DRAFT of the discussion and worksheets by the end of the month -- please work on these with your clients and collegues well before the meeting. We will have extra copies at the meeting. We will be able to fund one agent from each island on Dr. Rohrbach's extension account. Please decide amongst yourselves who will go and then call Genny, Dr Rohrbach's secretary, at 948-8157 to get the account information. If there are going to be any morning activities that day, Dwight Sato will let you know in advance.

enclosures

cc: Dr. Kefford
Dr. Nishmoto
Dr. Fuchigami

UH RESEARCHERS ON TARO PROJECTS as of May 3, 1990				
PRINCIPAL INVESTIGATORS	PROJECT NAME	PLANNED PROJECT DURATION	ACTUAL/PROPOSED FUNDING SOURCE	STATUS OF PROPOSAL OR PROJECT
Paull, Coltman	Taro corm growth and development as related to yield, storability and chipping characteristics	6/89-6/92	Fed-Diversified Ag.	On-going
de la Pena, Rotar	Taro, breeding, production & industry development	7/90-7/91	GACC C.A.P.E.	Recently funded
de la Pena	Taro variety eval. & improvement	7/90-7/91	GACC C.A.P.E.	Recently funded
Sato, Silva	Optimum fertilization and liming practices for dryland and wetland taro	1/89-12/90	GACC-Taro	On-going - refunded
Kawate, Miles	Registration of insecticides for the control of the taro root aphid in dryland taro	1/90-12/95	GACC-Taro	On-going
DeFrank, Sato	Weed control in taro	6/86-12/91	GACC-Taro	On-going - refunded
DeFrank	Safe chemical use (on taro) video		Investigators' funding	Pending o.k. on chemicals
Hollyer	The Taro Project (marketing and information management)	1/89-12/90	Fed-Diversified Ag.	On-going
Vargo, Sato, Manner, Natus, Raynor, Ragus, Fallanruw	A comparative study of low-input and high-input taro production in the American Pacific	6/89-6/91	LISA - Fed	On-going
Miyasaka	Utilizing genetic potentials of crop plants to solve problems of acid soils (using taro)	6/1/90-	406	Begining
Caldwell, El-Swaify, Uehara	Sustainability of taro cropping systems in Hawaii	6/1/90-	406	Begining

Uehara	Taro production model development (subcontracted to International Fertilizer Development Center, Al)	/87- /92	USAID-SPRAD-IBSNAT Coop.	On-going
Nip	Physico-chemical properties of taro starch (subcontracted out)	5/90-5/91	GACC C.A.P.E.	Begining
Nip	Taro production, handling and processing-Am. Samoa	6/88-5/91	406	On-going
Huang	Specification data development for Hawaii's taro products	5/90-5/91	GACC C.A.P.E.	Begining
Huang	Physical and chemical properties of taro gum and de-gummed taro products	6/1/90-	406	Begining
Campbell, Rotar, Hollyer	Taro researchers' database	12/89-3/90	Fed-Diversified Ag.	On-going
Teng, Ferreira	Integrated control of taro diseases in Hawaii	1/90-12/91	GACC-Taro	On-going
Smith (Ray)	USP Alafua campus (taro) research (various projects)	3/80-12/91	USAID-SPRAD	On-going
Abbott (Botany)	Assembling Hawaiian taro varieties from private & public collections for preservation purposes	5/90-5/91	Cooke Foundation	Begining
Giambelluca, Penn (Geography)	Estimating Water Requirements for Wetland Taro Cultivation in Hawaii	8/89 - 6/92	USGS, St of Hawaii, Water Res. Center	On-going
GRADUATE STUDENT RESEARCH				
Ferentinos (Caldwell)	Traditional Hawaiian taros for upland production	12/89-6/92	HATCH-Fed	On-going
Prasad (Uehara)	Effect of temperature & photoperiod on growth and development of taro	4/89-4/92	USAID-SPRAD-IBSNAT Coop.	On-going

Reprinted from JOURNAL OF THE AMERICAN DIETETIC ASSOCIATION
Vol. 28, No. 5, May, 1952
Printed in U.S.A.

Taro as a Source of Thiamine, Riboflavin, and Niacin[1]

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TARO (*Colocasia esculenta* (*L.*) *Schott*) was truly the "staff of life" of the old Hawaiians, and it was an important source of carbohydrate in the more southerly Pacific Islands where it continues to be extensively used, especially when breadfruit is out of season. The ancient Hawaiians, who were excellent farmers (1), developed many varieties and their two types of taro culture—wetland (submerged culture) and upland or dry land (nonsubmerged culture)—form the basis of segregating varieties. Both types of culture continue today (2).

Taro, one of the oldest cultivated crops in the world, is propagated by vegetative means rather than by seed, and the identification of taro varieties presents a difficult botanical and horticultural problem. The Hawaii Agricultural Experiment Station published a study of taro in Hawaii in 1939 (2) and described 84 named varieties. It is believed that the "old Hawaiians recognized 150 to 175 distinguishable forms" (2).

The Japanese taros in Hawaii were introduced by immigrants from Japan. These are similar to the type of taro referred to as "dasheen" in the southern United States.

The principal green vegetable of the ancient Hawaiians was tender taro leaves which they cooked with fish or pork in their underground ovens (*imu*). Other Polynesians also used taro leaves, and the Samoans today make a delectable dish, *palu sami*, by combining taro leaves with expressed coconut "milk," wrapping them both neatly in a large taro leaf, then in banana and breadfruit leaves, and cooking the package in an earth oven heated by hot stones.

In Hawaii, when taro is cooked and pounded (ancient times) or mechanically ground (modern times), the resulting thick paste is commonly called *paiai*. *Paiai* or commercial poi, which by law must contain not less than 30 per cent solids, is thinned with water for home and institutional use to produce poi which contains 16 to 18 per cent solids. (Ready-mixed poi sold commercially must contain not less than 18 per cent solids.) Poi is the form in which the ancient Hawaiians ate most of their taro and which is preferred by Hawaiians today.

If poi is permitted to stand at room temperature, acids, chiefly lactic, are formed (3). The resulting subacid, pasty product has a characteristic flavor much enjoyed by those accustomed to it.

Poi is an excellent food for babies and is well tolerated by people with digestive disturbances (4). Taro has also been recommended for use in the diets of people allergic to common starchy foods (5).

Taro can be made into flour which may be incorporated into many baked products or which may be reconstituted with water to make poi (6).

Potgieter found the calcium and phosphorus of taro well utilized by human subjects (7) and by rats (8), when poi and taro flour respectively were the principal dietary sources of those minerals.

Biologic experiments have shown the cooked taro to be a relatively good source of thiamine (9). Since rats will not readily eat the raw vegetable [all the taros are irritating to the mucous membranes because of the raphides of minute calcium oxalate crystals which they contain (10)], it was not possible

[1] Published with the approval of the director as Technical Paper No. 236, Hawaii Agricultural Experiment Station. Received for publication July 19, 1951.

[2] The authors wish to thank Francis A. Bowers for identifying the varieties of taro and taro leaves; Leonard Wong who raised and furnished the samples of Bun Long and Piko Kea taro corms and the taro leaves; and Kiyo Nakatani of Captain Cook, Hawaii, who furnished the Japanese taro. We are also indebted to J. P. Kapua, Poi Inspector for the Board of Health, Honolulu, who arranged for the samples of taro and poi; and to the Aloha Poi factory, Kalihi Poi Shop, and Waimea Poi Mill for providing, without charge, the samples of raw and cooked taro and commercial poi.

[3] Present address, National Dairies Research Laboratory, Oakdale, N. Y.

[4] Present address, The Pennsylvania State College, State College.

to learn by biologic means how much thiamine is lost as a result of cooking.

This paper reports the losses in thiamine, riboflavin, and niacin when several varieties of taro were cooked by laboratory (home) methods and when cooked commercially and ground to make the thick paste known as commercial poi or *paiai*. Included also are data on the amounts of the three B vitamins in raw and cooked taro leaves.

SAMPLES AND METHODS

Corms of two distinct wetland varieties of taro—*Piko Kea* (an Hawaiian type much used for poi) and *Bun Long* (introduced from China and used both as cooked taro and for poi)—were obtained directly from the grower and identified by a station agronomist familiar with taro varieties. The Japanese taro was believed to be the *Tsurunoko* variety (2).

Three corms 4 to 6 in. long were used for each raw sample. Three different corms cooked in the skins at 15 lb. pressure for 45 min. were used for the cooked samples. For the Japanese taro, 5 cormels (2 to 3 in. in diameter) were used for the raw sample. Six cormels were cooked without paring in boiling water for 35 min. In each case the skins were removed and the corms and cormels chopped and mixed before sampling.

Two varieties of taro leaves—*Haokea* (Hawaiian) and *Bun Long* (Chinese)—were analyzed in the raw state and after steaming for 1 hr. (The leaves were placed in a pan without water in a pressure cooker but *not* under pressure.) Stems and the heaviest part of the mid-ribs were removed and discarded. Fifteen to twenty-five leaves were used for each sample.

Since most of the taro in Hawaii is eaten in the form of poi prepared by small commercial factories, it was desirable to learn if the three B vitamins in the taro and their retention after commercial cooking were of the same order as for the home-cooked product. Three poi factories cooperated by furnishing samples of (a) raw taro, (b) cooked taro, and (c) freshly ground taro (*paiai*). Five corms were used for each of the taro samples, and the *paiai* was taken from 5-lb. lots. Two of the *paiai* samples were allowed to stand at room temperature for three days, attaining the degree of acidity desired by most poi eaters, when the B vitamins were again determined.

The taros from each factory were not identified but were of mixed varieties.

Satisfactory information on the preparation of commercial poi by Factory No. *1* could not be obtained. As the methods and cooking periods used in Factory No. *2* and No. *3* differed considerably, they will be described in some detail.

In Factory No. *2*, about 3000 lb. taro (thirty 100-lb. bags) are cooked at one time in a large rectangular container with two metal sides and bottom, and two sides of removable wooden planks. The bottom of the cooker contains 6 to 8 in. water which is heated to steam by an oil burner. Eight bags of taro are placed on an iron frame about 6 in. above the water and on the bags loose corms are piled in a thick layer. A second layer of taro corms, removed from the bags, is separated from the lower one by an iron frame to permit better circulation of steam, and a number of burlap bags cover the top. The entire load of taro to be cooked at one time is approximately 4 ft. thick. Cooking begins at 5 P.M. and is continued for 3½ to 4 hr. The cooked corms remain in the container until 5 o'clock the next morning when processing begins, but all the taro is not removed from the cooker until about noon. The taro corms are shoveled from the cooker into a large tank of water and the peels removed by hand. The corms are then placed in a second vat of water, where they are washed twice and trimmed if necessary, before being ground into the paste called *paiai*.

In Factory No. *3*, thirty to forty bags, each containing 100 lb. unpeeled taro, are placed in a cooker similar to that used in Factory No. *2*. The water in the bottom of the container is heated by steam pipes from a boiler that is maintained at 80 lb. pressure for 2 to 2½ hr. Again the taro is cooked in the early evening and held in the cooker overnight. The next morning, the bags of cooked taro are emptied into washing machines where running tap water and continuous agitation remove most of the loose skins on the taro. The taro is transferred to a large shallow tank containing running water where each corm is inspected and trimmed by hand before being mechanically ground. The *paiai* emerges into another shallow tank of water from which it is lifted by hand and placed in Cellophane bags ready for the market.

Thiamine was determined by the thiochrome method and riboflavin and niacin by microbiologic methods (11).

RESULTS AND DISCUSSION

Cooked taro, such as used for poi, contained 0.08 to 0.1 mg. thiamine per 100 gm., confirming the biologic experiments which showed 0.09 mg. per 100 gm. (9). The sample of Japanese taro (dasheen) gave a lower value (0.07 mg. per 100 gm.) than was previously obtained by biologic means (0.125 mg.) (9). These values of approximately 0.1 mg. thiamine per 100 gm. proved cooked taro and cooked potatoes to be about equally good sources of thiamine (12).

As would be expected, the more labile thiamine showed a greater degree of destruction than did riboflavin or niacin. Rather wide variations in losses of thiamine are indicated by the figures in Tables 1 and 2. In round numbers as much as 75 per cent or as little as 35 per cent of thiamine may be retained when taro is cooked before making into poi. Grinding the taro, making it into *paiai*, and allowing

TABLE 1

Retention of thiamine, riboflavin, and niacin in home-cooked taro and taro leaves

FORM OF TARO	MOISTURE	THIAMINE			RIBOFLAVIN			NIACIN		
		As assayed	Dry weight	Retention	As assayed	Dry weight	Retention	As assayed	Dry weight	Retention
	%	*mg./100 gm.*	*mg./100 gm.*	%	*mg./100 gm.*	*mg./100 gm.*	%	*mg./100 gm*	*mg./100 gm.*	%
Taro corms, raw										
Piko Kea (Hawaiian)	62.6	0.210	0.562		0.030	0.080		0.61	1.63	
Bun Long (Chinese)	58.4	0.174	0.419		0.026	0.063		0.66	1.58	
Dasheen (Japanese)	74.4	0.084	0.328		0.016	0.062		0.64	2.50	
Taro corms, cooked										
Piko Kea	74.3	0.111	0.432	77	0.030	(0.117)		0.47	1.83	(112)
Bun Long	59.6	0.100	0.248	59	0.025	0.062	98	0.58	1.44	91
Dasheen	74.9	0.073	0.291	89	0.015	0.060	97	0.60	2.39	96
Taro leaves, raw										
Haokea (Hawaiian)	82.5	0.230	1.315		0.464	2.650		1.60	9.15	
Bun Long	80.5	0.168	0.862		0.440	2.256		1.34	6.87	
Taro leaves, cooked										
Haokea	83.6	0.173	1.055	80	0.450	2.742	103	1.56	9.52	104
Bun Long	81.4	0.131	0.704	82	0.415	2.230	99	1.24	6.67	97

it to sour appear to have little effect upon the thiamine values. The retention of thiamine in the Japanese taro was greater (89 per cent) than in either of the poi taros (59 and 77 per cent).

It was expected that the longer cooking period ($3\frac{1}{2}$ to 4 hr.) used by Factory No. *2* would cause greater losses of thiamine than the shorter cooking period (2 to $2\frac{1}{2}$ hr.) used by Factory No. *3*, but this did not prove to be true. Judging from the figures in Table 2, approximately 20 per cent more thiamine was retained by both the cooked corms and the *paiai* in Factory No. *2* than in Factory No. *3*. Whether it was an unusually low value for the raw corms from Factory No. *2*, a greater leaching of thiamine resulting from more washing in Factory No. *3*, or whether it was a problem of sampling cannot be decided from these data. More carefully controlled experiments than are feasible in the small factories and many more assays would be required to obtain a conclusive answer. However, it is believed that the data presented in Table 2 give a true picture of the range of values for thiamine, riboflavin, and niacin in raw and commercially cooked taros and in commercial poi.

Variations between corms were not determined, but they are probably as great as between other units, such as leaves of turnip greens and sweet potatoes (13). The difficulty of sampling products from the factories might well account for the seeming lack of consistency in the retentions of all three vitamins when the raw taro corms, the cooked taro corms, and the *paiai* are compared. Judging from the results in Tables 1 and 2, it may be concluded that thiamine is less well retained (35 to 75 per cent) than riboflavin and niacin which, though showing wide variations for the factory samples (60 to 95 per cent), are well retained in the home cooked products (91 to 98 per cent).

Taro cooked in the underground oven (*imu*) by the ancient Hawaiians doubtless retained as much or more of the vitamins than does that cooked by modern methods.

Since the ancient Hawaiians had no grains, they needed to eat large quantities of taro to satisfy their caloric requirements. The senior author has been reliably informed (10) "that an amount of poi equal to 5 lb. of modern commercial poi would be an average amount for a man or woman, but that the old Hawaiians might eat 10 or 15 lb. of such poi a day depending on the work they were doing and the abundance of the supply."

Sufficient taro to supply 2400 calories (about 2000 gm. *paiai*, or less than 5 lb.) would furnish approximately 1.6 mg. thiamine, 0.56 mg. riboflavin, and 10 mg. niacin. This would suffice to meet the Recommended Dietary Allowance of the National Research Council for thiamine, but would furnish less than one-third the riboflavin and more than one-half the niacin.

SUMMARY AND CONCLUSIONS

Three varieties of taro cooked in the laboratory and samples of raw taro, cooked taro, and *paiai* obtained from three poi factories were used to study the retention of thiamine, riboflavin, and niacin.

The relatively long cooking period and/or high temperature required to make taro palatable resulted in rather poor retention (35 to 75 per cent) of thiamine in taros used for poi. The better retention of thiamine (89 per cent) in the Japanese taro

TABLE 2

Retention of thiamine, riboflavin, and niacin in cooked taro and paiai from three poi factories

FORM AND SOURCE OF TARO	MOISTURE	THIAMINE			RIBOFLAVIN			NIACIN		
		As assayed	Dry weight	Retention	As assayed	Dry weight	Retention	As assayed	Dry weight	Retention
	%	*mg./100 gm.*	*mg./100 gm.*	%	*mg./100 gm.*	*mg./100 gm.*	%	*mg./100 gm.*	*mg./100 gm.*	%
Taro corms, raw										
Factory 1	61.5	0.238	0.618		0.043	0.112		0.75	1.95	
Factory 2	57.9	0.172	0.409		0.035	0.083		0.78	1.85	
Factory 3	61.4	0.256	0.664		0.043	0.111		0.74	1.92	
Taro corms, cooked										
Factory 1	63.8	0.080	0.221	36	0.028	0.077	69	0.57	1.57	80
Factory 2	63.3	0.086	0.234	57	0.029	0.079	95	0.64	1.74	94
Factory 3	59.8	0.103	0.256	39	0.027	0.067	60	0.58	1.44	75
Taro corms, cooked and ground (paiai)										
Factory 1	69.8	0.068	0.225	36	0.025	0.083	74	0.45	1.49	76
Factory 2	70.0	0.078	0.260	64	0.023	0.077	93	0.49	1.63	88
Factory 3	64.0	0.093	0.258	39	0.038	0.106	95	0.64	1.78	93
Taro corms, cooked and ground (paiai), and held at room temperature for 3 days										
Factory 1	69.8	0.060	0.198	32	0.027	0.089	80	0.45	1.49	76
Factory 3	64.0	0.082	0.228	34	(0.049)	—	—	0.67	1.86	97

(dasheen) was probably due to the shorter cooking period.

Taro cooked in the laboratory showed excellent retention of riboflavin and niacin (91 to 98 per cent), but retention in the commercially cooked taros was less and there was a greater range of values (60 to 95 per cent), the latter possibly the result of variations due to sampling.

The ancient Hawaiians who depended on taro as their main source of calories could easily satisfy their needs for thiamine and meet the modern National Research Council's recommendation for this vitamin by the daily consumption of 2000 gm. *paiai*.

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TB: TARO

ABSTRACT OF REPORT OF JANUARY 25, 1965

POI - ITS USE AS A FOOD FOR NORMAL, ALLERGIC AND POTENTIALLY ALLERGIC INFANTS.

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Poi, prepared from taro, one of the oldest of cultivated crops, has been the staple carbohydrate food of Polynesia and particularly the Hawaiian Islands for centuries. Other parts of the worlk depend largely on the cereal grains, especially wheat, rye, corn, rice and others but none of these were grown in ancient pre-Captain Cook Hawaii, and for this reason, as well as other limitations of food supply, poi was the major food stuff. The Hawaiians were a tall, handsome race, characterized by spendid physique and good teeth. Much of this is attributed to the enormous amounts of poi they consumed. However, since the Islands were discovered by Captain Cook in 1778, with the introduction of the wide variety of foods used elsewhere such as the various cereal grains, beef, pork, milk, etc., the use of poi has gradually declined. Despite this, its value as food for infants, has long been recognized by Hawaiian physicians, including the very very capable pediatricians of Honolulu.

It has recently been felt, more on the mainland United States than anywhere else in the world, that allergic disease has been increasing both relatively and absolutely. Physicians are gradually awakening to the importance of the prophylaxis of these disorders which start largely in early infancy and childhood with manifestations of various types, particularly gastrointestinal disturbances, eczema (a very stubborn skin rash), frequent respiratory illnesses and asthma. When initiated by foods, which is very commonly the case in early infancy, the most important are the most commonly used, such as eggs, cereals (particularly wheat), and milk Adequate substitutes for eggs and milk are readily available but not for cereals. Poi, because of its relatively low allergenicity, has proven to be ideal for this purpose. As interestin the prevention of allergic disease

grows, poi should be used more and more for the starting carbohydrate food as a cereal substitute for infants born in allergic families who, because a tendency to develop allergic disease is inherited, are more likely to show such manifestations than those in non-allergic families. The importance of this problem is illustrated by the observation that about 20percent of children on the mainland U.S. suffer from allergic disease. A recent publication from the U.S. Department of Health, Education and Welfare, which did not become available until after this report was written, indicates that allergic disease accounts for almost 33 percent of all chronic disease reported in children under 17 years of age, and that one allergic disease alone, asthma, accounts for nearly one-fourth of the days lost from school because of chronic illness in this age group.

In the Department of Pediatrics, University of Rochester School of Medicine and Dentistry, Rochester, New York, it has been shown that poi is as adequate as the customary cereals for infant feeding. Moreover, it is very well tolerated even by premature infants. The experience of pediatricians in Honolulu with infants suffering from gastrointestinal disorders has been highly satisfactory. The taste of poi, which must be acquired by older children and adults, is not a factor in its acceptance by infants.

Poi also has a special property, unique in carbohydrates, in that it is an alkaline rather than an acid food and this doubtless accounts to a large degree for the excellent teeth of the ancient Hawaiians. It is also free from gluten as determined by chemical analysis, and its use in celiac disease, an illness of infants, caused at least in part by gluten in the ordinary cereals, deserves further investigation. It may also prove to be of help in a more common disorder

of infants, cystic fibrosis, one of the symptoms of which may be severe gastrointestinal disturbances. This is now being studies. Poi has already proven invaluable as a cereal substitute in individuals allergic to cereals and will eventually find a place in the treatment of various gastrointestinal diseases in older children and adults as well as normal, potentially allergic and allergic infants.

The manufacture of poi should be standardized so that each batch will have the same composition as every other batch. Research directed at making the taste of poi more acceptable to older children and adults, already initiated by the Parke, Davis Company, should be continued. Because poi is low in iron, this should be added just as has been done with the customary infant cereals which are also lacking in this respect. Studies should be continued relative to the dehydration ofpoi for shipment overseas as this will greatly reduce its bulk and cost. Mistures of poi with vegetables and fruits similar to the manner which is employed in the case of cereals should also be developed.

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N.Y. TIMES, OCT. 31, 1982. TRAVEL SECTION

Fare of the Country

In Hawaii, Poi Is The Staff of Life

By ROBERT TRUMBULL

"You haven't really been to Hawaii until you've tasted poi," residents of America's 50th state tell visitors. Poi, the pounded root of the taro, once a sacred plant whose heart-shaped leaves were used in sacrifices to ancient Polynesian gods, is as much a symbol of Hawaii as the surfboard.

Native islanders, especially the ones descended from the original Polynesian settlers of Hawaii, regard poi as their "staff of life," the equivalent of bread in the Western diet. Poi is often the first prepared food given to infants of all Hawaii's many races, and they never lose their taste for the tangy, slightly sour concoction.

Poi — it rhymes with boy — is an indispensable accompaniment to the steaming meat and fish, served wrapped in leaves, that are the main dishes of the luau, or traditional Hawaiian feast, but many islanders eat it for breakfast as well, in place of cereal, or use it as a dip for canapes. Manufacturers of the product ship it in bags by air to the mainland for Hawaiians living there.

For the typical newcomer to Hawaii, however, the first taste of poi is frequently the last. "Most of it comes back," Tom Caulfield, the catering manager of the Royal Hawaiian Hotel on Waikiki Beach, says of the poi served to tourists at the hotel's regular Sunday-night luau. Poi at these events is "mainly for decoration," or because it is traditional, Mr. Caulfield says.

Visitors are put off even before trying poi because the light brown, viscous mass "looks something like wallpaper paste," Mr. Caulfield says. A common tourist reaction to the first sampling of the preparation is that it tastes like wallpaper paste, too, or so they imagine. "They always screw up their mouths," says Mr. Caulfield.

Hawaiians wince at such expressions. The freshly made poi served at most commercial luaus is too bland for connoisseurs, who prefer the stronger flavor of the pulverized root, to which water is added to produce the desired consistency, after it has been allowed to ferment for three or four days.

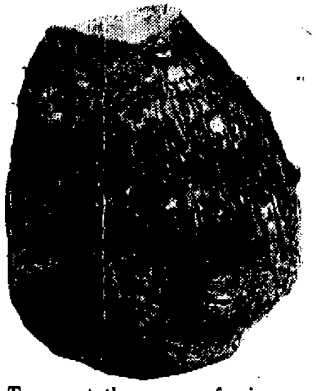
ROBERT TRUMBULL, formerly a Times correspondent, lives in Hawaii.

"The sourness of poi depends on how long you ferment it," says Randy Lee, the part-Polynesian owner-manager of the Willows, a popular Honolulu garden restaurant that serves Hawaiian delicacies in addition to more standard fare. "Some people say it is at its best when it looks up at you and winks."

The thickness of the mixture is a question of preference. Varying from the "one finger" poi to the thinner, "two finger" or "three finger" variety. A true islander scorns the forks and spoons, unknown in old Hawaii, provided at modern luaus for the uninitiated.

"Poi is definitely an acquired taste," says Miriam Tottori, a second-generation islander of Japanese descent who works at the Honolulu Poi Company, one of several concerns that manufacture the product for sale at supermarkets in plastic bags or glass jars (the metal can, once plentiful on Honolulu grocery shelves, seems to have disappeared). "It's like I had to acquire a taste for pizza," she said, adding, "I love pizza now."

A brochure on Pacific island foods put out by the South Pacific Commission, an international development agency based in Noumea, in the French territory of New Caledonia, lauds taro root, the solid ingredient of poi, as "an excellent source of calories" that "also provides fiber" and is "a good source of calcium and iron." The stalwart build characteristic of both sexes among native Hawaiians and other Polynesian peoples has been attributed to their heavy consumption of taro, either as poi or in other forms.



Taro root, the source of poi.

But the principal value of poi as baby food is its "hypo-allergenic" quality, says Claire Ho, a nutritionist with the Hawaii State Department of Health, who says she has brought up "two beautiful specimens of children" of her own on the preparation. "Poi causes no allergies at all," says Mrs. Ho. A few years ago, she recalls, a hospital in Akron, Ohio, telephoned for an emergency shipment of poi for an infant girl with an extreme allergy problem. "Hospitals keep poi on hand now," she says.

Taro root, under different local names such as dalo or talo, is a popular food throughout the Pacific in various forms. Besides being made into poi, a laborious process, it is boiled or fried, like potatoes. In Hawaii taro chips are a favorite alternative to the common potato chip. The leaves of the plant, which are rich in vitamins A, C and B2, are widely eaten as a vegetable but must be thoroughly cooked to dissolve the calcium crystals that irritate the throat and mouth.

"The Hawaiians were the only Polynesians to consume most of their taro in the form of poi," says Charles E. Snow, in his book, "Early Hawaiians," published by the University Press of Kentucky in 1974. In this way, he says, the Hawaiians obtained the needed organic acids supplied to other people by fruits that were lacking in ancient Hawaii.

Elderly Hawaiians can remember when much of community life revolved around the family taro patch. Women participated in cultivating and harvesting the plants, but the physically taxing work of beating the hard tuber into pulp with a heavy stone pestle was performed by the husky males.

Hawaiians mourn the fact that there are few taro patches left on the island of Oahu, where Honolulu is situated. The raw material for poi now comes mainly from other islands, especially the scenic Hanalei Valley on Kauai. And most of the preparation of poi, except the hand cleaning, is done by machines.

"Poi has become so expensive that people are eating less of it," says Maile Yardley, the food columnist of The Honolulu Advertiser and author of several Island cookbooks, who is part Hawaiian. At a Honolulu supermarket, an eight-ounce jar of poi costs $1.39. Bought in bulk, with the necessary water to be added by the purchaser, it costs $1.75 for a plastic bag of 18 ounces.

Photographs by Werner Stoy/Camera Hawaii

Visitors to the islands often have mixed reactions to their first taste of poi.

Customarily, tastes of poi are taken alternately with bites of such Hawaiian delicacies as laulau, or pork and butterfish with succulent taro greens, wrapped in a large leaf and steamed; kalua pig, or pork baked over hot stones in an underground oven; lomilomi salmon, a cold mixture of salted salmon, onions and tomatoes, or pipikaula, a beef jerky flavored with soy sauce.

A sampling of Hawaiian dishes, including poi, is offered at the Royal Hawaiian Hotel on Sunday evening along with a program of island songs and dances, for $28. The telephone number for reservations is 808-923-7311. A less elaborate but authentic Hawaiian lunch is served at the Willows, 901 Hausten Street (808-946-4808), for $8.95. Dinner with more courses and Hawaiian entertainment is slightly more.

On morning expeditions to the Ala Moana Center, Honolulu's giant shopping complex near Waikiki, which can be reached by the No. 5, No. 8 or No. 20 bus, I often stop at a small restaurant with a takeout counter on the ground level called the Poi Bowl and take home for lunch a couple of laulaus at $2.50 each, with a $1 portion of lomilomi salmon and a 45-cent serving of poi. ■

Religious Prohibitions

Since *ali'i* of the top ranks, both male and female, were tantamount to gods, both their persons and their belongings were sacred and under *kapu* that no one, even lower-ranking *ali'i,* could violate without punishment by death. A *kapu* which barred members of the two sexes or people of different ranks from eating together was universal, strictly enforced, and also punishable by death.[14] This *kapu* is said to have been invoked by Wakea, the primordial sky god and male principle; and to have derived from the sacred *kalo.*

Kalo was one of many foodstuffs that, in this male-dominated religion full of phallic symbolism, were *kapu* for women to handle, even to prepare for food. Only men could cultivate and harvest *kalo,* this body of Kāne, and make it into *poi. Mai'a,* sacred to Kanaloa, were also forbidden to women, except for three varieties which Wakea had declared *noa,* free of *kapu.* The coconut,[15] an embodiment of Kū, was *kapu* to women as well; they never made *'aha* (coconut cordage or rope), although women made all other kinds of cordage. The *pua'a* (pig), a *kinolau* of Lono, was forbidden to women, too. The punishment for a woman eating a food *kapu* to her sex is not spelled out, but the rationale for these restrictions appears to have been religious: that women should not consume foods that were used sacrificially.[16]

Overall, women's lives were governed by many more *kapu* than men's were. The places a woman could go and what she could do were in many respects tightly circumscribed. *Kapu* effectively excluded her even from the central religious practices, for women were not permitted to go where images of the gods were — to enter either the *heiau* or the *hale mua,* where the family altars were kept and the daily offerings presented.

Men or women who violated major *kapu* had no recourse but to flee to *pu'uhonua,* places of refuge, that were maintained on each island, occasionally occupying whole *ahupua'a. Pu'uhonua* were a third variety of *heiau* specifically for this purpose, and their priests were charged with caring for those who sought protection within their walls. The Pu'uhonua o Honaunau in Kona, a national historical park, is the most famous of these places of refuge.

The Seasonal Calendar

Hawaiian religion regulated the timing of many events, including planting and fishing, according to a lunar calendar. The lunar, or synodic, month started and ended with the new moon, lasting the roughly four weeks that it takes the moon to go through all of its phases. Each day had a specific name, often linking it to a particular god. Nine of the days, comprising four periods during each lunar month, were dedicated to worship of the four principal gods — Kū, Kāne, Lono, and Kanaloa. During these periods, planting and certain kinds of fishing were disallowed, as were some other forms of work such as beating *kapa.* It is not clear what sort of work was permissible.

The remaining days were held to be propitious for various purposes, such as planting particular kinds of fruits or vegetables.[17] For example, the interval preceding the nights of Kāne was thought to be a good time to plant *mai'a.* At the full moon, planting *'uala* and *kalo* was recommended, as was weeding and mulching *kalo.* These activities were to be coupled with prayers to Kānepua'a,[18] one of the lesser gods associated with Lono and, secondarily, with Kāne.

Rituals Related to Crops, Including Makahiki

Prayers for the crops were offered not only during the four *kapu* periods but also at the time they were planted, at intervals during their growth and maturation, and at the harvesting.[19] The first yields of any crop were offered to the gods, primarily the god most revered by the individual who had raised it. During a period *kapu* to that god,[20] the food was cooked in a ritual fire,[21] and one portion became the offering, while another was eaten by the *maka'āinana* and members of his family. After this ceremony, the food was *noa* and could be eaten with no more than the customary daily offering.

The large ceremonies associated with crops, one writer has observed, attained a scale of size and a level of organization and cost (in terms of energy and material goods) that qualifies them to be labeled "state religious cults."[22] Certainly this holds true for the annual *Makahiki na o Lono* (time of the coming of Lono), particularly as it was celebrated at the Hiki'au *heiau* on the shores of Kealakekua Bay, on Hawai'i. Though now marred by the presence of two Christian monuments at its entrance, this stands as one of the best preserved of the old Hawaiian *heiau,* and it was here that the annual observance of Makahiki started and ended.[23]

Makahiki was a religious occasion, welcoming the return of Lono as the bringer of rain and winds.[24] The observance occurred during the season when southerly *(kona)* cyclonic storms start in Hawai'i, watering the islands' leeward slopes. Its beginning was set at the first new moon after the constellation Makali'i, known in the West as the Pleiades, was seen rising in the eastern sky at sunset. The date of this celestial phenomenon varies from year to year, but in Hawaiian historic time, it has always fallen between mid-October and mid-December. The Makahiki lasted about four months for the *ali'i* and priests involved in preparing and carrying out its elaborate ceremonies,[25] but it lasted only half as long for *maka'āinana.*

The ceremonies centered on a procession around each island. Three nights before the start of the procession, the

Lā 'au Hawai'i - Traditional Hawaiian Uses of Plants

Isabella Aiona Abbott
Bishop Museum Press 1992

Fig. 17. [ABOVE] Altar enclosure, the only remaining structure on the platform of *Hiki'au heiau* at Kealakekua Bay, Hawai'i, which played a key role in Makahiki ceremonies.

Fig. 18. [LEFT] Image of the god Lono at the top of the *akua loa* staff, which headed the procession to each *ahupua'a* during the Makahiki. Collection of Bishop Museum. Bishop Museum photograph.

feather gods were worshiped, and on the final night, priests prayed all night long before wooden images of the gods. The following day, a very sacred day, priests prepared the *akua loa* (lit., the "long" god), a pole about eighteen or twenty centimeters (seven or eight inches) in diameter and two or three meters (six or nine feet) long which bore at its tip a head of Lono. One or more white pieces of tapa hung from a crosspiece below the head, with the result that, from a distance, the *akua loa* resembled a sail. The crosspiece also held a feather *lei* and, as symbols of starvation or famine, skins of the *ka'upu* (a native bird) and fronds of the *pala* fern, which Hawaiians resorted to as a food in times of hardship.[26]

That night everyone feasted and celebrated, and toward midnight they bathed in the sea, a custom of purification

that preceded all major religious observances.[27] The following day, the *akua loa* was brought out and exhibited, formally beginning the Makahiki. The *akua loa* symbolized Lono during the Makahiki and would be the ritual center for most of the ceremonies during this period. The staff was made of *kauila*,[28] perhaps selected because its name means "lightning," and lightning was considered a *kinolau* of Lono.

With the Makahiki, many special *kapu* came into force, as Fornander describes in ringing, poetic language:

"And Lono had decreed that man was forbidden to kill; war was prohibited, there was to be no fighting; the ocean was *kapu*, not a canoe was to sail; the *kapa* anvil was *kapu*, and no cloth was to be beaten; the drum was *kapu*, not to be tapped; the conch shell was *kapu*, not to be blown; the land was *kapu* to Lono, the earth, life, the mountain, the ocean, the raging surf, the family, the sailing canoe was *kapu* to Lono."[29]

Simultaneously, the usual *kapu* of the lunar cycle were set aside, *heiau* closed, and religious services were suspended.[30]

The *akua loa* procession, consisting of the *mōʻī* (ranking chief), other *aliʻi*, and priests, set off the next day to visit each *ahupuaʻa* in turn, circling the island counter-clockwise. At the entry to each *ahupuaʻa*, the procession stopped at a stone altar topped with a block of *kukui* wood representing a pig. It was these altars that gave rise to the designation *ahupuaʻa*, for the word *"ahu"* refers to an altar, and *"puaʻa"* means pig. The pig being another of Lono's *kinolau*, these altars were places full of import, and it was there the procession received *hoʻokupu* (offerings) from each *ahupuaʻa*. *Hoʻokupu* consisted mainly of food -- live pigs and dogs, dried fish, salted sea urchins, and containers of *poi* and other prepared foods -- but also non-food items such as plain *kapa*, bundles of feathers, and decorated loincloths and bedding *(kapa moe)*.

The word *hoʻokupu* means "to cause to grow." In keeping with the Hawaiian conception that the *mōʻī* was the scion and living embodiment of Lono, these contributions were understood as *mōhai* (ceremonial gifts), fruits of the land and the sea and of human labor, tendered to those who were the very source of nature's productivity.[31] In this context, it is completely inappropriate to think of *hoʻokupu* as the Hawaiian equivalent of taxes, as many recent writers have. Monetary offerings made to churches today are not regarded as taxes; neither should the material *hoʻokupu* of Makahiki be considered as such.

Once the *hoʻokupu* were accepted as sufficient, the *akua loa* procession continued to the next *ahupuaʻa*, and a group of bearers took the offerings back to the home district of the *mōʻī*. This returning group followed a second symbol known as the *akua poko* (the "small" god). As the name indicates, this staff was shorter than the *akua loa*, little more than a yard long. It was decorated with the figure of a man in a feather helmet, had no crosspiece, and was sharpened at its lower end so that it could be placed in the ground.

Fig. 19. *Pala* fern *(Marattia douglasii)*, used as a sign that the Makahiki *kapu* had been lifted from an *ahupuaʻa*. Courtesy of Florence Wagner.

When the *akua loa* and *akua poko* had departed, *makaʻāinana* gathered *pala* fern to carry on their backs as a sign that the land had been released from *kapu*.[32] Worshipers of Kāne gathered *kalo* leaves, roasted them, and displayed them on the sides of their houses, showing that the *kapu* on labor in their *loʻi* had been released. At the same time, the *aliʻi* sent out canoes to fish, indicating *ahupuaʻa* by *ahupuaʻa* that the *kapu* on the sea was ended.[33]

After the *akua loa* procession had finished its circuit of the island and just before it returned to the house of the *mōʻī*, people from every *ahupuaʻa* and district gathered for boxing matches *(mokomoko)*, wrestling, games of skill, and *hula*. Boxing and wrestling commemorated the legend that Lono killed his wife in a fit of jealousy, traveling thereafter from

place to place and engaging in boxing matches in a display of grief and regret. Boxing was a cruel, punishing sport in prehistoric times.[34]

Several other ceremonies were held to honor Lono, including one in which the *akua loa* and *akua poko* were dismantled and stored again in the *heiau luakini*. This indicated that the close of Makahiki was at hand and perhaps was the concluding event on some islands, but at least on Hawai'i, at Kealakekua Bay, the final ceremony entailed putting *ho'okupu* to sea in an unpainted canoe—Lono's canoe. With a large basketful of foods between its outriggers, the canoe was sailed back and forth across the bay to signify that all *kapu* had been lifted from the land and sea; then the canoe was headed into the open ocean and set adrift.

For four decades after Western contact, certain ceremonies of the Makahiki continued to be observed.[35] In Kona, during the time of Kamehameha I, the accumulated *ho'okupu* were divided by the *mō'ī* and distributed to the priests, specialist craftsmen, members of the court, lower-ranking *ali'i*, and those who served in battle. After Kamehameha's death, with abolition of the old Hawaiian religion and especially with the destruction of images and *heiau* that began in 1819, Makahiki ceremonies as described above no longer were practiced.

I have recounted the elaborate ceremonial of the Makahiki in detail because I believe that it shows how deeply their religion penetrated the lives of both *maka'āinana* and *ali'i*. To pass off this annual celebration as unimportant (or as a subject that has been given too much emphasis) is to overlook what it tells us about Hawaiian society. Makahiki was much more than a gesture of thanksgiving and a break from routine; it gave form to the belief that maintaining a right relationship with the gods and the earth is humanity's basic spiritual challenge. It is also important not to ignore Makahiki's biological significance: a two-month period when the land could rest, plants could grow without being harvested, and the ocean could replenish itself.

CHAPTER 4

The Staple Crops, *Kalo* and *'Uala*

E Ku-ike-olo-walu-e,
I olowalu ka huli i ka makalua a kaua.
I olowalu ke kalo i ola au ka mahi'ai,
I ola ka hono hale,
I ola ka 'ohua
I ola ka 'ohana,
I ola na malihini kipa mai,
A i ola ia'u ia (ka inoa o ka mahi'ai).
'Amama. Ua noa.

O Ku-ike-olo-walu,
May the taro top in our planting hole grow large.
May they grow large that I the planter may live,
The dwellers in the house may live,
That the dependants may live,
That the family may live,
That the visiting stranger may live,
That I (the name of the planter) may live.
'Amama. It is free of tabu.

— from June Gutmanis, *Na Pule Kahiko*

Kalo (taro, *Colocasia esculenta*) and *'uala* (sweet potato, *Ipomoea batatas*) were the most important crops for the ancient Hawaiians. They furnished not only the carbohydrate base of their diet and goodly amounts of high-quality vitamins and minerals but also were *kinolau* of the gods Kāne and Lono, respectively. One sign of their cultural importance lies in the large number of varieties of the two species that developed and the even larger number of names that were applied to them: interviewing in the 1930s, Dr. Handy gathered 342 names for *kalo* varieties and 230 for *'uala*.[1]

All Polynesian societies probably started out with a set of four or five food plants that could provide the carbohydrate base of their diets — taro, bananas, yams, breadfruit, and in most cases sweet potatoes, too.[2] In each island group, one of these came to predominate, though others were grown as well. Social factors may have affected Polynesian dietary preferences to some degree, but geography was probably the controlling force. The Marquesas Islands, for example, are mountainous, with few coastal plains that could accommodate a large taro crop. Breadfruit became the Marquesan staple because the trees could be grown on steep ridges and in narrow valleys, which is exactly where they were placed and can be found now. Seventy names were known for breadfruit in the Marquesas,[3] but only one in Hawai'i.

Hawaiian geography presented an opposite situation, favoring the emergence of *kalo* as the principal staple. Breadfruit grows successfully here but does not produce as well as it does in the Marquesas, which lie ten degrees closer to the equator and have a slightly warmer climate. The broad, flat valleys of Hawai'i (particularly of Kaua'i, O'ahu, Maui, and Moloka'i) afforded the Hawaiian planter excellent acreage for *kalo* and adequate-to-abundant supplies of cool water necessary to cultivate wetland *kalo* varieties.[4]

Kalo Traditions and the Ancestry Of the Hawaiians

The myth of the origin of the Hawaiian people is known in several versions, but all of them begin similarly and give *kalo* a prominent place.[5] When the sky principle Wakea coupled with the earth principle Papa, their first child, Hāloanaka, was stillborn,[6] but a *kalo* plant sprouted from the place where the fetus was buried. Their second child was a daughter, *Ho'ohōkūkalani,* by whom Wakea later had a human son named Hāloa, the ancestor of the Hawaiian *ali'i* and thus of all Hawaiians.[7] In order to make a union with his daughter possible, Wakea established the social code that separated the sexes, including the *kapu* requiring that they eat separately — the first *kapu* — and the *kapu* isolating women during menstrual periods and childbirth.[8] This creation story, the *Kumulipo,* set the foundations of Hawaiian society such that, in the nineteenth century, when King Kalākaua felt constrained to demonstrate his rightful claim to the throne, he authorized a genealogical search that traced his family line all the way back to Hāloa, and the *kalo* leaf appears on the crown he wore during his reign.

Biogeography may also have shaped the Hawaiians' affinities for their gods. It appears that the Polynesians who settled the islands were followers of K[illegible] T[illegible]

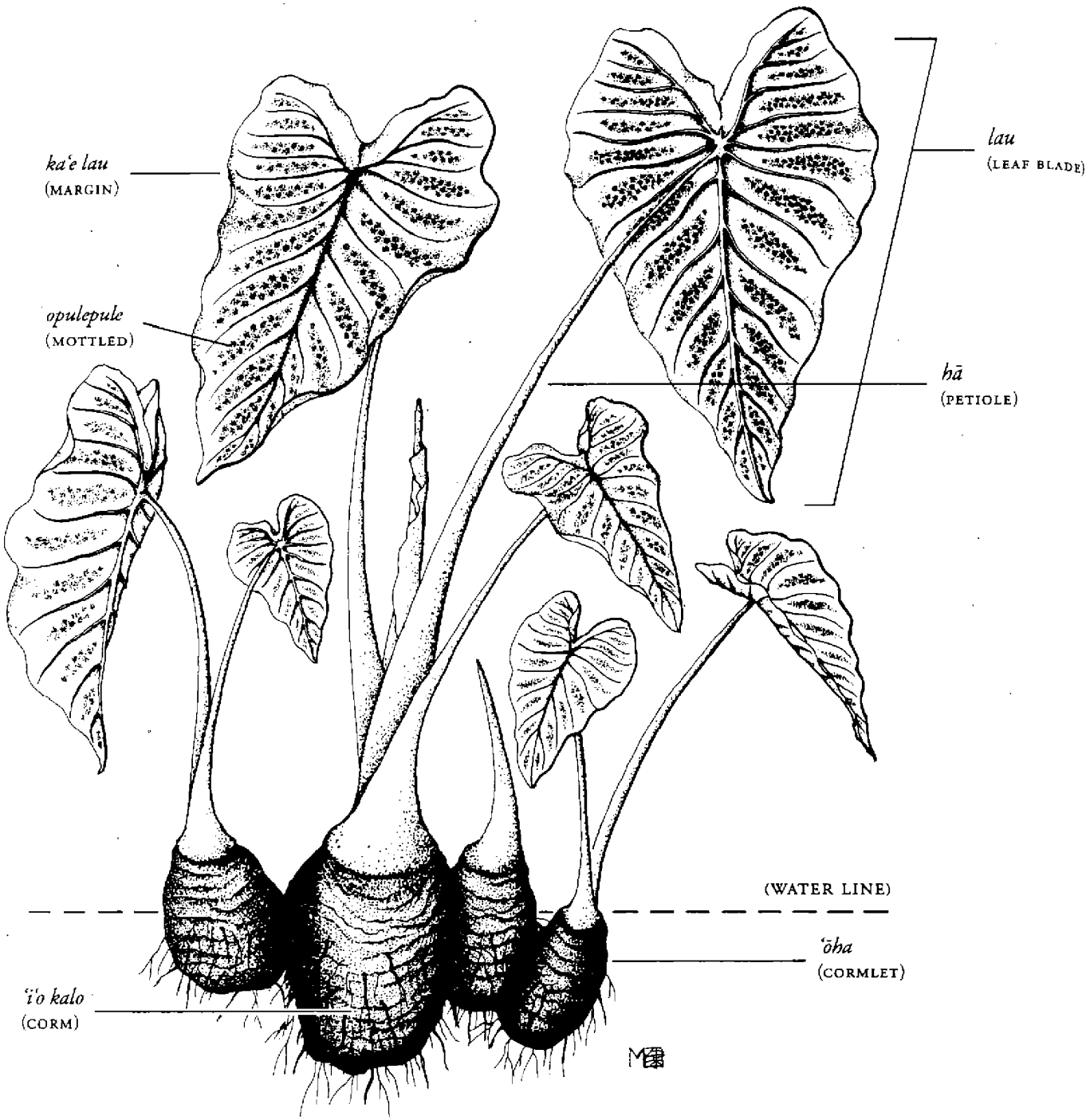


Fig. 20. Diagram of the *'elepaio* variety of *kalo*, which has green-and-white mottled leaves. Hawaiian and English terms for important parts of the plant are indicated.

southern Polynesia, and they came to populate areas that had the water necessary for growing the crop that is his *kinolau*. During the Expansion Period, however, as population pressure drove some people into drier lands, more suitable to *ʻuala* crops, the traditions of Lono seem to have strengthened correspondingly.

The Biological Origin and Diversity of *Kalo*

Although controversy remains about where taro originated and was domesticated, anthropologist Douglas Yen, a student of early plants in the Pacific islands, believes it was under cultivation in the New Guinea highlands between five and ten thousand years ago.[9] Before they started tending the plant, people must have discovered by a protracted and probably painful trial-and-error process that long cooking is necessary to make it edible. Taro is full of needle-like and knob-like crystals of calcium oxalate that make it very painful to eat raw but which can be dissolved and rendered harmless by exposure to heat.

Once taro's usefulness as a food was known, the ancients evidently studied its preferences, learned to raise the yield by cultivating it, and then began to share the crop with neighboring peoples. Genetic analyses of taro varieties show that, early on, two distinct varietal lines developed, with different chromosome counts. The telltale genetic evidence has enabled researchers to conclude that both lines were carried from mainland Asia through the Ryukyus to Japan and China as well as southward through Timor in present-day Indonesia and on to New Caledonia.[10] Only one of the pair was established in northern Melanesia (New Guinea, the Solomon Islands, and the New Hebrides) and passed on from there to Polynesia. Prior to Western contact, the second line was not grown anywhere in Polynesia, with the possible exception of New Zealand.[11]

Of the 342 names for *kalo* varieties that Handy recorded in the 1930s, only about half could still be matched to particular plants. Handy himself was later able to confirm sixty-seven varieties, using the same characteristics Hawaiians had used in developing their *kalo* classifications: the color of the corm or stem (which is also known as *"kalo"*), the petiole *(hā)*, its base *(kumu)*, its margin *(lihi)*, the color of the junction of the petiole and blade *(piko)*, the color of the blade *(lau)* and any markings on the surface, differences in lobing, color of the margin, the veins, and differences in color of the top and bottom surfaces.[12] The great difference between the number of varieties that Handy could identify and the number of names he compiled suggests that some *kalo* varieties had been lost. It is impossible to determine how many varieties had disappeared, however, since many of the 342 names he gathered were surely duplicates, resulting from one variety [illegible] in different places

Fig. 21. *Kalo* growing in mounds, which was the method the old Hawaiians used for cultivating "wetland" *kalo*. I. Abbott photograph.

Kalo-Growing Practices

Both wetland and dryland (also called "upland") *kalo* probably were grown in each *ahupuaʻa*, with different varieties planted to ensure a stock of *kalo* for *poi* all year-around. Wetland varieties could be grown on stream banks, in marshy areas of freshwater springs, or in the "patches" or pondfields that the Hawaiians called *loʻi*. Its name notwithstanding, dryland *kalo* also favors very moist climates, doing best in shady areas where the annual rainfall exceeds 127 centimeters (50 inches).[13]

Forest land was frequently cleared for dryland *kalo*, and two centuries ago, such *kalo* beds in upland Kona earned Hawaiians an excellent reputation as farmers in the eyes of the early European explorers.[14] In the rainy zone *mauka* of Hilo and along the Hāmākua coast, similar beds of dryland *kalo* are still commonly seen today. In upland Kona, at Hāna, Maui, and in other places where there are few streams, good planting practices and adequate rainfall usually permitted growth of dryland *kalo* sufficient to support large populations. In these forest plantings, one of the steps Hawaiian planters took to protect *kalo* beds was to use fern fronds as mulch during periods of bright sunshine and to remove the fronds during rainy spells.

In contrast, wetland *kalo* came to occupy much of the flat, arable land in each valley in Hawaiʻi. Dr. Handy's careful exploration of *ahupuaʻa* in the 1930s revealed that even small valleys, now thought to be too dry for *loʻi* farming, had *kalo* terraces in them.[15] Demonstrating the extent of prehistoric wetland *kalo* cultivation was one of Handy's most meaningful contributions to Hawaiian ethnobotany and to our knowledge of Hawaiian culture in general.

While maintaining existing *loʻi* was a routine and relatively simple task requiring little more than releveling the

Fig. 22. The *huli*, a cutting including the top of the corm and the stem tip enclosed in the petioles, used as the vegetative means of propagating *kalo*. Courtesy of Calvin Hirai.

Fig. 23. *'Ohana* (cormlets of *kalo*), formed by adventitious roots issuing from the parent plant. They may be left in place after the parent plant is removed to start new plants, but often they are

soil and shoring up the banks, making new *lo'i* must have been a major undertaking, probably carried out just once in a generation. The initial work usually involved all the men of an *ahupua'a*—men only, since *kalo* was a sacred plant of Kāne and *kapu* to women—and consisted of burning off the vegetation, then using *'ō'ō* to remove roots, dislodge boulders, and loosen the soil. After the dry soil had been removed, water was run into the *lo'i* several times until the bottom was roughly level, and a treading or stamping party was held to pack the soil. For this final step in the project, men, women, and children were all invited into the *lo'i*, "and no chief or chiefess held himself too tabu to tread in the patch."[16] A feast followed this event.

After the soil had settled, *pu'epu'e* (mounds) were made about three feet apart in straight rows, and the *lo'i* was ready to inundate and plant. Since *kalo* rarely produces seeds, it is always propagated in one of three other ways. The most common is to take *huli* (vegetative cuttings) from the upper six to eight centimeters (two to three inches) of the corm, containing the stem apex, and the lower ten to twelve centimeters (four to five inches) of the *hā*. The alternative methods are to plant buds borne in the axils of the leaves[17] or to plant *'ohā*, which are outgrowths produced by adventitious roots of the parent plant.[18] In modern times, *'ohā* have usually been harvested for family consumption, leaving the main plant to mature further.

Cutting off the tops of the *kalo* corms to make *huli* was accomplished with a *palau*, a tool with convex cutting edges at each end. This wooden implement was approximately twenty centimeters (eight inches) long and about three centimeters (one inch) thick at the blade ends, which were finely honed.[19] It was grasped in the center with one hand and the ends used alternately to make the cuts. These traditional *kalo* cutters were replaced in the post-contact period by knives, particularly machetes.

Huli were made well in advance of the planting date and left immersed in water or in a damp place to encourage development of abundant adventitious roots. These were then set out three to a mound. The water level in the *lo'i* never reached the bottom of the *huli;* contrary to the popular impression, the mounds were never submerged. Weeds were removed as they appeared during the first six months but thereafter were mostly shaded out by developing plants. Except for regulating the flow of water, the grower left his *lo'i* undisturbed until harvest.[20]

In experiments with eight varieties of *kalo*, all maturing in six to twelve months, Dr. Handy found only one that needed to be harvested promptly at maturity. The other varieties could remain in the flooded *lo'i* for two to twenty-four months after reaching maturity. This feature of the plant makes *kalo* a very flexible crop and allowed a *lo'i* to double as a storehouse. The planter could harvest what he needed,

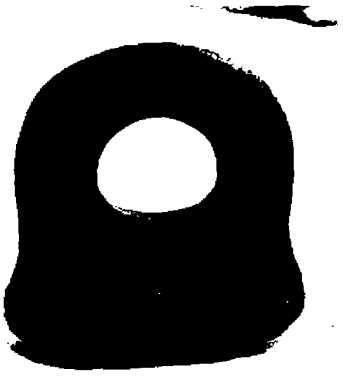


Fig. 24. Stone pounders for mashing *kalo*. The stirrup-shaped pounder is from the island of Kauaʻi.

Dryland *kalo* was grown in much the same way as the wetland varieties, also being planted in mounds.[21] Today, where Hawaiian families hold land in moist regions, small dryland patches are frequently seen. Dryland varieties take a little more time to mature than wetland *kalo* — eight to twelve months. Depending on the variety, they may remain in the soil three to twelve months beyond maturity,[22] or even longer. The Laʻaloa variety, Mrs. Pukui's family favorite, can be left growing indefinitely.[23]

Preparation and Consumption of *Kalo*

Kalo corms were sometimes eaten in chunks after being baked, but the most important way of eating them, of course, was in the mashed form known as *poi*. Making *poi* in olden days was strictly the province of men, but Mrs. Pukui learned how to do the pounding when she was young, with the justification that women needed to know this skill in case an emergency called the men of the family away.[24] I, too, learned the process, by watching and helping as my great-uncle made *poi* each Friday for my family on Maui.

For us, the process began with my great-uncle's bringing *kalo* from the high valley of Kahoma where he lived and planted to my grandmother's house on the beach in Lahaina. He set the *kalo* to boil in a clean, five-gallon kerosene can while he fished or went into town to buy a few groceries. After he returned, he let my brother and me help peel the hot *kalo*, then laid out his *poi* board on *lauhala* mats and began pounding the *kalo*. His *poi* board measured about one meter (three feet) in length and was slightly hollowed out, like a shallow tray. He periodically dipped his fingertips into a bowl of water as he worked, adding several cups of it, bit by bit, to the mass. He constantly turned the mass as he mashed it with the pounder. The *lauhala* mats beneath the board cushioned the blow of his stone.

As the *poi* gradually became a smooth, somewhat sticky, grayish-red paste, my brother and I were frequently scolded

Fig. 25. Cooked *kalo* being mashed on a *poi* board made of *ʻōhiʻa lehua* wood. I. Abbott photograph.

for trying to steal fingersful before it was properly finished. Freshly made *poi* has something in common with freshly made bread; few things are quite as enticing. By my great-uncle's standards, *poi* was "finished" long before it reached the consistency of the *poi* sold in supermarkets today. He stopped at the state called *paʻiʻai*, when the mass was smooth and solid. It ferments less readily in this condition and is lighter than ready-to-eat *poi*, an important consideration since my great-uncle would carry his portion back to the high valley.

Apart from the fact that he cooked the *kalo* in a metal can instead of an *imu* (earth oven), my great-uncle made *poi* just as our ancestors did a thousand years ago. His pounder

(pōhaku kū'i) was a smooth lava rock fashioned with a knob on top *(pōheoheo)*, a handle or *kū'au*, and a flaring base *(mole)*. I am not sure what wood his *poi* board was made of, but most were *'ulu* or *'ōhi'a lehua* wood, and some were large enough for two men to use at once, about two-thirds larger than a one-man board like my great-uncle's. Most of the upper surface was recessed to a depth of about eight centimeters (three inches), with a rim to contain the *kalo* and the water being added as the pounding went on. These were highly valued tools. I remember my great-uncle, in those magical days of my childhood, washing his *poi* board carefully after each use and keeping it covered when stored.

Portions of the *pa'i'ai* that he left us were mixed with additional water each day, as needed for our meals. I watched my mother perform this procedure (called *ho'owali'ai)* countless times in our Honolulu home. Turning the mash with her hand in a rotating motion *('owai)*, she added very small quantities of water and made certain it was entirely absorbed before adding more. As she did so, she used her middle and index fingers to wipe *(kahi)* the inside rim of the bowl above the *poi* so that the sides were clean. When the *poi* was mixed to her liking, she strained it through a kind of cheesecloth thicker and denser than any I can now find. In earlier times, the straining was done with *'a'a'a*, the fibrous cover of developing *niu* fronds. Further details of *poi* preparation are given elsewhere by Mrs. Pukui.[25]

As for eating *poi*, some prefer it fresh and others like it two or three days old—slightly fermented or "sour"—and no doubt this question of taste is very old, indeed. Certainly there is no doubt that *poi* was at the heart of the traditional Hawaiian diet, routinely eaten at every meal except in times of shortage. Though *poi* was sometimes made from other ingredients, namely, *'uala* or *'ulu*, Hawaiians of old unquestionably preferred *poi kalo* to any other. It was their carbohydrate of choice probably to an even greater extent than bread and other baked wheat products are for North Americans today.

In the 1930s, when *poi* was consumed in larger quantities than currently and could still be found in five- and ten-pound bags in the grocery stores, it was not rare to find a Hawaiian man who could consume the contents of a five-pound bag at one sitting. Probably his ancestors would have eaten *poi* in such portions, too, and large, old storage containers for *poi* now in museum collections indicate that it once was prepared in very big amounts. *Maka'āinana* probably made *poi* for themselves every few days in smaller quantities.

Kalo was prepared and eaten in other ways besides as *poi*. Its leaves *(lū'au)* were cooked, wrapped in *ti (Cordyline fruticosa)* leaves, and baked in an *imu*. When the *lū'au* were combined with fish or pork and baked in such a wrapper, the dish was called *laulau;* after Western contact, chicken and beef were often substituted for the fish or pork. Whatever its exact ingredients, to this day the *laulau* remains a favorite dish in the islands, popular with many ethnic groups other than Hawaiians.

Another Hawaiian use of cooked *kalo* is *kulolo*, a dish in which the fresh corm is grated, mixed with coconut cream, wrapped in *ti* leaves, and steamed in an *imu*. The origin of this dish, now used as a dessert, is not known, but if it was eaten prior to 1819, it must have been reserved strictly for men. Consumption of coconut was forbidden to women.

'Uala, the Second Staple

Sweet potato, or *'uala*, ranked second only to *kalo* in providing carbohydrates and minerals in the Hawaiian diet. *'Uala* were cultivated and eaten throughout the islands but were important especially in settlements on leeward coasts too arid even for "dryland" *kalo*. The hardiest varieties of *'uala* will tolerate habitats with less than thirty inches of rainfall annually, and the plant will grow successfully in almost any kind of earth except a sticky, clay-like soil. Even pockets of semi-disintegrated lava can support *'uala*,[26] and at Keone'ō'io, Maui, *'uala* are being grown today in soil-filled depressions on the dry lava fields of southern Haleakala.

A vine with large, underground tubers, a single *'uala* plant often covers a sizable area. The leaves may be eaten either raw or cooked, but the crop was raised principally for its tubers, which are enlarged storage roots. *'Uala* vines tend to produce tubers quite prolifically; with some varieties, as many as three crops can be harvested from the same bed annually.

The Mysterious Origins of *'Uala*

The origins of *'uala* are even more tangled than those of *kalo*. There are three separate lines of sweet potatoes, known vernacularly as the Kumara, Batata, and Camote lines, and all of them entered the Pacific region at relatively early dates.[27] The three are genetically unstable, so their prehistoric dispersion cannot be reliably traced by analyzing the sort of chromosomal patterns that help clarify the travels of taro, but documentary, archaeological, and linguistic evidence offers reason to believe that it was the Kumara line that reached Hawai'i and that it did so without European assistance.

The three lines of sweet potatoes all originated in South America, and at least two of them, the Batata and Camote lines, were established in Central America before European explorers arrived. Columbus carried the Batata line from the Caribbean to Europe, and from there it was spread rapidly eastward, reaching Yunnan province in southwestern China by 1525. By the early seventeenth century, it was growing in

Reprinted from the Hawaii Medical Journal
March-April, 1948, Vol. 7, pp. 296-299

The Possible Role of Poi in the Epidemiology of Infectious Intestinal Diseases

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ACCORDING to Allen and Allen,[1] who made the first study of the microbiology of poi, the foodstuff is prepared by allowing crushed, cooked taro to undergo fermentation by bacteria, yeasts, mycoderms, and oidia. They concluded that the process of fermentation occurs in two phases: the first, in which acid-producing bacteria predominate, effects the characteristic changes in souring poi in a kind of fermentation which resembles that which takes place in souring milk; the second, in which yeasts, mycoderms, and oidia become prevalent, does not lead to any appreciable changes in the poi, at least during the period in which it is normally kept before being eaten or discarded.

Allen and Allen also reported that freshly ground poi contained a varied flora, made up not only of the species of Streptococcus and Lactobacillus which cause the souring of the poi, and of the yeasts, mycoderms, and oidia which predominate in the second phase, but made up also of a number of "contaminants" derived from the equipment and the water of the poi factory and from the persons of the workers who help to prepare the poi. These contaminating bacteria include Escherichia coli, Aerobacter aerogenes, Pseudomonas aeruginosa, chromogenic bacteria, spore-forming bacilli, and various other forms in rather large numbers, but they were found to persist "for only three or four hours . . . due to the unfavorable growth conditions created by the acid-producing organisms."

Bilger and Young[2] made a qualitative inventory of the products of the fermentation of poi, and showed that lactic acid, acetic acid, formic acid, [ethyl] alcohol, acetaldehyde, and carbon dioxide were produced in the course of eight days by the action of microorganisms on the carbohydrates of poi. Their analyses of poi indicated that about 29 per cent of poi is made up of these carbohydrates, about 27 per cent being in the form of starches, and the rest being present as pentosans, reducing sugars, and sucrose. In the first twelve hours of fermentation the reducing sugars were rapidly decreased, but no appreciable change was noted for the starches until the second day, after which they decreased steadily.

An interest in the history of infectious disease in Hawaii, combined with an awareness of the methods by which poi is manufactured, mixed, and served, suggested that poi might have been—and might still be—an important vector in the dissemination of infectious intestinal diseases among the inhabitants of Hawaii. This paper reports the results of a study to determine whether bacterial pathogens of the enteric group can be disseminated under natural conditions of preparation, storage, and use of poi.

Methods

The procedure employed consisted essentially of inoculating a measured volume of poi with a known number of test organisms of the colon-typhoid-dysentery group, and in making daily enumerations of these test organisms during the subsequent course of storage, observing the effect of time, temperature, pH, and numbers and kinds of associated microorganisms upon the test organisms as the poi underwent fermentation. The test organisms used were Escherichia coli, Eberthella typhosa, Salmonella schottmuelleri, and Shigella paradysenteriae. The strain of E. coli employed was isolated from human feces in the University of Hawaii bacteriology laboratory. The strains of pathogens were obtained from the Bacteriological Laboratory of the Territorial Board of Health at the beginning of this study. Nothing is known of their history.

Zero-hour poi was obtained from the poi factory* and, after being taken to the University laboratory, was immediately mixed with tap water to the consistency of "three-finger† poi." (Mixtures of one part of poi to two parts of water gave a product of this consistency.) A Waring Blendor was used for mixing, to insure a uniform sample. A 200-cc. portion of this mixture was

[1] Allen, O. N. and Allen, E. K. The manufacture of poi from taro in Hawaii: with special emphasis upon its fermentation. Hawaii Agr. Exp. Sta., Bull. 70, Nov. 1933.

[2] Bilger, L. N. and Young, H. Y. A chemical investigation of the fermentations occurring in the process of poi manufacture. Jour. Agr. Research 51: 45-50, (Jan.) 1935.

* The See Wo Poi Factory, Honolulu, generously furnished samples of poi whenever they were needed, and their cooperation is gratefully acknowledged.

† The allusion is to the number of fingers required to be dipped into a bowl of the poi in order to secure a mouthful of it: the thinner the mixture, the more fingers are needed.—Ed.

then measured into each of two clean beakers. Duplicate plate counts to determine the number of microorganisms present in the diluted poi were prepared from appropriate dilutions, using 1 per cent glucose agar as the plating medium.

At the same time the pH of the diluted poi was determined electrometrically with a Macbeth pH meter.

The inoculum of test organisms being studied was then added to each of the two beakers of diluted poi, and was thoroughly distributed by vigorous mixing, using a clean glass stirring rod. It was early decided that relatively small numbers of the test organisms should be added to the samples of poi being studied. Preliminary tests suggested that one cc. of a 1:1000 dilution of a four-hour culture in nutrient broth of the test organisms would give a conveniently small number of organisms for each cc. of poi. In every instance the number of test organisms being added to the poi samples was determined by making plate counts in duplicate of suitable dilutions of the four-hour broth culture, using 1 per cent glucose agar as the plating medium.

One sample of the inoculated poi was incubated at room temperature, the other at refrigerator temperature (in these studies, about 13° C.).

Daily attempts were made, once each test was begun, to recover the test organisms from each of the inoculated samples. Platings of appropriate dilutions of one-cc. portions of the poi were made in duplicate, the medium used depending upon the organisms being sought. Endo's agar was used for the enumeration of Escherichia coli, bismuth sulfite agar for both Eberthella typhosa and Salmonella schottmuelleri, and S-S agar for both Salmonella schottmuelleri and Shigella paradysenteriae. The first plating was made twenty-four hours after the inoculum was added, and platings were continued until no recovery of the test organism could be obtained, either in direct cultures or from enrichment cultures in Selenite-F enrichment medium. In order to be certain that no surviving organisms were being overlooked when the end of each test was being approached, suspect colonies from the plate cultures were transferred to Kligler's iron agar slants. Those giving typical cultural reactions were checked immediately in spot-agglutination tests with specific diagnostic antisera.

At the same time, total counts of all organisms in the poi samples were made by plating in duplicate one-cc. portions of appropriate dilutions of the sample, using 1 per cent glucose agar as the medium. The samples were thoroughly mixed with a clean glass stirring rod before any portions of them were removed for plating.

Daily determinations of pH were made electrometrically after each day's portion for plating had been removed.

During the course of a year, 13 different tests were made to determine the effect of fermenting poi upon these test organisms. Escherichia coli was studied first because it was a good indicator organism, being readily identified as long as it was present, and because, of course, it was a safe organism with which to work while defining the general technics of these investigations. Five successive tests were made with E. coli. Once the experimental procedure had been outlined and proved, the pathogens were studied. Eberthella typhosa was used in four tests, Salmonella schottmuelleri in two, Shigela paradysenteriae in one, and all four of the test organisms, in a mixed inoculum, were used in a last climatic test.

No attempt at using "aseptic technic" to keep the poi from being contaminated with air-borne or water-borne organisms was made during the mixing of the poi and its subsequent distribution and testing, because it was the intention of these studies to subject the poi samples to the same treatment that they were likely to receive in the home. Once the poi samples were inoculated with pathogens, however, they were treated with proper respect and precaution.

Data and Discussion

Results of some of the tests performed are summarized in Table 1. All of the data assembled are too plentiful even to summarize, but those presented in Table 1 will suffice to reveal the fidelity to pattern which all of the tests with any one test organism exhibited throughout the series.

TABLE 1.—*Length of survival of test organisms in inoculated poi.*

TEST ORGANISM	NUMBER ADDED PER CC. OF POI	LENGTH OF SURVIVAL AND FINAL pH*			
		at room temp.		at refrig. temp.	
		days	*pH*	*days*	*pH*
E. coli	1100	4	3.7	10	4.1
	1150	4	3.7	15	4.1
E. typhosa	250	2	4.3	8	4.4
	570	2	4.3	8	4.4
S. schottmuelleri	1470	2	4.0	8	4.6
	375	1	4.0	6	4.6
S. paradysenteriae	2925	2	3.8	5	4.3

* Figures indicate the last day on which platings revealed test organisms in one-cc. portions of the incubated poi, and the pH readings of the poi obtained at the same time these platings were made. (The test organisms disappeared, in other words, in the twenty-four-hour interval following the times indicated in this table, when the pH of the poi had become slightly more acid than the readings given in the table.)

These results show that pathogenic organisms of the enteric group are able to survive in refrigerated poi for considerable periods of time—for from five to eight days—longer than poi is usually

stored in the home without being eaten. It can be concluded, then, that poi contaminated with these organisms, either at the factory or at the time it is mixed by hand in the home, is potentially dangerous to consumers provided that the inoculum is not so small as to be unable to initiate infection in any event, and provided that the poi is refrigerated during the time it is kept in the home before it is eaten.

On the other hand, poi which is stored at room temperature probably becomes safe enough to eat

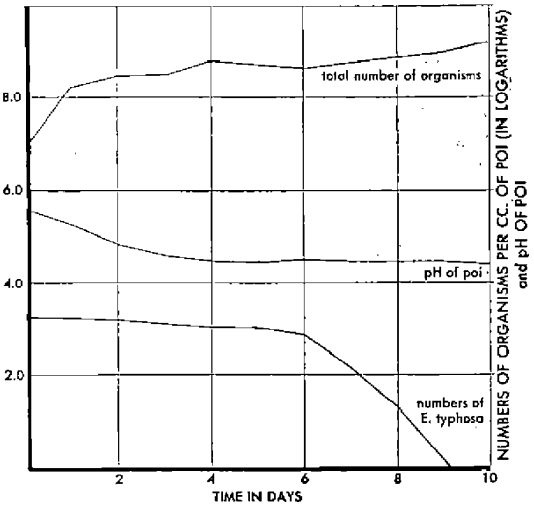

FIG. 1. Effect of total number of organisms and of pH of poi on rate of disappearance of E. typhosa in refrigerated poi.

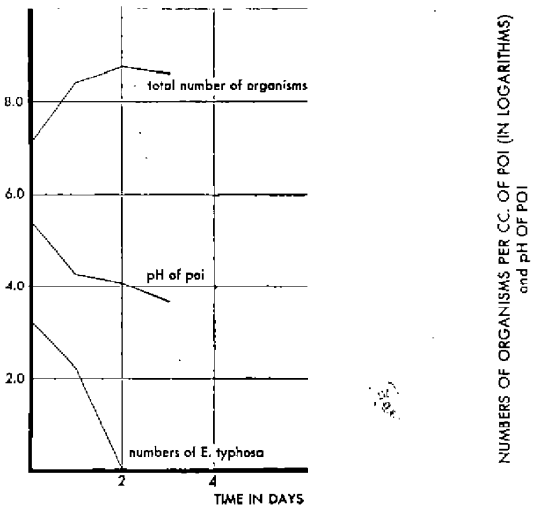

FIG. 2. Effect of total number of organisms and of pH of poi on rate of disappearance of E. typhosa in poi stored at room temperature.

in a short time, for pathogenic organisms are rapidly killed during the process of fermentation, which is hastened, of course, by the warmer temperatures. The poi is potentially infectious only during the first one or two days after it is mixed, during the earlier stages of fermentation. Fresh poi, or sweet poi, as it is sometimes called, is preferred by many people to sour poi, and is frequently served in place of sour poi at public luaus and in the home. People who eat this kind of poi might be endangered. Those who prefer sour poi, and who hasten the process of souring by leaving the fermenting poi at room temperature, will probably be safe from infection.

The rate of disappearance of the pathogenic organisms from the souring poi is correlated with the accumulation of the products of fermentation in the poi. The rate of accumulation of these products obviously depends, in turn, upon the temperature of incubation and upon the number of microorganisms of the natural flora growing in the poi. Figures 1 and 2 show this relationship quite clearly for Eberthella typhosa. Similar curves were obtained for the other two test organisms. The increasing concentrations of the products of fermentation are reflected in changes in pH (as well as in other manifestations, like color, odor, consistency, etc.), and pH determinations offer the most convenient criterion for measuring the extent to which fermentation has progressed. It is not yet possible to say which products of growth of the microorganisms in the poi are responsible for the destruction of the pathogens. Perhaps it is merely the "hydrogen-ion concentration" achieving the "critical pH" of the early authors that accounts for the disappearance of the pathogens, or perhaps it is some more specific substance that acts upon them. The fact that the pH at which the pathogens last appear in the poi samples kept at refrigerator temperatures is measurably higher (that is, less acid) than is the pH at which they last appear in the poi samples incubated at room temperature, would suggest that nothing as simple as the hydrogen-ion concentration alone is the lethal agent, but that one or more of the products of growth must be liberated in sufficient quantities before the bactericidal effect can be achieved, or that, at least, the pathogenic organisms must be exposed for longer periods of time to lower concentrations of the products of growth which act against the bacteria. The numbers of pathogenic organisms introduced into the poi also have some significance, apparently; when very small inocula were used, the pathogens disappeared sooner than was the case with larger inocula.

In any event, the pathogens are destroyed, for attempts to reclaim them by dilution and plating in appropriate media and by subculturing in enrichment broths were uniformly unsuccessful.

A few secondary observations can also be drawn from the data obtained, and should be noted here. These tests showed that E. coli and A. aerogenes and other coliform organisms present in the natural inoculum of the poi can survive in the fermenting poi for longer periods than the observations of Allen and Allen indicate they did. In poi incubated at room temperature E. coli was still present at the end of four days; and it persisted in refrigerated poi for as long as fifteen days. In these investigations A. aerogenes and the other coliform organisms were found to be less hardy than E. coli, even though originally they may have outnumbered the E. coli cells added to the poi. (The great numbers of A. aerogenes and coliform organisms found in the earlier platings of all poi samples would suggest, too, that they play an important part in the initial stages of the fermentation.) E. coli survived the other members of the coli-aerogenes group by as much as five and six days at refrigerator temperature, and by two days at room temperature. When, after a few days, the Aerobacter and coliform organisms did die out, they disappeared almost overnight: they were plentiful in poi samples in which the fermentation process had achieved a pH of 4.0, but had disappeared completely twenty-four hours later, when the pH was 3.8 Even before they disappeared, the yeasts, mycoderms, and oidia had begun to supplant them.

Conclusion

In view of the results obtained in this series of investigations, it can be concluded that poi, if it should become contaminated with pathogenic organisms of the intestinal group, can serve, like other foods, as a vector in the epidemiology of the enteric diseases. Paradoxically, it is the poi which is stored most carefully, in that modern triumph of sanitation and preservation, the refrigerator, which is potentially the most dangerous agent, for the pathogens may persist for as long as eight days in refrigerated poi. Poi which is stored at room temperature succeeds in purifying itself within three days. Under the usual conditions in the home, then, the more sour the poi is—and the sooner it gets sour—the safer it will be to eat.

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Department of Agricultural and Resource Economics
3050 Maile Way • Gilmore Hall
Honolulu, Hawaii 96822

June 6, 1990

TO: To Those Interested in the Taro Industry

FROM: Jim Hollyer, Taro Project Coordinator

RE: Missing section of Taro Industry Analysis No. 4

Please find enclosed the middle section of the Industry Analysis which had been inadvertently left out of last weeks' package. Hope this hasn't caused any problems. Hope to see you on Friday, June 15, 1990 in Hilo.

cc: Ken Rohrbach

WORK SHEET NO. 4 - TARO INDUSTRY ANALYSIS 1990 - SECTION I

A. LAND

1. Analysis:

   a. Taro requires land with an ample supply of water for either paddy culture of wetland taro or irrigation of dryland taro.

   b. For dryland or upland taro, land must be relatively level with few stones. It should also have a deep soil profile and fine textured. Currently, wetland taro production is limited to the large rain-fed stream valleys such as Hanalei, Waioli, Waipa, Waimea, Wailua and Hanapepe Valleys on Kauai; Waipio Valley on Hawaii; Waihee, Wailua and Keanae Valleys on Maui; and Windward Oahu.

   c. On Maui, Keanae and Wailua Valleys will remain in taro production, although the area can be increased if more farmers, especially from Alu Like and other Hawaiian groups, are given lands to cultivate. The water delivery system needs to be improved and watershed cleared if more land is to be put into lowland taro production.

   d. On Oahu, high land prices, high lease costs and water shortages have discouraged large scale taro production. Upland taro production, of traditionally wetland varieties as well as others, on former sugar lands has started to show the feasibility of expanding into this type of production for the poi market. The relatively lower labor requirement of upland taro production will help encourage new taro farmers.

   e. Kauai provides the key for the expansion of the wetland taro industry. There are lands available in Hanalei Valley suitable for taro. The U.S. Fish and Wildlife Service has completed the irrigation project which has improved the water distribution system and opened up additional acres of taro land. The Hawaii Department of Land and Natural Resources has made repairs and maintenance of the water system in Waioli Valley and the Hawaiian farmers have opened up some taro lands in Waipa Valley for lowland taro production.

   f. Approximately 12 acres is a good economically feasible and labor efficient unit for a full time family taro farming. With proper mechanization, 25 acres is a good economical unit for a full time farmer.

2. Bottlenecks:

   Overall priority _____

   a. Existing State policies do not adequately protect suitable taro lands and water sources from being taken away for domestic and other use.

   (1) Impact if this bottleneck is (is not) eliminated:

(a) If existing farm lands are not kept in production and if more lands are not made available, the industry cannot expand when and if the demand for taro and taro products increases. If an objective evaluation of taro lands can be completed, the State and Counties will have the information needed to establish proper land and water use policies.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Evaluate current and potential taro production areas.

(b) Enforce State and County policies which protect the limited amount of lands where water suitable for taro production is found.

DLNR - Department of Land and Natural Resources DOA - Department of Agriculture CTAHR - College of Tropical Agriculture and Human Resources State LUC - State Land Use Commission

B. WATER

1. Analysis:

a. On average, taro requires approximately 0.2 inches (5,400 gallons) of water per acre per day for growth. To this amount, additional water is required to compensate for seepage and evaporation from the paddy. Additional water is also needed to adequately cool the paddy. Water requirements are higher in the summer, and water requirements vary with location and farm.

b. On Hawaii, the main problem of the Waipio Valley is flooding. The difficult road and poor accessibility of Waipio Valley is also a problem and is not conducive to the improvement of taro production on Hawaii.

c. Oahu farmers do not have enough water because their sources are being intercepted to provide domestic and irrigation water for other areas.

d. A study of the water availability and flood control requirements of major taro growing areas is needed.

e. On Maui, the water shed area is blocked and the irrigation ditches for Keanae and Wailua Valley are in need of repairs and clearing of debris, sand and gravel which are blocking the normal flow of water into the taro fields.

2. Bottlenecks:

Overall priority _____

a. Less than optimum distribution and control of water (flooding) in the important taro production areas.

(1) Impact if this bottleneck is (is not) eliminated:

(a) If the water distribution systems in taro production areas can be improved, existing areas can be made more productive and more areas can be used for taro production. Periodic floods and crop destruction can be eliminated with proper flood control measures.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Enforce the law on water rights to provide sufficient water in Waiahole Valley and other areas on Oahu for taro production.

(b) Develop a water system to provide sufficient water, especially in the summer, to allow the Wailua and Keanae Valleys on Maui to remain in taro production.

(c) Study the water distribution and control concerns of the important taro production areas so that the most important water related bottlenecks can be specified.

DLNR, City and County of Honolulu, County of Maui

C. CAPITAL

1. Analysis:

a. A full time farmer would need working capital in order to start. If land were purchased, this would be additional expense.

b. Income would be zero for the first two years and would not reach its potential until almost four years from the start.

D. LABOR

1. Analysis:

a. The taro industry needs young people to insure a future for taro in Hawaii. New young farmers need practical training to adequately prepare them for taro farming.

b. Mechanization of production and harvesting is needed to compensate for the labor problem.

c. Taro industry as well as agriculture in general, has to compete for labor and as more development takes place, labor will become limiting. Better management to insure maximum production will increase labor efficiency.

E. CULTIVARS

1. Analysis:

a. There are many different cultivars or varieties of taro available in various nurseries throughout the Pacific and Asia.

b. Over 130 varieties have been identified in the UH variety nursery, each with different characteristics. A comprehensive program to evaluate host resistance to diseases including Pythium soft rot, hard rot (guava seed), Phytophthora leaf blight under both upland and lowland conditions needs to be established.

c. Efforts to find varieties with high yields is continuing. A breeding program to develop varieties with the specific qualities and characteristics which meet the demands of processors and market outlets needs to be established.

2. Bottlenecks:

Overall priority _____

a. No comprehensive system to classify and index currently known varieties for disease and insect resistance, quality and yield.

b. No breeding program to develop new varieties with qualities such as longer shelf life, better chipping recovery, etc.

(1) Impact if this bottleneck is (is not) eliminated:

(a) If improved varieties are developed or found, taro farming can be made more profitable. Farmers will enjoy higher yields and less loss to pests and diseases. The market for fresh and processed taro can be expanded if varieties with longer shelf life are available.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Establish a program to breed, screen, classify, and index taro varieties for yield, resistance to diseases and insects, low acridity, optimal growth characteristics, high starch content (for poi), and acceptability for the fresh market.

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F. INSECT CONTROL

1. Analysis:

   a. Root aphids and mites on dryland taro can be major problems on the Island of Hawaii.

   b. Taro leafhopper (*Tarophagus proserpina*) is a serious taro pest but can be controlled with predators. Most of the farmers are satisfied with this control method. At times, it may be necessary to transfer or introduce the predators into leafhopper infested areas. There are no major uncontrollable insect pests of paddy taro at this time.

   c. There are no insecticides registered for use on taro at this time.

2. Bottlenecks:

   Overall priority _____

   a. Lack of effective controls for mites and root aphids which are pests in dryland taro production.

   (1) Impact if this bottleneck is (is not) eliminated:

      (a) Without effective control of taro root aphid, dryland taro yields can be reduced by as much as 75 percent.

   (2) Action required and agency responsible for eliminating this bottleneck:

      (a) Identify effective chemicals for controlling mites and root aphids.

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      (b) Register effective chemicals.

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      (c) Develop integrated pest management schemes for taro.

      CTAHR, DOA, Industry

G. DISEASE CONTROL

1. Analysis:

   a. Diseases which affect the corm are important in both wetland and dryland cultivation of taro.

   b. In wetland taro culture, the most serious corm diseases are Pythium soft rot and hard rot ("guava seed").

   c. The epidemiology of Pythium soft rot is not well understood. The environmental component of soft rot needs to be elucidated and incorporated into tests before the efficacy of fungicides may be reliably stated. Some varietal resistance to soft rot has been observed. Reduction of pathogen populations may be expected by a dry fallow of the paddy between crops.

   d. Hard rot (guava seed) is of unknown etiology and epidemiology. Control of this disease is difficult to study because of inability to reproduce it on demand.

   e. The corm diseases of dryland taro, although not well defined as those of the wetland crop, include black rot (*Ceratostomella fimbriata* and *Endoconidiophora* sp.), Southern wilt (*Sclerotium rolfsii*), Pythium root and corm rots (*Pythium aphanidermatum, P. splendens, P. myriotylum, Pythium* spp.), bacterial/fungal/nematode rot and others.

   f. Epidemiology and etiology of root and corm rots in dryland taro cultivation are not well known. They have not been studied intensively. Since impact on aquatic flora and fauna are minimal, fungicide identification and registration in the dryland crop should be more expeditious.

   g. Foliar diseases of taro are sometimes devastating. Corm yield and quality could be reduced and leaf yield could be drastically reduced by leaf diseases. High rainfall areas are vulnerable to great losses in a short time from diseases such as leaf blight (*Phytophthora colocasiae*) and leaf spot (*Phyllosticta colocasopphila*).

   h. Several chemicals will control foliar diseases most of the time. Work should be done to register chemicals for foliar disease control.

   i. Virus diseases do not appear to be a problem at present. The quarantine on taro from the Solomon Islands and Papua New Guinea will reduce the chances of alomae and bobone from entering Hawaii. Dasheen mosaic virus is wide spread in taro here. Yield loss resulting from dasheen mosaic virus infection of commercial cultivars is not known.

   j. Refrigerated shipping would probably reduce transit and storage rots. The cost benefit ratios of refrigerated shipping are not known.

2. Bottlenecks:

Overall priority _____

a. Lack of sufficient integrated control measures (biological, cultural and chemical) to control diseases.

(1) Impact if this bottleneck is (is not) eliminated:

(a) Both growers and processors will continue to suffer from insufficient and poor quality product.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Identify and quantify host resistance; identify and register effective chemicals and identify cultural practices for controlling Pythium root and corm rot, guava seed and other taro diseases.

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(b) Study etiology and epidemiology of root and corm rots with emphasis on Pythium root and corm rot and guava seed.

CTAHR

(c) Identify host resistance to Pythium soft rot and guava seed.

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(d) Determine the role of fertility and methods of fertilizer application on the incidence and severity of Pythium soft rot and guava seed.

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(e) Determine the role of herbicides and methods of herbicide application on the incidence and severity of Pythium soft rot and guava seed.

CTAHR

(f) Determine the role of fallow and sanitation on the incidence and severity of Pythium soft rot and guava seed.

CTAHR

(g) Determine the role of water management in the incidence and severity of Pythium soft rot and guava seed.

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(h) Determine the etiology of dryland taro corm rots.

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(i) Identify control points -- cultural, biological, chemical -- of dryland taro corm rots.

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(j) Determine the causal agents of storage and transit rots and the point of corm infection.

CTAHR

(k) Determine the role of cultural practices on the incidence of storage rots.

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H. WEED CONTROL

1. Analysis:

a. Preplant cultivation and paddy preparation are effective weed control measures.

b. Chemical control of weeds is possible, but no herbicide is registered at this time. The herbicide Goal is very promising and will be an effective chemical for weed control if properly applied.

c. Azolla as a ground cover is effective for weed control.

2. Bottlenecks:

Overall priority _____

a. Lack of effective control measures for weeds.

(1) Impact if this bottleneck is (is not) eliminated:

(a) Weed control is a major operation in taro production. The average cost of weed control amounts to 15 to 20 percent of the total cost of production. This cost increases with the increase in cost of labor.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Register herbicide for weed control in dryland and wetland taro production.

CTAHR

I. CULTURE AND MANAGEMENT

1. Analysis:

a. It is possible to harvest one crop of Chinese taro every 9 months with a net yield of 30,000 lbs/acre/crop, and _____ every ___ months with a net yield of _____ lbs/acre/crop. Luau leaves can be produced at the rate of 15,000 lbs/acre/crop.

b. Many farmers are satisfied with their current cultural practices. However, the farmers do not know what the optimum cultural practices are. Optimum water management for paddies need to be determined. Optimum practices of flooding and drying paddies need to be determined. Optimum fertilizer practices (through the irrigation system or broadcast application) need to be determined as well as the effect of paddy flooding or drying on fertilizer uptake and use.

c. There are some who feel that large future expansion of the industry will occur on dryland because more of this type of land is available and it is easier to mechanize dryland taro production. Under ideal conditions, dryland and paddy taro yields are about the same on a per month basis.

d. Taro responds to fertilizer and lime applications well and the need to develop techniques of predicting nutrient needs through plant and soil analysis should be given serious considerations. Taro requires fairly high levels of calcium also.

2. Bottlenecks:

Overall priority _____

a. Optimum water management for wetland and dryland taro production are unknown.

(1) Impact if this bottleneck is (is not) eliminated:

(a) If the water requirement of wetland and dryland taro are accurately known, farmers can make more efficient use of the available water. With better information on taro water requirements, government officials can make objective decisions on water use issue in taro production areas based on hard data.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Determine the optimum water management for wetland taro production in paddies.

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(b) Determine the optimum water requirement for dryland taro production.

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2. Bottlenecks:

Overall priority _____

a. Optimum fertilization and liming practices are unknown.

(1) Impact if this bottleneck is (is not) eliminated:

(a) If optimum fertilization and liming practices can be determined, some farmers will be able to increase their per acre production. Farmers who are over-fertilizing will be able to lower their cost of production.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Determine optimum fertilization and liming practices in wetland and dryland taro.

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(b) Determine optimum or critical levels of nutrients in dryland and wetland taro tissue.

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J. MECHANIZATION

1. Analysis:

a. Harvesting machinery must be developed. Several existing machines show promise, but some modifications are necessary.

b. A small and easy to handle tractor for the harvesting machinery is needed. A big 4-wheel tractor is difficult to get in and out of the paddies.

c. Mechanization for dryland taro production needs to be developed.

2. Bottlenecks:

Overall priority _____

a. Lack of machines that can be used in dryland taro production for leveling, huli planting, harvesting, etc.

(1) Impact if this bottleneck is (is not) eliminated:

(a) Many operations could be mechanized, thus leading to more productive labor and better management through operation scheduling if useful machines could be found or developed.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Evaluate and modify existing machines from mainland and foreign countries.

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2. Bottlenecks:

Overall priority _____

a. Inaccessibility of paddies to conventional machines and lack of sufficient traction in available machines for use in paddies.

(1) Impact if this bottleneck is (is not) eliminated:

(a) Farmers would be able to use wider selection of tractors if the traction of existing tractors can be improved or the accessibility of the paddies can be improved.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Examine ways to improve traction of tractors and accessibility of paddies to existing machines.

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2. Bottlenecks:

Overall priority _____

a. Lack of mechanical harvesting machinery.

(1) Impact if this bottleneck is (is not) eliminated:

(a) Since harvesting is currently up to 40 percent of the total time required in taro production, availability of mechanized harvesting system could make taro production more profitable.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Develop machines for mechanical harvesting upland and wetland taro.

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K. POST-HARVEST HANDLING AND PROCESSING

1. Analysis:

a. Hulis must be saved from harvested corms. Hulis must be selected according to vigor and corm quality.

b. Corm losses after harvest depend on the time of the year and the area the corms came from.

c. Corms can be stored for 3-4 weeks if the corms are refrigerated immediately after they are harvested. However, this is not economically feasible.

d. For poi sold in the Honolulu market, it is more economical to import the taro corm from the neighbor islands and do the processing on Oahu.

e. Surface transportation causes losses because of disease and dehydration.

2. Bottlenecks:

Overall priority _____

a. Surface transportation causes losses because of disease and dehydration.

(1) Impact if this bottleneck is (is not) eliminated:

(a) Losses of 50 to 100 percent occasionally occur during transportation of taro corms from the Neighbor Islands to Oahu. Better post-harvest handling and/or treatments can eliminate or reduce serious losses and deterioration of taro corms during shipment and storage. The U.S. Mainland market for taro corms cannot expand if better and proper handling techniques are not used to increase the shelf life and storage of taro corms from Hawaii.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Evaluate better post-harvest handling practices to reduce losses in transportation.

CTAHR, DOA, Industry

(b) Investigations of methods to increase post-harvest life to shipments from Hawaii to U.S. mainland.

CTAHR, DOA, Industry

L. MARKETING

1. Analysis:

a. There is potential for exporting fresh taro corms to the Mainland which needs to be developed.

b. The market for other uses of taro, especially taro chips, have become popular and there seems to be lack of raw materials to keep up with the demand.

c. College researchers have developed taro products that require market testing.

2. Bottlenecks:

Overall priority _____

a. Inadequate commercial market development for taro and taro products.

(1) Impact if this bottleneck is (is not) eliminated:

(a) Farmers may have problems marketing taro if supply exceeds demand. Farmers will not be able to expand production without causing an over supply or glut on the market.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Produce several new taro products at pilot plant level for test marketing.

CTAHR, DOA, Industry

(b) Develop new taro products such as breakfast food or energy food.

CTAHR, Industry

2. Bottlenecks:

Overall priority _____

a. Insufficient information on market potential.

(1) Impact if this bottleneck is (is not) eliminated:

(a) Farmers will continue to have problems in marketing taro. Farmers will not be able to expand production without causing an over supply or glut on the market.

(2) Action required and agency responsible for eliminating this bottleneck:

(a) Make an economic feasibility study of selected taro products.

CTAHR, DOA, Industry

(b) Launch a market promotion of taro products if found economically feasible and acceptable by consumers.

CTAHR, DOA, Industry

TARO INDUSTRY ANALYSIS NO. 4

PART I. The State of the Industry

for your careful review and comment

TARO INDUSTRY ANALYSIS NO. 4

Taro forms the basis or is an intricate part of many traditional diets worldwide. In its various forms, (e.g. baked, boiled, fried, whole or mashed) taro is a nutritious food consumed by millions of people everyday. According to the FAO Production Yearbook, 12.6 billion pounds of taro (*Colocasia*) were produced worldwide from 2,440,360 acres in 1987. Major producing areas are Africa (8 billion pounds), Asia (3.9 billion pounds), and Oceania (667 million pounds). Taro is the 14th most consumed vegetable on a world-wide basis.

A. The Taro Market in Hawaii: An Introduction

While there is some cross-over buying by consumers/processors, there are basically four somewhat distinct markets for taro in Hawaii: the dasheen, poi, Chinese, and Samoan markets. The dasheen, Japanese, or "sato imo" type taro (the small cormels are eaten, but the mother corm is usually not), is consumed cooked, but unprocessed, primarily by oriental consumers and is typically eaten as a side vegetable to a meal. The "poi taro" (produced under both dry and wet cultivation conditions), usually the Lehua variety for commercial usage, is more often than not processed and is the basis for two primary products: poi (the traditional Hawaiian pudding-like starch-staple) and kulolo (a equally traditional fudge-like confection). Raw corm-to-poi/kulolo processing facilities presently number about 12 State-wide. The market for poi taro products is typically the "local" population and the visitor industry as an introduction to traditional Hawaiian foods at staged luaus. Chinese taro is consumed in its cooked non-processed form; as an increasingly popular snack chip and in more traditional Chinese dim sum dishes, among others. Lastly, the Samoan taros (Niue [Samoan pink], Manu'a and Palagi) are consumed almost exclusively by the Samoan population in Hawaii and are very often eaten in a cooked whole form as a substantial part of a meal.

As each taro variety caters to a somewhat distinct clientele the demand for the product often varies throughout the year with the social activities of that clientele, for instance, the demand for Chinese taro may be higher around the time of the Chinese New Year as there are many Chinese rituals or celebrations observed at this time, with taro being an important ingredient in many foods.

The supply of each taro variety depends on a number of conditions. For example, poi taros are very susceptible to flooding conditions in the valleys where they are usually grown. Chinese taro availability is governed by the former condition, along with its own price, and (often) the price of ginger, i.e. as the price of ginger goes up, the supply of taro often goes down, as currently most Chinese taro farmers (located on the Big Island) grow the often more profitable ginger as well. In the case of dasheen, some 80 percent of local demand was meet by Hawaii farmers in 1989 (Hawaii Agricultural Statistics Service). *Dasheen will not be discussed further in this analysis.* Samoan taro demand is meet almost exclusively by Western Samoa and to a lesser extent by growers in American Samoa. The demand for these varieties of taro appears to be greater than supply during most of the year, in which case both poi taros and Chinese taros are consumed by the Samoans (and other Polynesian groups) living in Hawaii. Some other Polynesian groups, such as the Tongans, grow taro for their own needs in places such as the North Shore of Oahu. There does not appear to be a constraint on the production end in the Samoas, more that the available air-cargo space is very limited, and boat-shipped taro is often considered undesirable as the taro often arrives in less than marketable shape. The Samoan taro market in Hawaii must compete for the limited supply with the much larger Los Angeles market.

B. Market for Hawaii Grown Taro on the U.S. Mainland and Canada

Taro is consumed by various ethnic groups on North America; the primary type is the Chinese taro. The ethnic groups in the West Coast markets that eat Chinese taros include the Chinese, Vietnamese, Thais, Malaysians, Filipinos, and Laotians, among others. These people consume taro in much the same way as do their Asian counterparts in Hawaii. However, in the frozen section of the oriental markets in Los Angeles, nearly a dozen different processed taro-based products are available. These include taro bun, ice cream, ice bars, and tofu-like products. The major taro product that is consumed, however, is the corm itself. Major competitors in this market include the Dominican Republic, Costa Rica, Florida, and Brazil.

Fresh taro leaves and taro stems are marketed in Hawaii and on North America. Taro leaves are a traditional part of Hawaiian luaus as Laulau, are eaten by Samoans as Palusami, and the peoples of the Caribbean region consume taro leaves in various types of soups, e.g. Callaloo. Taro stems are commercially produced in green houses in California and are eaten by the Vietnamese and other Asian groups there. The Vietnamese use the stems in soups as well as in other dishes. Countries importing taro leaves to the U.S. in 1986 include Brazil, Dominican Republic, and Jamaica. It is unknown how much fresh and frozen taro leaves are shipped from Hawaii to North America.

II. CURRENT STATUS AND POTENTIAL OF THE TARO INDUSTRY IN HAWAII

Taro production in Hawaii is currently undergoing a metamorphosis which is begin driven by a combination of market signals and production conditions.. The areas traditionally used for the production of wetland taro are being cultivated less and less each year, while acreage slated for the production of taros under dryland conditions has increased over the same period (Table 1). Total taro production Statewide declined from 6.2 million pounds in 1988 to 6.0 million pounds in 1989. Despite the decrease in total production, the farmgate value (for the corms alone) increased slightly to $1,996,000 in 1989, up from $1,904,000 in 1988, due to the increased average farm price of taro per pound (Table 1) (Hawaii Agricultural Statistics Service, 1990).

Table 1. Acreage and Price of Hawaii Grown Taro in 1989 for the State

General Taro Type	Acres of Taro Commercially Grown in Hawaii	Percent and Direction of Change Over Year Previous	Farm Gate Price ($/lb)	Percent and Direction of Change Over Year Previous
Poi	290	-7%	$.285	+10%
Chinese	140	+21	$.401	+2%
Samoan	very little	n/a	$.790*	+ ??
TOTAL	430	+23		

Source: Hawaii Agricultural Statistics Service, 1990.

* This is the landed price in Hawaii: Farm Gate in Samoa + Air shipping, industry contact is source.

The Island of Kauai remained the largest overall producer of taro with 64 percent of the State's total production in 1989; nearly all of it of the wetland type. However, Kauai's 1989 production of all types of taro was only 4.16 million pounds; 250,000 pounds less than in 1988. The Big Island was the major force in Chinese taro production in 1989, with 130 acres under cultivation (Table 2). The other 3 major islands, very important in a regional sense, contributed less than 50 percent of the taros for the Statewide poi market and about 10 percent to Statewide Chinese taro supply.

Table 2. Acreage and Price of Hawaii Grown Taro in 1989 for the State and by Island

Area	Acres of Poi Taros Commercially Grown by Area	Percent and Direction of Change Over Year Previous	Acres of Chinese Taros Commercially Grown by Area	Percent and Direction of Change Over Year Previous
Kauai	180	-6%	[2]	[2]
Hawaii	35	-14	130	+23%
Maui/Molokai/Oahu	75	-7	10	0
STATE	290	-7	140	+21

Source: Hawaii Agricultural Statistics Service, 1990.
[2] Kauai combined with Maui, Molokai, and Oahu to avoid disclosure of individual operations.

Approximately 92 percent of taro corms produced in the State were processed into poi and taro chips. Most of the corms processed into poi were grown under wetland culture and those made into taro chips were grown under upland conditions. The *Honolulu Arrivals* for taro corms for chips increased from 289,000 pounds in 1988 to 560,000 pounds in 1989, an increase of 94 percent. Taro corms sold as fresh taro declined from 600,000 pounds to 500,000 pounds in that year (Hawaii Agricultural Statistics Service, 1990).

Foreign taro imports of 733,000 pounds, the most ever imported to Hawaii and mostly from Western Samoa, accounted for approximately 10 percent of the State's total taro supply in 1989 (Table 3). Imported taro corms were used mainly as table taro for the Samoans and other Polynesian groups.

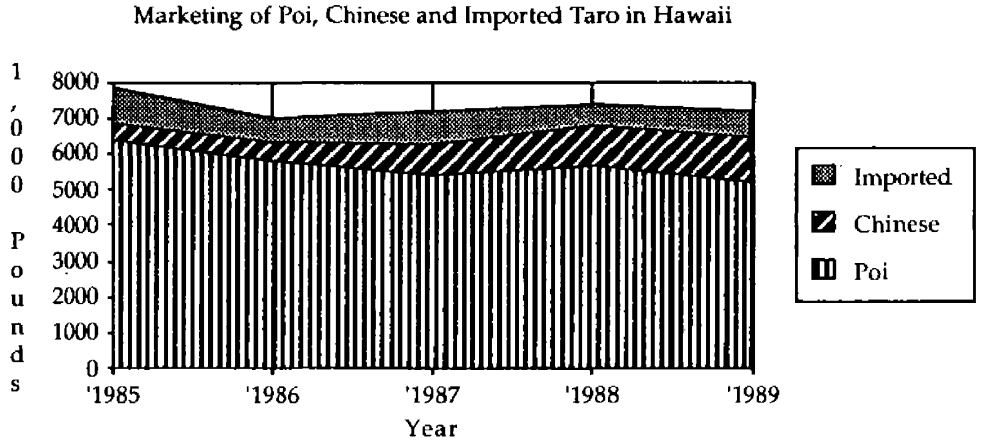
Table 3. Volume of Hawaii Grown Taro and Imports in 1989 for the State

General Taro Type	Amount Commercially Marketed in Hawaii (lb)	Amount Imported (lb)	Percent and Direction of Change Over Year Previous	Share of Hawaii Market 1989
Poi	5,270,000	0	-8%	73%
Chinese	1,230,000	0	+11	17
Samoan/	very little	733,000	+16	10

Source: Hawaii Agricultural Statistics Service, 1990 and per communication.

Looking at a 5-year trend, taro consumption in general is on the rise (Figure 1). While poi taros have decreased in usage, the Chinese and imported taros, the latter mainly from Western Samoa, are experiencing some growth due to the demand created by their specific markets.

Figure 1. A 5-Year Trend of Marketings of Poi, Chinese and Imported Taro in Hawaii



A. An Island by Island Perspective of Taro Production Conditions

Production possibilities for taro are a very island-specific, area-specific and input-specific phenomenon. For instance, in one area on one island, land and water may not be a problem, but the availability of affordable labor is (e.g. Hanalei Valley, Kauai). While in another, there are willing farmers, but little capital for inputs (e.g. Molokai). In still another, land and farmers are available, but the condition of the watershed area limits water flow (e.g. Keanae area, Maui).

Hanalei Valley on the Island of Kauai has maintained its position as the center of wetland taro production in the State. Improvements in the irrigation system by the U.S. Fish and Wildlife Service is continuing to benefit local farmers, however, the lack of readily available and affordable labor, due to increased competition for labor between agricultural and non-agricultural industries, has started to affect taro production in Kauai and elsewhere. Much of the lands made available in Hanalei Valley as a result of the irrigation project of the U.S. Department of Interior Fish and Wildlife Service are still unused. This represents a potential increase of 125 acres if farmers are able to put it into production. A portion of Bishop Estate lands in Waipa Valley, Kauai is being farmed, but much still remains unused. Repairs and maintenance of the Waioli Valley water system will also enable farmers to increase the production in that area.

Production of lowland taro in Waipio Valley on the Island of Hawaii has also continued to decline. Some taro farmers in the Waipio Valley who have traditionally grown wetland taros, have now started to plant Chinese taro for the luau leaves. The recurring floods in the area continue to make the production of lowland taro difficult, however, some of the previously established taro growers are starting to put some fields back into production. In the Hilo-Hamakua area, Chinese taro production is on the upswing. Limiting supply from that area is the concurrent growth of ginger.

The Island of Molokai has a great deal of farmable land, however, at the present time there is only a relatively small local demand for poi taros and only one poi miller. For this area to become a larger producer farmers will need to secure start-up capital.

On the Island of Maui, there is considerable acreage that can be used for lowland taro production if irrigation systems are improved. For instance, in the Keanae area the watershed is clogged with trees. In the West-Maui area, traditional wetland growing areas are being revived. In all some 200 additional acres of lowlands can be put into production.

As measured in acres, luau leaf is the dominant taro product on Oahu, with at least 4 major producers. Some lowland taro farms are slowly going into production on Oahu despite the increasing difficulty to keep lowland fields under continuously flooded conditions. Production of poi taro under upland conditions on Oahu is slowly gaining a foothold. *It is this method of production which could help ease the declining supply of poi taros for the poi market and change the face of the industry for a long time to come.*

B. Conclusions

Taro has a long and honored tradition in Hawaii as it has in many other parts of the world. Life style and population-mix changes; affecting markets, and increased competition for water, land, capital, and labor by both agricultural and non-agricultural enterprises; affecting production, has forced a change in the appearance of Hawaii's taro industry. A review of historical documents, including newspapers, reveals however, that these type of influences have always been a part of Hawaii's post-contact taro industry. The task at hand for today's taro farmers is to incorporate the impact of these changes into their current and future production and marketing plans. One example of where this is working is that of the increased planting of taro varieties (which here-to-fore were considered only to be "wetland" varieties), under dryland-irrigated conditions. By using this method it may be possible for the farmer to substitute capital (a scarce commodity) for labor (and

even scarcer commodity) in the form of mechanization. So too are the following methods for today's farmer to increase profits and remain competitive.

- The vertical integration of farm and processing facility
- The diversification of taro varieties and products
- Year-round crop availability
- The coordinative planning between producer and buyer
- The cooperative use of labor and equipment

Taro

Economic Fact Sheet # 1
June 1989

Department of Agricultural and Resource Economics
College of Tropical Agriculture and Human Resources
University of Hawaii

By
Kevin M. Yokoyama, James R. Hollyer,
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CROP PROFILE

SPECIES

- There is a great deal of confusion surrounding the taxonomy of taro. Taro (cocoyam) is often used as a collective term for the edible aroids, of note the genera *Colocasia* and *Xanthosoma*. According to one classification scheme, there are two major varieties of *C. esculenta*, var. *esculenta* and var. *antiquorum*. The dasheen of the West Indies (which is generally referred to as taro in the Pacific) is considered var. *esculenta*, and the eddoe of the West Indies (generally referred to as dasheen in the Pacific and in Asia) is var. *antiquorum*. *Xanthosoma*, a Hispanic staple, has a similar appearance to *Colocasia* and is often confused with taro. Some common names for *Xanthosoma* are tannia, malanga, and yautia.

- In Hawaii, important varieties of taro are Chinese (Bun Long), poi (usually Lehua Maoli), Samoan (Niue), and Japanese taro (dasheen or araimo). The first three are varieties of *C. esculenta* var. *esculenta*; the fourth is a variety of *C. esculenta* var. *antiquorum*.

PRODUCTIVITY

- Taro is often categorized by the location where it grows, i.e., in the wet lowlands or the drier uplands. Wetland taro is planted like rice, while dryland taro is cultivated similarly to corn. The number of pieces of planting material required per acre ranges from 8100 to 16,200.

- Most taros mature six to 10 months after planting.

- FAO's 1987 worldwide production statistics for *Colocasia* note an average yield of 5200 pounds per acre.

- In experimental trials in Hawaii, intercropping dryland taro with other plants, especially legumes, appears to increase taro corm yields.

- Major diseases and pests of taro include *Phytophthora* leaf blight, *Pythium* rot, dasheen mosaic virus, and nematodes. *Phytophthora*, for example, can destroy up to 30% of a crop's final yield, and Pythium is capable of destroying the entire crop.

USES AND PRODUCTS

- The taro plant is widely used in the Pacific Islands, Africa, Asia, the West Indies, and Central and South America. The taro corm is fried, roasted, baked, or boiled.

- Nutritionally, the taro corm is high in carbohydrates and potassium, but low in calories and sodium.

- Taro has hypoallergenic properties that may make it appealing for the manufacture of specialty items such as baby food. The small starch grains (1 to 4 μm) are easily digested by those with stomach ailments.

- Some popular uses of the corm include the production of poi. This traditional Hawaiian food is considered a good first cereal for infants, and is sold fresh, dried, and in airtight containers. Yield of poi ranges from 25 to 60% by weight, depending upon the quality of the corms.

- Taro leaves can be eaten like spinach and the shoots like asparagus. A half cup of cooked leaves contains 97% and 39% of the U.S. RDA of vitamins A and C, respectively.

- Taro flour production was investigated in Hawaii as early as the 1800s, but successful commerciali-

zation of this product has not yet occurred because of the availability of other inexpensive starches, e.g., cornstarch. The conversion yield of taro corm to flour is between 21 and 25%.

- Taro slices can be fried as chips. Approximately 30 pounds of chips can be made from 100 pounds of whole fresh taro. In Hawaii, Chinese taro is the preferred chipping variety because it can be fried without precooking, and the purple veins produce a unique-looking chip. However, due to the large and irregular shape of corms, large-scale production may be somewhat limited because of constraints in mechanization.

- In experimental trials, cooked taro packaged in airtight containers retained its original flavor and texture.

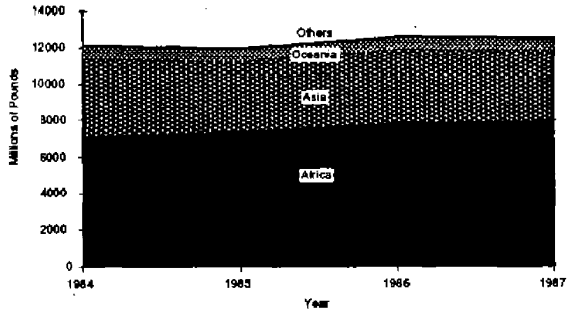
- Some other potential uses for taro corms include silage for animal feed, fabrication of cosmetics and plastics, and flavoring for ice cream.

WORLD SUPPLY AND DEMAND

TARO SUPPLY

- In 1987, 12.6 billion pounds of taro (*Colocasia*) were produced worldwide from 2,440,360 acres, according to the FAO Production Yearbook. Major producing regions are Africa (8 billion pounds), Asia (3.9 billion pounds), and Oceania (667 million pounds).

- In 1987, the countries of Oceania produced the following amounts, in millions of pounds: Papua New Guinea (411.4), Western Samoa (85.8), Tonga (66), Solomon Islands (52.8), Fiji (24.2), American Samoa (8.8), Kiribati (6.6), New Caledonia (6.6), Wallis (4.4), and Niue (2.2).



World Taro Production

TARO DEMAND

- Taro is consumed primarily in producing countries and is often the major dietary component.

- World trade statistics on taro are scarce because data are combined with those of other root and tuber crops. Limited information can be found under the Standard International Trade Classification (rev. 3) number 054.83.

U.S. MARKET

SUPPLY

- Domestic production of taro is limited, mostly to the states of California, Florida, and Hawaii. In 1988, the area under commercial cultivation was, in California, fewer than 20 acres of *Colocasia;* in Florida, 50 to 100 acres of *Colocasia* and 2000 acres of *Xanthosoma* ; and in Hawaii, 430 acres of *Colocasia.*

- In 1986, 47.4 million pounds of fresh, chilled, or frozen taro (dasheen and tannia, TSUSA number 1360000) were imported to the United States. Major suppliers were the Dominican Republic (41,767,636 pounds), Costa Rica (1,995,663 pounds), Jamaica (1,219,104 pounds), and Western Samoa (888,202 pounds), accounting for 97% of the total. (Effective in 1989, the Harmonized Tariff Schedule of the United States number 0714.90 replaces TSUSA number.)

- Some producing countries have high quality standards for export taro. For example, the Dominican Republic sizes the corms, then individually wraps them in paper, and ships in boxes.

- Hawaii ships Chinese taro to the U.S. Mainland. The corms are ungraded, unsized, and shipped in 50-pound bags. Hawaii-grown Japanese taro is graded, but little if any is exported.

- Fresh and cooked taro leaves are supplied by Hawaii and countries such as Brazil, the Dominican Republic, and Jamaica.

- In Los Angeles, the price of taro root from Hawaii was 50 to 80 cents per pound on February 1, 1989. Taro from Costa Rica and the Dominican Republic was 50 to 75 cents per pound. For latest market information, contact the Federal-State Market News Service in Honolulu, (808) 548-7161; Los Angeles, (213) 894-3077; San Francisco, (415) 556-5587; Seattle, (206) 764-3753; New York City, (212)

Concentration of Asians, Pacific Islanders, and Hispanics: Present and Potential Markets for Taro

542-2225; Chicago, (312) 353-0111; Miami, (305) 326-1254; and Houston, (214) 767-5375.

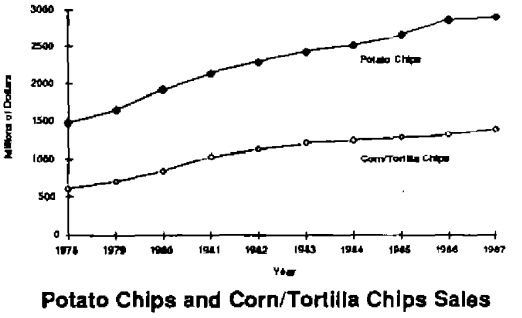
DEMAND

Corm and Leaf Market

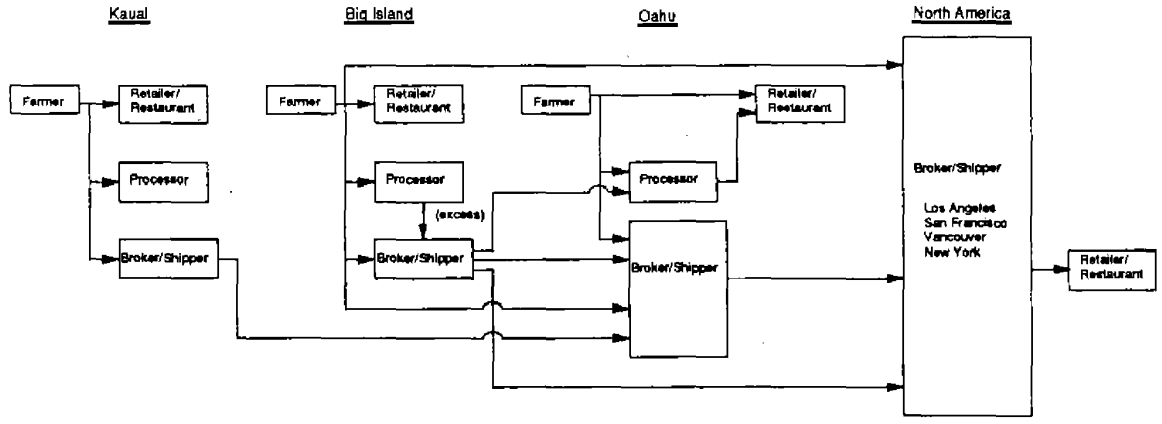
- Taro corms are a traditional part of the diet for many immigrants to the United States. Some Asian, Hispanic, and Pacific island people prepare and eat them like a potato. Others consume them in soups or as a complementary vegetable.
- In some Oceanic countries, the edible aroids are the most widely consumed starchy staple, followed by sweet potato, cassava, and yam. For example, in Western Samoa, the average daily per capita consumption of taro is 1 to 1.5 pounds.
- Asian, Hispanic, and Pacific islander populations are heavily concentrated in California, Florida, Illinois, and New York. These locations and others are present and potential markets for fresh and processed corms and leaves (see map).
- A produce industry magazine, The Packer, lists buyers of taro root in California, Florida, New York, and Canada.

Possibilities: Snack Chip Market

- Eighty-three percent of all Americans snacked in 1987, and the snack food market is increasing despite the new health-conscious attitude. Estimated sales in this industry have grown from $8.5 billion in 1978 to $25.2 billion in 1987, up 4.2% from the previous year.
- In 1987, potato chips accounted for 11.5% of the total snack food sales, while corn/tortilla chips accounted for 5.6% of the market.
- Frito-Lay accounted for 33% of the $2.9 billion potato chip market in 1987. Borden, Inc., sales were estimated at $375 million. Other major manufactures include American Brand, Eagle Snacks Division, Suncoa (Food Product) Division, and Heileman Baking Division.
- Chips are also made from various species of taro. For instance, in Western Samoa chips are made from *Xanthosoma*, while chips in Hawaii are made from *Colocasia*. Presently, there are five taro chippers in Hawaii.
- There is a potential for taro chips in the traditional chip market as well as in the novelty, upscale, and ethnic submarkets. Some examples are sweetpotato chips manufactured by Yammers (IHB Inc.) and Zapp's, and rainbow-colored potato chips marketed by Chips & Dips by Eula. Ethnic snacks include yucca, plantain, and cassava chips.



Potato Chips and Corn/Tortilla Chips Sales



Distribution Channels for Fresh Chinese Taro Corms in Hawaii

Possibilities: Baby Food Market

- Retail sales of baby foods in 1987 amounted to $2.2 billion. Of this, cereals and vegetables accounted for 8% of the market, or $16 million. Because taro is also a nutritious vegetable, it may be able to capture some of this valuable market.

- Up to 20 percent of the infants in the United States are said to be allergic to standard baby food made with eggs, milk, and cereals. Therefore, taro-based products, such as poi, may have a potential to satisfy some of this demand. Currently, there are 13 poi processors in Hawaii.

- Gerber Products Company had about 70% of the baby food market share in 1988. Other major manufactures of baby foods include Beech-Nut Nutrition, and Heinz. The Thomas Grocery Register lists specialty baby food producers including Loma Linda Foods, Mead Johnson Laboratories, and Health Valley Natural Foods.

TARO IN HAWAII

- In 1988, there were 153 farms planting 420 acres of Chinese and poi taro in Hawaii. Total value for these two crops was $1.9 million for the 6.8 million pounds harvested. An unknown number of farms planted 10 acres of Japanese taro in the same year, valued at $147,000.

- Eighty farms grew the Chinese variety on approximately 110 acres. The value of the 1.1 million pounds produced was $433,000. The average statewide farm gate price for taro used in chipping and table consumption was 39 cents per pound. Typically, the higher quality table taro received 5 cents more per pound than did chipping taro.

- Chinese taro can be harvested in six to 12 months, poi taro in 12 to 18 months, and Japanese taro in seven to 10 months. The yields range from 8000 to 20,000 pounds per acre, 24,000 to 32,000 pounds per acre, and 20,000 to 25,000 pounds per acre, respectively.

- Nearly 50% of the Chinese taro was used for chip manufacture in 1988. The Big Island produced about 90% of this variety.

- Taro for poi was produced on 310 acres on 75 farms in 1988. The 5.7 million pounds were valued at approximately $1.5 million, for an average farm gate price of 26.9 cents per pound. Sixty-one percent of the taro used for poi making was grown on Kauai.

- Hawaii consistently imports more taro for the fresh market than it produces. In 1988, Hawaii imported 615,000 pounds of fresh taro (*C. esculenta* var. *esculenta* Niue), accounting for 51% of the total supply. Major suppliers included American and Western Samoa, the latter accounting for the greater percentage. Sixteen percent of the total market supply of Japanese taro (43,000 pounds) was also imported in the same year.

- Hawaii exports taro primarily to the Los Angeles and San Francisco markets. Wholesalers on the West Coast cater to restaurants and retail outlets.

TARO INDUSTRY ANALYSIS NO. 4

PART II. The Worksheet

for your careful review and comment

June 1, 1990

Taro Industry Analysis No. 4 - Taro Worksheet

Land

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources Required	Resources Allocated	Resources Supplement Source	Impact if bottleneck not eliminated
	Existing State policies do not adequately protect lands suitable for taro production and water sources from being taken away for domestic and other use.	(a). Evaluate current and potential taro production areas. (b). Enforce State and County policies which protect the limited amount of lands where water suitable for taro production is found.	DLNR[1] DOA[2] CTAHR[3] LUC[4]						If existing farm lands are not kept in production or if more lands are not made available, the industry cannot expand when and if the demand for taro and taro products increases. If an objective evaluation of lands suitable for taro production can be completed, the State and Counties will have the information needed to establish proper land and water use policies.

1 Dept. of Land and Natural Resources

3 College of Tropical Agriculture and Human Resources

Water

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources Required	Resources Allocated	Resources Supplement Source	Impact if bottleneck not eliminated
	Less than optimum distribution and control of water (flooding) in the important taro production areas.	(a). Enforce the law on water rights to provide sufficient water in Waiahole Valley and other areas on Oahu for taro production. (b). Develop a water system to provide sufficient water, especially in the summer, to allow the Wailua and Keanae Valleys on Maui to remain in taro production. (c). Study the water distribution and control concerns of the important taro production areas so that the most important water related bottlenecks can be specified.	DLNR City and County of Honolulu County of Maui	Good					If the water distribution systems in taro production areas can be improved, existing areas can be made more productive and more areas can be used for taro production. Periodic floods and crop destruction can be eliminated with proper flood control measures.

Diseases

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
	No comprehensive system to classify and index currently known varieties for disease and insect resistance, quality and yield. No breeding program to develop new varieties with qualities such as longer shelf life, better chipping recovery, etc.	(a). Establish a program to breed, screen, classify, and index taro varieties for yield, resistance to diseases and insects, low acridity, optimal growth characteristics, high starch content (for poi), and acceptability for the fresh market.	CTAHR	Good	3-5 years				If improved varieties are developed or found, taro farming can be made more profitable. Farmers will enjoy higher yields and less loss to pests and diseases. The market for fresh and processed taro can be expanded if varieties with longer shelf life are available.

Pest Control

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
	Lack of effective controls for mites and root aphids which are pests in dryland taro production.	(a). Identify effective chemicals for controlling mites and root aphids.	CTAHR Industry	Fair to Good	2-5 years				Without effective control of taro root aphid, dryland taro yields can be reduced by as much as 75 percent.
		(b). Register effective chemicals	CTAHR DOA Industry	Unknown					
		(c). Develop integrated pest management schemes for taro.	CTAHR DOA Industry						

Diseases

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
	Lack of sufficient integrated control measures (biological, cultural and chemical) to control diseases.	(a). Identify and quantify host resistance; identify and register effective chemicals and identify cultural practices for controlling Pythium root and corm rot, guava seed and other taro diseases.	CTAHR	Good	3 years				Growers will continue to produce less than optimum corms, which will in turn affect processors.
		(b). Study etiology and epidemiology of root and corm rots with emphasis on Pythium corm rot, and guava seed.	CTAHR	Good	3 years				
		(c). Identify host resistance to Pythium soft rot and guava seed.	CTAHR	Good	3 years				
		(d). Determine the role of fertility and methods of fertilizer application on the incidence and severity of Pythium soft rot and guava seed.	CTAHR	Good	3 years				
		(e). Determine the role of herbicides and methods of herbicide application on the incidence and severity of Pythium soft rot and guava seed.	CTAHR	Good	3 years				
		(f). Determine the role of fallow and sanitation on the incidence and severity of Pythium soft rot and guava seed.	CTAHR	Fair	6 years				

(continued)

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
		(g). Determine the role of water management in the incidence and severity of Pythium soft rot and guava seed.	CTAHR	Good	3 years				
		(h). Determine the etiology of dryland taro corm rots.	CTAHR	Excellent	3 years				
		(i). Identify control points - cultural, biological, chemical - of dryland taro corm rots.	CTAHR	Excellent	3 years				
		(j). Determine the causal agents of storage and transit rots and the point of corm infection.	CTAHR	Good	3 years				
		(k). Determine the role of cultural practices on the incidence of storage rots.	CTAHR	Fair	3 years				

Weed Control

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
	Lack of effective control measures for weeds	(a). Register herbicide for weed control in dryland and wetland taro production	CIAHR	Good	2-3 years				Weed control is a major consideration in taro production. The average cost of weed control amounts to 15 to 20% of the total cost of production. This cost increases with an increase in the cost of labor.

Water and Fertilization

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
	Optimum water management for wetland and dryland taro production are unknown.	(a). Determine the optimum water management for wetland taro production in paddies.	CTAHR	Good	2-3 years				If the water requirements of wetland and dryland taro are accurately known, farmers can make more efficient use of the available water. With better information on taro water requirements, government officials can make objective decisions on water use issues in taro production areas based on hard data.
		(b). Determine the optimum water requirement for dryland taro production	CTAHR	Good	2-3 years				
	Optimum fertilization and liming practices are unknown	(a). Determine optimum fertilization and liming practices in wetland and dryland taro	CTAHR	Good	2-3 years (GACC funded project in progress)				If optimum fertilization and liming practices can be determined, some farmers will be able to increase their per acre production. Farmers who are over-fertilizing will be able to lower their cost of production.
		(b). Determine optimum or critical levels of nutrients in dryland and wetland taro tissue.	CTAHR						

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
	Lack of machines that can be used in dryland taro production for leveling, huti planting, harvesting, etc.	(a). Evaluate and modify existing machines from mainland and foreign contries.	CTAHR Industry	Good					Many operations could be mechanized, thus leading to more productive labor and better management through operation scheduling if useful machines could be found or developed.
	Inaccessibility of paddies to conventional machines and lack of sufficient traction in available machines for use in paddies.	(a). Examine ways to improve traction of tractors and accessibility of paddies to existing machines	CTAHR Industry	Good					Farmers would be able to use wider selection of tractors if the traction of existing tractors can be improved or the accessibility of the paddies can be improved.
	Lack of mechanical harvesting machinery	(a). Develop machines for mechanical harvesting of upland and wetland taro.	CTAHR Industry						Since harvesting is currently up to 40% of the total time required in taro production, availability of mechanized harvesting systems could make taro production more profitable.

Post Harvest

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
	Surface transportation causes losses because of disease and dehydration.	(a). Evaluate and implement better post-harvest handling practices to reduce losses in transportation.	CTAHR Industry DOA						Losses of 50 - 100% occasionally occur during transportation of taro corms from the Neighbor Islands to Oahu. Better post-harvest handling and/or treatments can eliminate or reduce serious losses and deterioration of taro corms during during shipment and storage. The U.S. Mainland market for taro corms cannot expand if better and proper handling techniques are not used to increase the shelf life and storage of taro corms from Hawaii.
		(b). Investigations of methods to increase post-harvest shelf-life to shipments from Hawaii to U.S. mainland.	CTAHR Industry DOA						

Marketing

Priority	Bottleneck	Action Required	Agency Responsible	Possibility of Success	Duration	Resources			Impact if bottleneck not eliminated
						Required	Allocated	Supplement Source	
	Inadequate commercial market development for taro and taro products.	(a). Produce several new taro products at a pilot plant level for test marketing.	CTAHR Industry DOA	Good	2 years				Farmers will not be able to expand production without causing an over supply or glut on the market.
		(b). Develop new taro products such as breakfast food or energy food.	CTAHR Industry	Good					
	Insufficient information on market potential	(a). Perform an economic feasibility study of selected taro products.	CTAHR Industry DOA	Good					Farmers will not be able to expand production without causing an over supply or glut on the market
		(b). Launch a market promotion of taro products if found economically feasible and acceptable by consumers.	CTAHR Industry DOA						