

PROCESSING
AND CHEMICAL INVESTIGATIONS
OF TARO

by

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HAWAII AGRICULTURAL
EXPERIMENT STATION
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HONOLULU, T. H.
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PREFACE

In 1935 the sum of \$410,000 of sugar-processing-tax funds was made available to the Hawaii Agricultural Experiment Station by the Secretary of Agriculture, with the approval of the President, for a series of investigations in connection with diversified agriculture in the Territory of Hawaii. Of this sum (which was continued available until expended by the Supplemental Appropriations Act, fiscal year 1936), \$13,000 was assigned to the taro-processing project for the purpose of investigating the utilization of taro in various food products other than the native poi, and a processing laboratory was consequently set up for this study. This bulletin describes the results of the investigation as conducted over an 18-month period, beginning on September 1, 1935.

Note: [REDACTED]

[REDACTED]; Mr. Ley resigned as of April 9, 1937, and Mr. Akau, as of October 27, 1936.

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SUMMARY

An extensive investigation of the processing of taro into various food products has been conducted, with semi-commercial-scale laboratory equipment. The principal results of this investigation are summarized as follows:

1. Taro can be converted into flour by a process involving cooking, peeling, grinding, refrigeration, drying, and milling.
2. Taro flour can be substituted for 15 to 20 percent of wheat flour in a wide variety of baked goods, with an increase in yield due to higher absorption and improved keeping qualities of the baked product due to the higher moisture content.
3. A beverage powder can be prepared from cooked taro by incorporation of flavoring and sweetening agents, followed by drum drying. The beverage powder mixes readily with milk and water and is considered highly palatable.
4. Taro can be utilized successfully in the preparation of various types of breakfast foods, such as grits, shreds, and flakes. The process of manufacture involves cooking, flavoring, drying, and toasting.
5. Taro food products have been shown to be of value in preparing diets for wheat-allergy cases.
6. Taro can be canned as a substitute for potatoes or other starchy crops.
7. Complete chemical analyses of two wetland and two upland varieties of taro have been made.
8. Public service patents No. 2,105,977 and No. 2,108,897 have been issued by the U. S. Patent Office as a result of the investigations. Patent No. 2,105,977 covers a process of refrigeration of cooked taro to facilitate drying; No. 2,108,897 covers a process of roasting taro cereals. Both patents have been dedicated to the free use of the people of the United States.

INTRODUCTION

Taro [*Colocasia esculenta* (L.) Schott] is an important food crop in widely extended tropical and subtropical regions. Approximately 300 horticultural forms (4),¹ divided among 9 botanical varieties (13), are known by various common names all over the world. The variety *typica* (see cover and fig. 1) includes the many Polynesian forms, of which about 80 have recently been identified as present in Hawaii (23).

Taro is one of the oldest of cultivated crops. It appeared in Chinese literature as early as 100 B.C. and has been grown in Egypt since before the time of Pliny (23-79 A.D.), who, according to Young (27), mentions it as one of the established food plants of the country. It is a staple food in such widespread regions as Syria, India, China, Japan, East and West Indies, South and Central America, and most of the island groups of the Pacific. In 1905, states Young (28), the dasheen (var. *globulifera*) was introduced into continental United States from Puerto Rico for cultural experiments, and has been grown successfully in Florida and other parts of the southern United States since 1913, at which time seed tubers were distributed by the U.S. Department of Agriculture on a broad scale (3, 25, 26).

In most parts of the world taro is cooked and eaten in much the same manner as the potato or the sweetpotato. In Hawaii and other Polynesian island groups, it is commonly eaten in the form of poi—a food prepared by pounding or grinding the cooked taro corms, mixing the mash with water, and allowing it to ferment (17, 18, 19). Only certain forms appear to be adapted to poi, however. The process of poi manufacture, with special emphasis upon its fermentation, has been investigated by Allen and Allen (1), while Bilger and Young (5) report analyses of poi at various stages in the fermentation.

The corms and leaves of practically all taro varieties cannot be eaten raw because of the extreme irritation produced in the mouth and throat. The hands are likewise affected when the raw taro is peeled or sliced. This irritation has been shown to be due to the presence of bundles of needlelike crystals of calcium oxalate called

¹ Reference is made by number (*italic*) to Literature Cited, p. 34.



FIGURE 1.—The taro corm (variety *Piialii*), the portion of the plant used in preparing poi, taro flour, et cetera.

raphides (6, 21, 24). "These raphides are enclosed in what appears to be an elongated transparent capsule filled with mucilage. The capsules are situated in the partition wall between two vacuoles, their ends projecting into the adjacent vacuoles." The vacuoles fill with water when crushed by chewing or by artificial maceration, and as the water passes through the capsule walls the pressure is increased so that the needles are ejected with considerable force. The irritation is therefore caused by mechanical means. According to Stafford (21), Peddler and Worden found that treatment with boiling water, dilute nitric acid, or dilute hydrochloric acid, or drying destroyed the irritating effect.

Some varieties of taro are remarkably free from irritation. Most common of these are the Hawaiian *Mana Keokeo* and a Chinese variety *Iliuaua*, which may be eaten raw without injury.

The poor keeping qualities of poi, and to a lesser extent its appearance and texture, have led to numerous attempts in Hawaii to prepare other foodstuffs from the taro corm.

As early as 1823 missionaries experimented with the manufacture of taro flour by sun drying the scraped taro and grinding it in a handmill (9). It is interesting to note their comment that taro in this state was sometimes found to be improved. In the Archives of Hawaii for the year 1852 is a patent application by Dr. Fricke of Honolulu for a process for preserving taro by sun drying. The patent was refused on the ground that the process had been used since time immemorial.

In 1874, Charles Alden of Wailuku, Maui, received a patent on a process for preserving fruits and vegetables, including taro. The Alden process involved drying in "furnaces." In 1883, F. H. Enders, also of Wailuku, was issued a patent for the manufacture of taro flour. Three years later Patents No. 38 and 39 of the Kingdom of Hawaii, covering the manufacture of taro flour, were issued to A. Bielenberg and A. Barnes of Wailuku. The method involved grinding the taro, dried by the Alden process, into a flour which could be converted into poi by cooking. Thrum's Annual (22) in 1887 mentions the process as follows:

"All honor is due to Alden Fruit and Taro Company of Wailuku in their preparation of so valuable a product as their taro flour in a condition that not only keeps for any length of time, in any climate, but can be, and is, made serviceable in parts of the islands where taro itself is unobtainable . . . It is becoming a favorite article of household supply and has the recommendation of the entire medical faculty of Honolulu, for the sick room. In its present shape its cheapness also commends it for the use of hotels, plantations, *etc.*"

King Kalakaua was vitally interested in the possibilities of taro flour. In October 1886 an act (11) was passed by the Legislative Assembly of the Hawaiian Islands and signed by Kalakaua, authorizing the Minister of Finance to pay the Alden Fruit and Taro Company "the sum of twenty dollars for each ton of Taro Flour that may be manufactured and exported and sold abroad by it from this kingdom for the term of three years . . ." In September 1888 another act (12) "to encourage the production and sale of taro flour and other products of taro" was signed by Kalakaua. This act authorized the Minister of Finance (Mr. L. A. Thurston) with the approval of the cabinet to pay from time to time "sums not to exceed in all \$5000 for the purpose of defraying the actual expenses incurred in attempting to introduce taro flour and other products of taro into foreign markets."

Various products were prepared from the taro flour. Thus in 1888 Patent Number 90 was issued to E. H. Bailey of Wailuku for an improved process for the manufacture of macaroni and crackers from taro flour.

The manufacture of taro flour was carried on intermittently by the Alden Company, and in continental United States a market was

established for the flour under the name of Taro-Ena. A dried taro meal product, Mi-O-Na, was marketed in the mainland United States at the turn of the century. In 1903, according to the Pacific Commercial Advertiser, the Territorial Board of Health voted down the proposal to substitute taro flour for poi as the staple food of the Molokai leper settlement.

Apparently the taro-flour industry at that time was not a profitable enterprise, for in the Pacific Commercial Advertiser for October 18, 1907 is an account entitled "Losing Game for Twenty Years," describing how numerous people had lost considerable sums of money in the Alden Fruit and Taro Company and its successors. A Dr. Wile of Connecticut is said to have spent some \$60,000 in undertaking to acquaint the American people with "nature's food," while King Kalakaua lost \$6,000 in the business.

Some years later the taro-flour industry was revived by the establishment of a company manufacturing a product called Taro Mano. At the Southwest Pacific Exposition at Long Beach, California, in 1928, this product was awarded a diploma and a silver medal. At that time the value of this "powdered poi" for sufferers of various stomach and intestinal complaints was widely heralded. It was predicted in the Honolulu Advertiser that it would be only a question of time until the product would be well known on the American table. The Taro Mano Company operated for only a short time, however.

Since 1928 several individuals in Hawaii have been interested in taro flour and have prepared it in small quantities. In continental United States the possibility of developing a dasheen-flour industry has been considered at various times (16, 28). No doubt similar enterprises have appeared in other parts of the world. Most of the attempts have been too far from the source of supply however.

Taro is said to be unsuitable for the manufacture of starch due to the small grain size. MacCaughey and Emerson (19) give the diameter as from $1/25,000$ to $3/25,000$ of an inch. This small size and the mucilaginous character of the juice (28) make the separation of the starch not commercially possible by any ordinary process. Young (27) states that the dasheen starch separated experimentally had value as a sizing for textiles.

TARO PROCESSING

In order to investigate methods of processing taro, small-scale commercial equipment (see fig. 2) was procured for carrying out the following operations: Cooking, grinding, drying, milling, mixing, and baking. The basic process studied was the manufacture of taro flour, but the processing of cooked taro into various other food products was also investigated.

Manufacture of Taro Flour

Cooking the Taro

Since practically all varieties of taro when eaten are irritating to the mucous membranes of the mouth and throat, the manufacture of taro food products must, at some stage, involve cooking. The procedure employed by Hawaiian poi factories is undoubtedly an evolution of the primitive method of cooking foods in an *imu*, or pit, in which the heat from preheated stones is effectively retained by a well-packed covering of damp earth. In the poi factories the taro, covered with several thicknesses of burlap sacks, is loaded into wooden vats with slotted bottoms. Water is boiled in open pans under the vats, and cooking is accomplished by the hot vapor which gradually penetrates the mass of taro. The time required is about 4 hours.

The conditions described above were reproduced experimentally with a steam-jacketed iron kettle containing sufficient water to develop steam within the kettle at atmospheric pressure. Under these conditions the time required for proper cooking was likewise found to be about 4 hours.

Pressure-cooking investigations were conducted in a vertical retort. Steam was supplied at both the top and the bottom of the retort in order to insure rapid, uniform distribution of heat, and the condensate was continuously removed by means of a steam trap. The pressure applied was held constant throughout each test but varied among individual runs from 13 to 17 pounds. The time allowed for cooking varied from 45 minutes to 2 hours.

Contrary to popular belief, it was ascertained that taro could be uniformly and well cooked under pressure, within the range used. The time required varied with the size, texture, and variety of the corms, with an average time of about 1 hour. Occasionally very



FIGURE 2.—*Semi-commercial-scale laboratory set up for taro-processing studies.*

large corms required 90 minutes to be cooked thoroughly at the center and be nonirritating.

In commercial practice taro is never peeled before cooking, due to the fact that the fibrous outer skin is much more easily removed from the corm after cooking. This practice was followed in most of the laboratory operations. In the poi factories, taro is cooked without any washing other than the field washing which all taro receives before being put into bags. Washing and partial trimming prior to cooking were undertaken in some of the laboratory tests, but these preliminary operations were found to present no advantages and were accordingly discontinued. The cooked taro, after being allowed to cool to facilitate handling, was peeled, trimmed, and washed. Trimming consists of removing bruised, diseased, and decayed portions of the corms, as well as any remaining small particles of skin.

Records were compiled on a total of 96 lots, including 30 varieties of both upland and wetland taro and covering both atmospheric and pressure cooking. The average yield of sound, cooked material, available for processing into flour or other products, is given below.

	<i>Percent</i>
Raw taro as received	100.0
Raw taro, washed and partly trimmed	91.3
Cooked taro	92.1
Cooked taro after peeling	70.7
Cooked taro, peeled and fully trimmed	61.4
Dried cooked taro (average moisture content, 11.1 percent)	23.8

Grinding

After cooking and peeling, the taro may be ground into *paiai*¹ by means of a low-speed attrition mill (175 to 250 R.P.M.). Special design of the plates is necessary to prevent overheating and subsequent stickiness.

Refrigeration

Cooked taro, *paiai*, and poi are characterized by their sticky, viscous nature. This stickiness has always been a major obstacle in the processing of taro. Hand slicing is slow and difficult, due to the fact that the slices stick together. Cooked taro, either sliced or ground, clings tenaciously to the trays in which it is placed for drying. Furthermore, drying tends to take place only on the surface and not throughout the mass, so that a sort of case-hardening results. This hard, dry, outer coating causes drying to be exceedingly slow and uneven. Likewise, when the material is thoroughly dry, it becomes hard and brittle and hence difficult to mill. The dried product is always unevenly colored, being darkest on the surfaces that are most exposed.

A study of methods of decreasing the viscosity revealed that refrigeration brings about a hardening or setting of the material with resultant complete loss of stickiness. The change is purely physical, and freezing is unnecessary. The refrigerated corm, *paiai*, or poi is firm and can be cut readily with a knife. The material can be reduced mechanically into thin slices, shreds, or crumbs. The resulting smaller aggregates show no tendency to stick together and feel dry to the touch.

Conditions for refrigeration vary to some extent with the nature of the taro. The average optimum temperature was found to be 36° F., maintained for 36 hours. Lower temperatures are unnecessary, although lowering the temperature below 36° did decrease the setting time. Material maintained at 25° F. set completely in 24 hours. The highest temperatures at which satisfactory setting took place occurred between 43° and 46° F., and at these temperatures the time of setting was longer.

Rapid freezing did not bring about setting, as shown by the fact that material rapidly frozen and kept frozen for 4 hours returned to the viscous state on thawing.

¹ *Paiai* is the ground, cooked taro corm with the addition of very little or no water. Poi is made by diluting *paiai* with water and allowing it to ferment.



FIGURE 3.—*Shredding refrigerated taro prior to drying. Note the firm texture of the unshredded material, and the discrete character of the shreds.*

The refrigerated cooked taro not only can be handled and reduced with ease (see fig. 3), but can be dried uniformly without case-hardening and discoloration. The crumbly and somewhat flaky texture allows circulation of air through the material, resulting in rapid and readily controlled drying.

Refrigeration is so vital a step in the processing of taro that the essentials of the process have been covered by United States Patent Number 2,105,977, issued to the authors and assigned to the people of the United States for free use.

Laboratory investigation showed that the setting is due to pectization of the taro starch. Partial hydrolysis of the starch by malt was found to prevent setting entirely. Removal of the proteins in the taro by hydrolysis with the enzyme papain had no effect upon the setting.

Drying

Three methods of drying were employed during the course of investigations in this field. These consisted of: (1) Tray drying in a current of suitably conditioned air at atmospheric pressure; (2) drum drying, also at atmospheric pressure; and (3) spray drying.

It was found that, under atmospheric conditions, taro could be dehydrated satisfactorily without impairing flavor or color, and without appreciable change in chemical composition. Hence it was deemed unnecessary to carry on investigations under reduced pressures.

Tray Drying. The first steps in the preparation of taro for drying consist of cooking and peeling, as already described. At this point the peeled corms may be either refrigerated, or ground into *paiai* prior to refrigeration. The most economical procedure was found to be conversion into *paiai*, refrigeration, and subsequent shredding of the solidified material. For small quantities a hand shredder may be used, while for handling larger amounts practically any commercial mechanical shredder is satisfactory. Although it is obvious that smaller shreds will present a greater surface to the air, the size of the shreds was found to be only a minor factor in the rate of drying.

Data on tray drying were obtained by the use of an insulated cabinet through which heated air was circulated (see fig. 4). The feed air was heated by thermostatically controlled electric feeder strips, and the supply of relief, or fresh, air was controllable within any limits.

In a total of 82 runs, the following factors were varied singly and in combination to observe their effects on the dried material: Total charge of wet material; temperature, velocity, and humidity of drying air; percentage of relief air admitted; and heat supply and time of run. The conditions must be varied considerably with the type of material being dried; however, from the data obtained on these runs, the following conclusions may be drawn:

Drying temperature. During the first hour the temperature should not rise above 145° F., since higher temperatures produce matting and retardation in drying. After the first hour the temperature of the incoming air can be varied between 140° and 190° without changing the character of the material appreciably.

Humidity. The relative humidity of the working air within the cabinet may be varied from 20 to 50 percent.

Time of drying. The total time of drying ranged from 4.5 to 13 hours, depending upon conditions established during the run and the initial and final moisture contents of the material. The rate of diffusion of moisture through the material imposed the minimum time limit. The character of the dried material showed no perceptible difference within this range in time of drying.

Heat supply. The heat required to produce 1 pound of dry material (average moisture, 9.6%) varied from 1.3 to 2.4 kilowatt hours, depending upon the conditions of the run.

Data on 10 representative runs are given in table 1.

Table 1.—Tray drying of refrigerated cooked taro (10 typical runs)

Time of run	Wet taro	Dry taro	Water evaporated	Heat supplied	Electrical energy per pound of dry material
<i>Hours</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Percent</i>	<i>Kilowatt hours</i>	<i>Kilowatt hours</i>
13	46.0	15.6	66.0	26	1.67
11	39.2	15.6	60.2	22	1.41
10.5	62.3	24.8	60.2	41	1.65
8	53.9	21.3	60.5	30	1.41
7	50.4	17.8	64.7	30	1.69
7	38.8	13.1	66.3	27	2.07
4.5 ¹	42.0	15.0	64.3	20	1.33
4.5 ¹	42.0	15.2	63.8	20	1.32
4.5 ¹	42.0	15.0	64.3	20	1.33
4.5 ¹	42.0	15.3	63.5	20	1.32

¹ The four runs listed last were identical with respect to all conditions.

Table 2 gives a summary of moisture determinations on cooked taro before and after tray drying.

Drum Drying. Paiai can be dried on a double-drum drier, provided sufficient water is added to make the mixture flow easily. Experiments indicated that the optimum dilution was from 10 to 15 percent total solids. Thorough mixing to eliminate lumps is essential.

The dried material, which comes from the drums in thin sheets, breaks up into fine flakes of very low density. It mixes readily

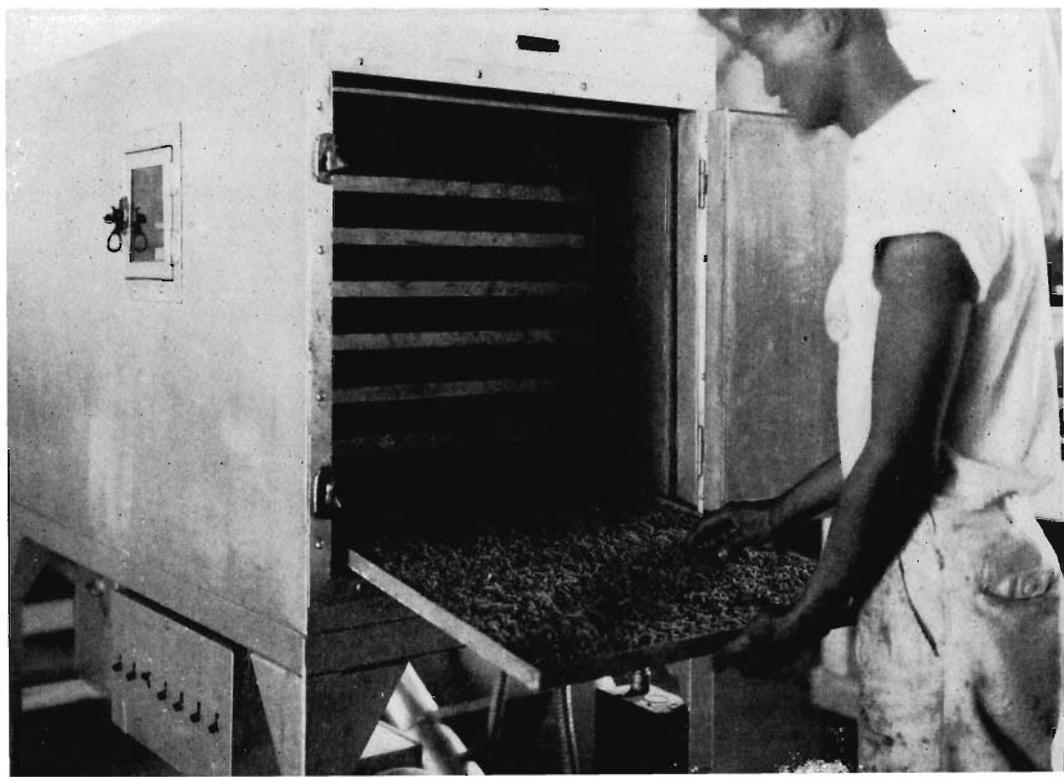
Table 2.—Moisture in cooked taro before and after tray drying

	Number of determinations	Maximum moisture	Minimum moisture	Average moisture
		<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Cooked taro, not dried	37	76.7	60.0	66.8
Tray-dried cooked taro	44	11.5	7.5	9.6

with water and other liquids. With a steam pressure of 70 to 80 pounds and a drum adjustment of less than $1/64$ inch, 6 to 8 revolutions per minute resulted in an average yield of $1\frac{3}{4}$ pounds per square foot of drum surface per hour.

The fuel consumed by drum drying was greater than by tray drying, due in part to the necessity of evaporating the excess water from the diluted *paiai*. Considerable heat losses also occurred by radiation from the drums.

FIGURE 4.—Drying refrigerated taro in a tray cabinet with heated air.



Spray Drying. Since equipment for spray drying was not available in the station laboratory, spray-dried taro flour was prepared by a commercial manufacturer of spray-drying equipment, from canned material supplied to them. The canned material was diluted to approximately 10 percent solids to facilitate pumping into the drier. The run was made with an inlet temperature of 500° F. and an outlet temperature of 200° F. Approximately 95 percent of the dried material was retained in the multiclone collector, indicating that about 5 percent of fine dust had passed into the bag filter.

The spray-dried flour was soft in texture and, for the most part, of exceedingly fine mesh. However, screening revealed a considerable quantity of rather large, hard pellets. The formation of pellets and other coarse particles was caused by an undue amount of settling in the drier itself, since the temperature could not be standardized in short runs with small amounts of material. The formation of pellets is not a serious difficulty and is largely minimized in long runs. Small particles of black scale which were present should likewise disappear with continued operation.

Fuel consumption for drying taro by this method from an initial moisture content of 70 percent to 10 percent was greater than for either of the other two methods.

Comparison of Methods of Drying. A comparison of the three methods of drying shows that, from a cost standpoint, tray drying is by far the most economical. Both the initial equipment cost and the operation cost are considerably lower than for drum drying or spray drying.

The texture of the dried taro produced by tray drying and grinding is likewise superior for general baking purposes.

The material obtained by drum drying is finely flaked and of low density, and does not adapt itself to baking as well as granular flour.

Spray drying produces a very fine flour. Since baked products from fine taro flour showed a marked tendency toward heaviness and sogginess, spray-dried flour is not considered as satisfactory as flour produced by grinding, in which the degree of fineness can be regulated.

Tray drying, therefore, is recommended for the production of a general-use taro flour.

In all of the canned samples, the odor was the same as in fresh taro, and the flavor and general character of the fresh material were preserved to a remarkably high degree. The taro was appetizing and very palatable. No difficulties should be encountered in canning various forms of taro on a commercial scale.

Milling

Milling processes in the production of taro flour involve only grinding and sifting of the tray-dried refrigerated taro. Initial experiments in grinding were conducted with the attrition mill used for grinding the cooked taro, but fitted with plates designed for dry materials. This method of grinding was extremely slow and inefficient. The plates tended to heat, and in many instances clogging occurred. A hammer mill was found to produce a superior flour with far greater efficiency.

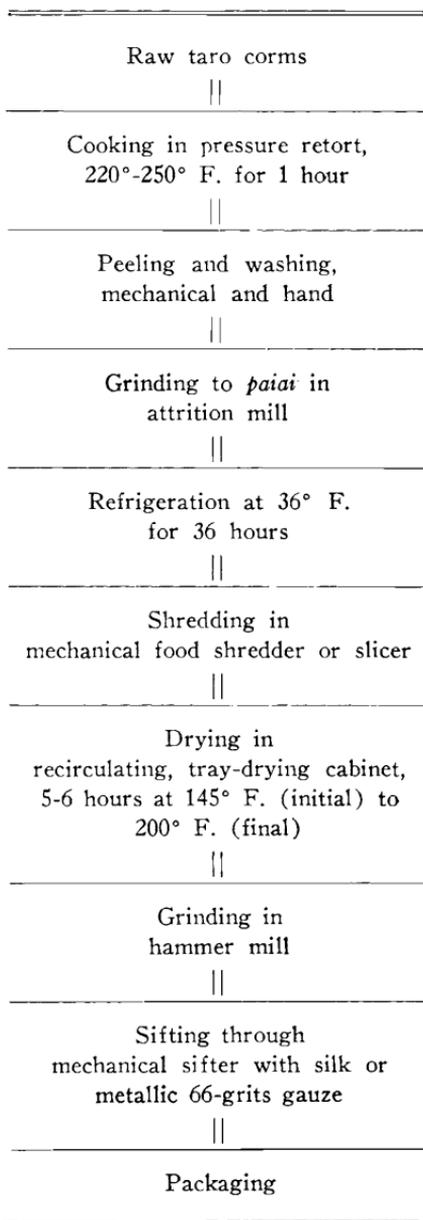
Sifting and grading of the flour involves no particular difficulties. Any kind of mechanical sifter employing silk or metallic screens may be used. A 66-grits gauze was found to produce the most satisfactory particle size for most baking purposes.

From numerous test runs the following conclusions were drawn (all tests were made with a 1/64-inch screen in the hammer mill and a 66-grits gauze in the sifter, with one sieve of 67/8 square-foot surface for two separations) :

1. The average rate of flour production was 75 pounds per hour.
2. Analysis of the fractional flour yields indicated that approximately 50 percent of the material was reduced to 66-grits gauze flour the first time through the mill at the rate of 100 pounds per hour. The remaining 50 percent was reduced at the rate of 50 pounds per hour.
3. Average loss of 1 percent may be attributed to sweepings, dust, and loss of moisture content. The dust lost can be collected as fines in suitable bags.
4. The tailings were reasonably clean, indicating adequate capacity of the screens.

Recommended Procedure for Manufacture of Taro Flour

The recommended procedure for the manufacture of taro flour on a commercial scale is given in the following flow sheet.



Properties of Taro Flour in Baking and Cooking

Comparison of Taro Flours

Twenty-four varieties of taro were tested to determine their processing characteristics and commercial suitability. With the exception of two, all had been grown under upland conditions, at the Pensacola branch station, although six are commonly classed as wetland varieties.

In general, it was found that any sound taro, either upland or wetland, which is capable of making good poi is satisfactory for processing into flour and other products. Taros which produce watery or mealy poi are not satisfactory. The color of the flour was dependent on the color of the variety of corm.

Extensive work was confined to the following five varieties, which were regarded as representative, resistant to disease, suitable as to yield, and readily available: Upland taros—*Mana Ulu*, a yellow taro maturing in around 12 months; *Lehua Palaii*, a pink taro maturing in 15 to 18 months. Wetland taros—*Piialii*, a pink taro maturing in 12 months or less; *Piko Uliuli*, a white taro maturing in 12 to 15 months; and *Piko Kea*, a white taro maturing in around 15 months.

These varieties, used exclusively in the baking tests, were found to present very few differences in behavior.

Potential Uses of Taro Flour

Comparison of taro flour with meals and flours prepared from grains and tubers reveals many significant points of difference. Taro flour is not only very low in proteins but entirely devoid of any glutenlike substance such as occurs in wheat. Hence it cannot be expected to lend itself to satisfactory aeration and rising in baking. Furthermore, while taro flour is prepared from the cooked corms, cereal flours and meals are customarily uncooked. This also applies to starches prepared from wheat, corn, cassava, arrowroot, etc.

One would expect to find the closest analogy to taro flour in potato flour. Both products are obtained by the dehydration of the cooked, peeled, underground portion of the plant and are composed of the entire portion without separation. Potato flour is also deficient in protein and cannot be used to replace glutinous flours in baking. Experimental evidence does prove a definite overlapping in the range of uses of potato and taro flours. The possible uses of the latter seem,



FIGURE 5.—*Left, bread made with taro flour substituted for 20 percent of the white flour; right, standard white bread.*

however, to extend over a wider range, since taro flour may be used also in preparations which ordinarily call for one of the uncooked starches.

Flavor and color are two characteristics which definitely distinguish taro flour from all the other common flours and starches. Both vary over a considerable range, depending on the variety used in the manufacture.

General Baking. Baking studies were designed to determine the following points: (1) The extent to which taro flour could be substituted for wheat flour in various products without materially altering the character and quality of the finished product; (2) the possibility of improving certain bakery goods through the use of limited quantities of taro flour; (3) the difference in the baking value of taro flours obtained from different varieties of wetland and upland taros; and (4) the effect of various modifications in the process of manufacture on baking value of taro flours. In so far as possible, standard recipes were used.

There was considerable variation in the proportion of taro flour which could be used to advantage in various products. Taro flour gave especially good results with bread (see fig. 5), rolls, layer cakes, doughnuts, hot cakes, and waffles, in proportions of from 15 to 20 percent. In cookies as high as 60 percent taro flour could be used. The color of every product was darker than that of the corresponding wheat-flour product, the volume equal or slightly less, and the texture slightly inferior only in the case of bread and rolls. The taste was mildly distinctive and was generally considered good. It was the consensus of those who tasted the products that taro flour improved both flavor and general eating quality of layer cakes

and doughnuts. The most satisfactory recipes developed are given in the appendix.

One of the most significant attributes imparted by taro flour was increased moistness and keeping quality, resulting from the exceedingly high absorption of liquid by taro flour.

Bread Baking. The use of taro flour in bread baking presents no difficulties when the following precautions are observed:

1. The taro flour should be carefully blended in order to avoid dark, sticky lumps in the finished goods. For bakers' use, a strong, hard wheat flour is preferable for blending with taro flour.

2. Dough should not be too slack because, although taro flour has a much higher absorption than white flour, the dough has a tendency to soften more than ordinary doughs. The absorption of taro-wheat flour blends was found to increase over normal to the extent of 1 percent for every 1 percent of taro flour used.

3. Slightly less time should be allowed for fermentation than with wheat-flour doughs.

4. A slow oven is necessary to permit thorough baking, since taro blends take on color much more quickly than white doughs.

The superior keeping quality of taro-wheat bread apparently results from its initial high moisture content, and not from any greater capacity for retaining its moisture. Five days after baking it was still possible to butter slices of the taro bread without crumbling; slices of the wheat bread, on the other hand, crumbled badly and could hardly be considered edible.

Preliminary laboratory investigations culminated in a large scale bread-baking test by the United States Army. Under the direction of Captain Talmage Phillips, 1,077 pounds of bread, containing 15 percent taro flour, were baked. This bread was issued to troops and officer personnel of the Hawaiian Department. Approximately 400 men tasted the bread, and there were no adverse reports concerning its palatability.

Under Army baking conditions, the following favorable factors were stressed: (1) Greater yield—a 15-percent blend of taro flour produced 16-percent more bread than wheat flour; (2) better keeping qualities; (3) local availability in case of emergency; and (4) the taro flour appears to be impervious to weevils and other insects which feed on wheat flour.

On the other hand the taro flour was found harder to handle because it was softer, and because more care was necessary in blending. Moreover, an additional baking time of 10 minutes was required for 1-pound loaves and 15 minutes for 2-pound loaves.¹

Cookery Other than Baking. In addition to baking tests, the possibility of utilizing taro flour as a "thickener" in puddings, custards, soups, and sauces was investigated. Although wheat flour is used to a limited extent, starches prepared from corn, wheat, arrowroot, and tapioca are far more important in this field. All of these are uncooked carbohydrates, possessing the properties of swelling and gelatinizing when cooked. Furthermore, they are all white and practically tasteless.

Taro flour on the other hand has an observable amount of color, usually of a purplish-brown cast, and a decided flavor, is precooked, and contains significant quantities of components other than carbohydrates. In certain combinations the flavor of the taro flour was considered objectionable; other combinations were pronounced highly palatable, and these latter included boiled custards, chocolate-flavored puddings, ice cream, and a variety of cream soups and meat gravies (see recipes in appendix).

Taro flour compares favorably in thickening power with the starches mentioned but does not "set" or gelatinize to the same extent on cooling.

Taro Flour in Allergy Diets. In the United States wheat has become recognized as a common cause of food allergies, and other common carbohydrate foods are also likely to produce allergic symptoms. The allergic properties of taro flour were investigated by Christine Laird² of the University of California Hospital in San Francisco. Her report in part was 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.

¹ Communication from Captain T. Phillips, Quartermaster Corps, to the Commanding Officer, Fort Shafter. The station wishes to express its appreciation to the Hawaiian Department of the United States Army for its cooperation in these studies and for permission to publish the findings.

² The authors wish to express their appreciation to Miss Laird for her contributions to this phase of the study.

“Due to the mineral and vitamin content, alkaline ash and caloric value of taro products they are a valuable adjunct to hospital diets.”

Miss Laird has included in her report a number of egg-, milk-, and wheat-free recipes, which will be found in the appendix. These recipes are exclusively for baked products, but certain recipes developed locally should likewise be of value in allergy treatment, since they cover a more extensive use of taro flour in the diet and likewise permit the elimination of one or all of the above-mentioned common offenders.

The ready digestibility of taro flour (14, 15) is also important in a consideration of this food in special diets, although this factor is undoubtedly of greater consequence in the treatment of digestive disturbances other than those arising from hypersensitivity to specific foods.

Poi from Taro Flour. Taro flour prepared by the recommended procedure can be mixed with water to give a product similar in general appearance, consistency, and taste to fresh, unfermented poi. Upon standing, however, the product does not undergo normal fermentation. Molds grow rapidly upon the surface, and the material becomes inedible in 24 hours.

Attempts were made to inoculate the flour-water mixture with dried (110° F.) 4-day-old poi. Fermentation of the mixture was rapid, but the resulting poi was found to be unsatisfactory in taste. Poi made from taro flour would seem to offer possibilities only where fresh taro is not available.

Roasted Taro

Dried cooked taro and taro flour become sticky and viscous upon the addition of water, regardless of the size and shape of the dried particles. For this reason breakfast cereals such as grits, flakes, and shreds prepared from unprocessed cooked taro are unsatisfactory. If the tray-dried taro is subjected to carefully regulated roasting, however, the particles retain their discrete character and show no tendency to revert to the viscous form in water.

The dried cooked taro is roasted as follows: The sliced or shredded material is placed on trays in a bake oven, heated for approximately 30 minutes at 250° F., then for approximately 15 minutes at 300° F., and finally for from 5 to 15 minutes at 350° F. The heating

time required at the final temperature is determined by observing the change in color of the material. A more uniform product is obtained if the material is agitated either intermittently or continuously during the roasting process.

The process of roasting is covered by United States Patent Number 2,108,897, issued to the authors and dedicated to the free use of the people of the United States.

Meal or Grits

When ground to the consistency of corn meal or grits, the roasted taro can be converted into a mush by the addition of hot water, with or without additional cooking. The mush is granular and similar in physical properties to mush made from wheat or corn meal.

The meal or grits can be used in the preparation of muffins, waffles, and other baked products. From 10 to 15 percent of the wheat flour in these products can be replaced by taro meal without causing sogginess.

The same material can be used as a base for various pudding preparations, adding sugar, salt, powdered milk, and chocolate or vanilla. Upon the addition of hot water or milk, in the proportion of one part of the solid mixture to 4 or 5 parts of liquid, a pudding results in which the individual taro particles are discrete and slightly gelatinous.

Breakfast Foods

Dry breakfast foods were prepared by incorporating flavoring materials into the taro before drying or roasting. Shreds, nuts, and flakes, to which malted barley (non-diastatic), papaya, or banana, along with sugar and salt, has been added, possess very palatable, nutlike flavors and do not undergo undue softening in milk and cream. The malted barley product resembles a grain cereal very closely. The optimum amount of malted barley in the dry product was found to be approximately 10 percent.

Beverage Foods

The object of investigations in this field was to prepare a taro product in a dried form which would disperse readily when shaken or beaten with milk and other liquids. The three standard methods

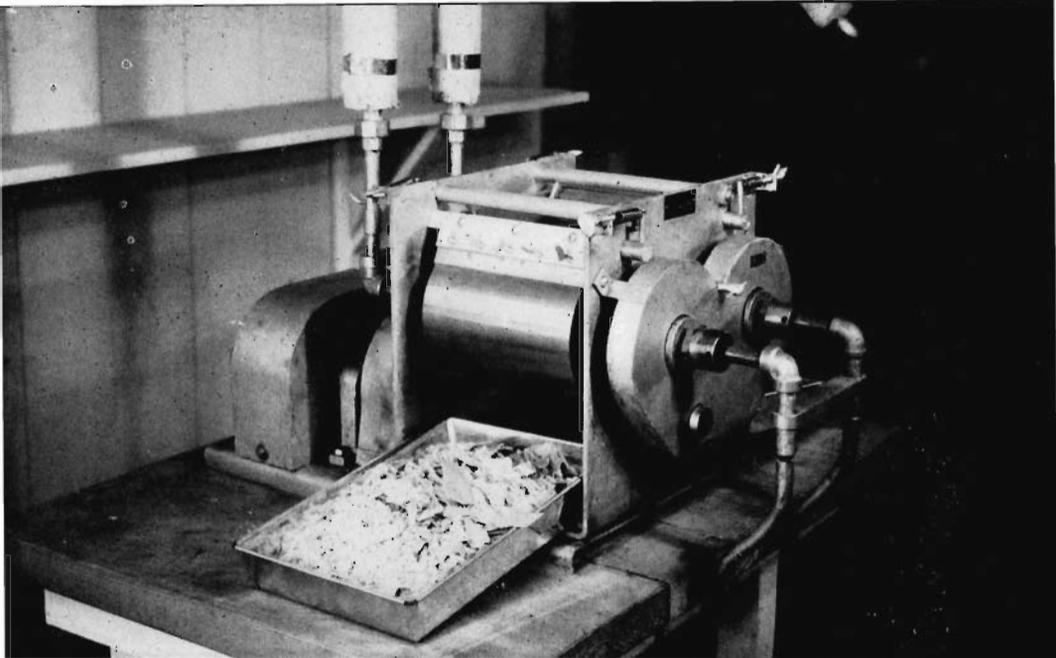


FIGURE 6.—*Finely flaked, drum-dried taro, suitable for grinding into a beverage powder.*

of drying were investigated; namely, tray drying, spray drying, and drum drying.

The tray-dried material was unsatisfactory because it did not disperse readily in cold liquids, even when reduced to a very fine powder by grinding, and the spray-dried powder, because of excessive lumping. By means of drum drying, however, a finely flaked product was obtained which dispersed readily when shaken or beaten with cold liquids.

Drum-dried taro powder (see fig. 6), without additional ingredients, has a pleasing flavor and may be used in purees, puddings, ice creams, eggnogs, and other drinks. The addition of certain other ingredients gives a product of more universal appeal, however. A formula for a chocolate-flavored taro beverage food is given below:

	<i>Pounds</i>
<i>Paiai</i> (30 percent solids)	11
Salt	3/16
Sugar	3/4
Diamalt	1/4
Cocoa	1
Water	12

The average yield of dry products from the above formula is $5\frac{1}{4}$ pounds. This product mixes readily with milk to give a thick drink of the malted-milk type.

Health Foods

Since dried taro is high in minerals (see p. 30) and in vitamin B (10) and the total ash is alkaline, it may be considered an excellent carbohydrate foodstuff. In addition to the food products already mentioned, numerous "health foods" have been proposed. Among these are the following:

Infant foods, in which the drum-dried taro powder is mixed with other carbohydrates;

Balanced diet foods, in which the taro is supplemented by addition of proteins such as skim milk or soybean meal; and

Invalid foods, prepared by incorporating other vitamin-containing materials into taro foods.

Canned Taro Products

Fresh poi, containing approximately 18 percent total solids, has been canned locally for several years. The product has had some introduction to markets in continental United States but finds little acceptance among the uninitiated. Canned cooked taro would seem to offer far greater commercial possibilities.

In order to determine the canning qualities of taro in various forms, experiments were conducted at a commercial cannery.

One portion of *Piko Uliuli* taro was pressure-cooked at a temperature of 215° F. for ½ hour and another portion, for 1 hour. A part of each portion was cut into suitable small pieces and packed into cans 4 inches high and with a diameter of 2¾ inches. Another part was ground before packing, while still a third part was ground and diluted with water to approximately 20-percent solids. The cans were sealed under 20-inch vacuum, preheated at 202° F. for ½ hour, then processed at 250° F. for 1 hour. Table 3 describes the products 30 days after canning.

In all of the canned samples, the odor was the same as in fresh taro, and the flavor and general character of the fresh material were preserved to a remarkably high degree. The taro was appetizing and very palatable. No difficulties should be encountered in canning various forms of taro on a commercial scale.

Table 3.—Taro canning data

Sample	Pre-canning cooking time at 215° F.	Form of material	Examination 30 days after canning—			
			Color	Texture	Appearance of inside of can	Remarks
1	<i>Hours</i> ½	Chunks	Red-brown	Moist, good	Slight discoloration	Similar to fresh cooked corm
2	1	do	Reddish	Firmer than sample 1	Unchanged	Mealier and dryer than sample 1, and not as good
3	½	Ground	Light salmon	Very firm	do	Slightly soggy; readily sliced
4	1	do	Very light salmon	Firmer than sample 3, mealy	do	Preferable to sample 3, more pleasing in appearance
5	1	Ground and diluted 20-percent solids	Light salmon	Creamy	do	Like poi but sweeter

Table 4.—Composition of taro and taro products

Form analyzed	Moisture	Protein	Fat ether extract	Starch	Sucrose	Reducing sugars	Pentosans
Steamed taro (20)	61.00	1.18	0.17	29.31	1.40	0.39	1.3
Fresh poi (5)	69.3	.31	.07	27.0	.03	.5	1.24
Dasheen (28)	62.77	3.03	.16	26.09	1.75		
Dasheen (7)	66.6	2.9	.2	21.8	1.71		
Taro (7)	75.1	2.0	.2	18.2	1.42		
Yautia (2)	70.0	1.7	.2	26.3			
Chinese taro (8)	72.37	1.48	.11				
Japanese taro (8)	81.40	1.44	.07				

Form analyzed	Crude fiber	Ash	Calcium	Phosphorus	Iron	Alkalinity of ash cc. N. acid/100 g.
Steamed taro (20)		0.59	0.026	0.061		
Fresh poi (5)	0.37	.46	.018	.057		
Dasheen (28)	.71	1.30				
Dasheen (7)	.7	1.42				
Taro (7)	.8	1.17				
Yautia (2)	.6	1.2				
Chinese taro (8)	.61	1.20	.023	.069	0.0017	14.50
Japanese taro (8)	.63	1.12	.013	.032	.0015	15.40

CHEMICAL STUDIES

Analyses of Taro

A few varieties of taro and some taro products have been analyzed by previous investigators. Table 4, on the opposite page, gives results reported in the literature.

In order to obtain more complete data, four of the most promising taro varieties were selected for complete analysis. These included two wetland varieties, *Piko Uliuli* and *Püalii*, and two upland varieties, *Mana Opelu* and *Lehua Palaii*.

Fifty pounds of carefully sorted, healthy corms were selected for each sample. The corms were washed, then peeled and cubed, using a Stellite knife to avoid iron contamination. The cubes were placed in 4-liter Pyrex beakers, covered with watch glasses, and cooked for 1 hour at 15 pounds pressure in a pressure cooker.

After refrigeration at 36° C. for 36 hours, the samples were dried in the tray drier on Pyrex dishes covered with cheesecloth. The dried samples were ground in a glass mortar, mixed uniformly, and preserved in Pyrex bottles for analysis. Careful precautions to avoid contamination were taken throughout the preparation of the samples. Methods of analysis are given at the end of this discussion.

The results of the analyses of the four varieties are given in tables 5 and 6. It will be noted that the upland variety *Mana Opelu* was considerably higher in mineral content than the other varieties. This variation would appear to be significant, although considerable weight must be given to growing conditions, which may vary widely.

It should be pointed out that no "by difference" factor has been introduced to cause the analyses to add up to 100 percent. The differences between the total of the given results and 100 percent are considered to represent undetermined constituents, such as organic acids, etc., the errors introduced by approximations in calculating protein and carbohydrate percentages, differences between ash determination values and the weights of actual compounds with which the elements are combined, and, most important of all, the doubtful meaning of customary moisture determinations on materials of highly colloidal nature.

Table 5.—Analysis of air-dried cooked taro

	Wetland varieties		Upland varieties	
	<i>Püalü</i>	<i>Piko Uliuli</i>	<i>Lehua Palaii</i>	<i>Mana Opelu</i>
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Moisture (vac. 70°-75° C. for 18 hours)	6.60	6.37	6.40	4.05
Ash	1.76	1.43	1.83	2.38
Crude fiber	1.45	1.31	1.17	1.68
Dextrins	.47	.48	.55	.95
Ether extract	.54	.52	.47	.68
Pentosans	2.48	2.37	2.06	3.40
Protein (nitrogen \times 6.25)	1.75	1.85	1.91	2.36
Reducing sugar	.49	.48	.66	.77
Starch	71.6	73.7	69.6	69.12
Sucrose	.08	.10	.10	.09

Table 6.—Ash analysis of air-dried cooked taro

	Wetland varieties		Upland varieties	
	<i>Püalü</i>	<i>Piko Uliuli</i>	<i>Lehua Palaii</i>	<i>Mana Opelu</i>
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Ash	1.91	1.54	1.96	2.48
Calcium	.059	.089	.106	.169
Chlorine	.081	.069	.084	.109
Copper	.0001	.0003	.0004	.0001
Iron	.0050	.0043	.0042	.0050
Magnesium	.054	.082	.086	.114
Manganese	.0012	.0010	.0001	.0001
Phosphorus	.119	.150	.113	.274
Potassium	.500	.408	.632	.879
Sodium	.0076	.0066	.0020	.0042
Sulfur	.0196	.0147	.0296	.0316
Zinc	.0031	.0001	.0005	.0007
Acid-base bal. cc.N.HCl per 100 g.	22.2	19.1	22.9	29.7

Taro Itch

Throat irritation caused by uncooked taro necessitates thorough cooking of the corms before they can be used in various food products.

Contrary to the findings of some investigators (21, pp. 69-71), drying alone does not destroy the cause of irritation.

Microscopic examination of microtome sections of the corms of *Pūalii*, *Kai Uliuli*, and *Piko Uliuli* varieties revealed the presence of calcium oxalate crystals in the form of raphides in all three. The general appearance and behavior of the raphides were as described by Safford (21). The raphides did not appear to be more numerous in one variety than another, although *Kai Uliuli* is apparently more irritating than either of the other two varieties. There were estimated to be two to three raphides per square centimeter of cross section. The raphides averaged about 0.12 mm. in length and 0.04 mm. in cross section. Upon heating the slide, some of the raphides expelled needlelike crystals in quantities of 15 to 20 each. These needles averaged about 0.1 mm. in length and 0.0003 mm. in diameter. Attempts to cause expulsion by water or drying failed. The crystals were not altered by heating to 100° C. They were insoluble in 95 percent ethanol, and in acetic acid, but dissolved readily in 1 percent hydrochloric acid. This is characteristic of calcium oxalate.

It is possible that the mechanical irritation caused by these needlelike crystals accounts for the itching sensation, as has been reported previously. Cooking does not affect the calcium oxalate chemically but eliminates the cause of irritation by rendering the raphides incapable of expelling the crystals, or by causing the expulsion with subsequent disintegration of the crystals into nonirritating forms.

In an effort to determine whether the relative irritation of various taro varieties could be ascertained by chemical means, two varieties of taro were analyzed for total calcium content before and after extraction with 1 percent hydrochloric acid. The extract was likewise analyzed for total oxalate present. The varieties chosen were *Kai Uliuli*, a very irritating variety, and *Bun-long*, which is practically nonirritating. The common *Piko Uliuli* variety, which is considered average in irritating effect, was likewise analyzed for oxalate content. The data in table 7 show that the oxalate content was too small to be determined accurately by the usual methods of analysis. Furthermore, there was apparently no relationship between the total calcium and the oxalate content. It must be concluded therefore that the actual quantity of calcium oxalate present in the taro corm is very small.

Table 7.—Calcium and oxalate content of raw taro varieties

Variety	Irritation	Total calcium	Calcium in extracted residue	Oxalate in 1% hydrochloric extract
		<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
<i>Kai Uliuli</i>	<i>Very irritating</i>	0.1005	0.0129	0.00003
<i>Bun-long</i>	<i>Negligible</i>	.0958	.0096	.00002
<i>Piko Uliuli</i>	<i>Average</i>	.07630005

Taro Starch

Taro is popularly claimed to be easily assimilable due to the small size of the starch granules. In order to clarify this, a series of microscopic measurements was made on the starch-granule size of the *Kai Uliuli* variety. Results gave an average random diameter of 0.0045 mm. The maximum granule was 0.0093 mm. and the minimum, 0.0025 mm. This is approximately one-tenth the size of the potato granule but of the same order of magnitude as that of rice.

Taro Pigments

The pigment of the yellow taro varieties, *Mana Ulu* and *Lehua Palaii*, is carotenoid in nature. Colorimetric analyses showed approximately 13 parts per million carotene in the dried taro. This compares with less than one part per million found in the white and red varieties. Due to the close chemical relationship between carotenoid pigments and vitamin A the potentialities of the yellow taros as a source of this vitamin are indicated.

The red color of the *Piialii* taro is due to an alcohol-soluble pigment of the anthocyanin type. The pigment is red only in acidic solution and turns green in basic media, a characteristic property of the anthocyanins. This accounts for the green color of fungi-diseased portions of the taro corm.

ANALYTICAL METHODS

Proximate Analyses

- Moisture* — Vacuum oven method, 70° C., 1-2 mm. for 18 hours.
Ash — 450° C.
Crude fiber — Association of Official Agricultural Chemists, Methods of Analysis, Third Edition (1930) pp. 280-281.
Dextrin — Ibid, p. 389.
Ether extract — Ibid, pp. 279-280.
Pentosans — Ibid, pp. 284-285.
Protein — Kjeldahl method. N \times 6.25. Ibid, pp. 18-21.
Reducing sugar — Acid hydrolysis method. Ibid, p. 282.
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Sucrose — Ibid, p. 281.

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Magnesium — Association of Official Agricultural Chemists. Methods of Analysis, Third Edition (1930) p. 106.
Manganese — Ibid, p. 106.
Phosphorus — Standard ammonium molybdate method.
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APPENDIX

TARO RECIPES

Taro bread

1 $\frac{3}{4}$ pounds taro flour	4 ounces salt
8 $\frac{3}{4}$ pounds white flour	3 ounces yeast
2 ounces shortening	1 gallon water
2 ounces sugar	
First punch	1 $\frac{1}{2}$ hours
Second punch	$\frac{1}{2}$ hour
On bench	10 minutes

Give short proof and bake 45 minutes in a slow oven.

Taro bread

15 pounds taro flour	4 pounds powdered milk
85 pounds wheat flour	3 pounds sugar
2 pounds salt	$\frac{1}{4}$ pound arkady
2 $\frac{1}{2}$ pounds shortening	75 pounds water
2 pounds yeast	

¹ Formula from which best results were obtained in the Army baking tests.

Parkerhouse rolls

$\frac{1}{4}$ cup taro flour	1 tbsp. shortening
1 $\frac{1}{2}$ cups bread flour	$\frac{1}{2}$ tsp. salt
$\frac{1}{2}$ cup scalded milk	$\frac{1}{4}$ yeast cake
1 tbsp. sugar	2 tbsp. boiled water, cooled to lukewarm

Combine milk, fat, sugar, and salt. Add the softened yeast cake, dissolved in lukewarm water. Add flour gradually to make a pour batter. Beat until tough and elastic. Add remaining flour and make a firm dough. Turn on to a floured board and knead until smooth and no longer sticking to the board. Place in an oiled vessel, cover, and place over hot water (not over 95° F.). Allow to double in bulk (2 $\frac{1}{2}$ hours). Loosen the sides with a spatula, place on a floured board, and knead. Roll to $\frac{1}{4}$ inch thickness. Lift dough from board and slap against board before cutting. Cut with 2 $\frac{1}{2}$ -inch-diameter cutter. Crease in middle. Brush half of circle with melted butter. Fold and pinch edges. Place in greased pan. Brush top with melted butter. Let rise until double in volume (1 hour). Bake for 13 minutes at 425° F.

(18 rolls)

Taro layer cake

$\frac{1}{4}$ cup taro flour	$\frac{1}{4}$ tsp. salt
$1\frac{3}{4}$ cups white flour	2 eggs
$\frac{1}{2}$ cup shortening	$\frac{3}{4}$ cup milk
1 cup sugar	1 tsp. vanilla
4 tsp. baking powder	

Cream shortening and sugar. Add eggs, and beat until fluffy. Mix and sift dry ingredients, sift a second time, and add to the first mixture alternately with the milk and vanilla. Bake in greased layer cake tins about 25 minutes, gradually raising the temperature from 350° to 400° F. (Serves 12)

Taro spice-nut loaf

$\frac{1}{4}$ cup taro flour	1 tsp. vanilla
$1\frac{3}{4}$ cups white flour	$\frac{1}{4}$ tsp. salt
$\frac{1}{2}$ cup shortening	1 tsp. nutmeg
1 cup sugar	1 tsp. cinnamon
2 eggs	$\frac{1}{4}$ cup chopped walnuts
$\frac{2}{3}$ cup milk	$\frac{1}{4}$ cup raisins
4 tsp. baking powder	

Cream shortening and sugar. Add well-beaten egg yolks. Mix and sift dry ingredients twice and add alternately with milk to the sugar-and-egg mixture. Add walnuts and raisins. Add vanilla and fold in egg whites, beaten stiff. Bake in greased loaf pan about 50 minutes, gradually raising temperature from 325° to 375° F. (Serves 10)

Taro muffins

3 tbsp. taro flour	3 tbsp. sugar
$1\frac{1}{4}$ cups white flour	1 cup milk
5 tsp. baking powder	2 tbsp. melted or liquid shortening
$\frac{1}{2}$ tsp. salt	1 egg

Combine dry ingredients and sift twice. Combine liquid ingredients and add to dry mixture, mixing only enough to dampen flour. Bake at 400° F. for 35 minutes. (8 muffins)

Taro doughnuts

$\frac{1}{2}$ cup taro flour	$\frac{1}{8}$ tsp. cinnamon
$1\frac{3}{4}$ cups white flour	$\frac{1}{8}$ tsp. nutmeg
$2\frac{1}{2}$ tsp. baking powder	$1\frac{1}{4}$ tbsp. shortening
$\frac{1}{2}$ cup sugar	1 egg
$\frac{3}{4}$ tsp. salt	$\frac{2}{3}$ cup milk

Cream shortening and half the sugar. Add remaining sugar to well-beaten egg and combine with first mixture. Add milk, then add flour mixed and sifted twice with baking powder, salt, and the spices. Roll to about $\frac{3}{8}$ inch in thickness. Fry in deep fat at a temperature of 370° F. (12 doughnuts)

Taro biscuits

$\frac{1}{4}$ cup taro flour	1 tsp. salt
$1\frac{1}{2}$ cups white flour	2 tbsp. shortening
5 tsp. baking powder	1 cup milk

Sift dry ingredients twice. Rub fat in with fingers or knife. Mix with milk to consistency of soft dough. Roll lightly to $\frac{1}{2}$ -inch thickness. Cut with biscuit cutter. Place on lightly floured cookie sheet. Bake for 15 minutes at 450° F. (18 biscuits)

Taro cookies

1 cup taro flour	$\frac{1}{2}$ cup milk
$\frac{1}{2}$ cup white flour	1 tsp. salt
$\frac{1}{2}$ cup rolled oats	2 tsp. baking powder
$\frac{3}{4}$ cup brown sugar	$\frac{1}{8}$ tsp. cinnamon
$\frac{1}{2}$ cup shortening	$\frac{1}{8}$ tsp. ginger

Cream shortening and sugar. Mix dry ingredients and sift twice. Add milk alternately with sifted dry ingredients to the sugar and shortening. Roll and cut. Bake at 375° F. for 15 minutes. (36 cookies)

Taro-wholewheat pancakes

$\frac{1}{4}$ cup taro flour	1 tbsp. baking powder
$1\frac{1}{4}$ cups wholewheat flour	$1\frac{3}{4}$ cups milk
$\frac{1}{4}$ cup yellow corn meal	1 tbsp. melted or liquid shortening
1 tbsp. sugar	$\frac{1}{2}$ tsp. salt

Mix wholewheat flour, corn meal, and taro flour thoroughly, sifting together. Resift with the other dry ingredients. Make a hole in the center of the dry ingredients. Pour in the melted shortening and the milk. Stir with a few swift strokes only until they are blended. The batter may be prepared in advance if covered at once and placed in the refrigerator overnight or longer. (Serves 4)

Taro waffles

$\frac{1}{4}$ cup taro flour	1 tbsp. baking powder
$1\frac{3}{4}$ cups white flour	$\frac{1}{2}$ tsp. salt
1 tbsp. sugar	1 tbsp. melted or liquid shortening
2 cups milk	1 egg

Mix white flour and taro flour thoroughly, sifting together. Resift with the other dry ingredients. Make a hole in the center of the dry ingredients. Pour in the melted shortening and the milk. Stir with a few swift strokes only until they are blended. Stir in the beaten egg. The batter may be prepared in advance if covered at once and placed in the refrigerator overnight or longer. (Serves 4)

Taro chocolate pudding

3	tblsp. taro flour	¼	tsp. salt
3	tblsp. sugar	1	pint milk (2 cups)
1	tblsp. powdered cocoa or chocolate		

Mix dry ingredients thoroughly. Add sufficient milk to make a smooth paste. Heat the remainder of the milk nearly to boiling in double boiler. Stir in the paste mixture and cook for 5 minutes, continuing to stir. Pour into a bowl and serve when cold, either plain or with cream.

Cream of taro soup

1	tblsp. taro flour	2	tsp. butter
1	pint milk (2 cups)		pepper
¼	tsp. salt		

Add taro flour gradually to the cold milk in a saucepan, stirring continuously. Season to taste with salt, pepper, and a little butter. Stir while heating to desired temperature (boiling is not necessary as taro flour is precooked). Cream of taro soup may also serve as a creamy base for chowders, or may be varied by the addition of mushrooms, asparagus, pureed tomatoes, or other vegetables.

Taro meat gravy

Since taro flour is precooked, meat gravy may be prepared by adding taro flour to juices of roasts, etc. just before serving. Use only half as much taro flour as you would of other thickeners. Stir for only a few moments. Taro flour may also be used as a thickener for soups and stews.

*RECIPES FOR ALLERGY DIETS*¹*(Egg-, milk-, and wheat-free)*Rowe elimination 1 and 2 cookie

¼	cup taro flour	4	tblsp. vegetable oil
½	cup cornstarch	¼	tsp. salt
⅓	cup rye flour	¼	tsp. soda
2	tblsp. finely shredded pineapple	½	tsp. cream of tartar
3	tblsp. rice bran	1	cup pineapple juice
½	cup sugar		

Batter must be thin to make thin cookie; if necessary add water or more pineapple juice to make batter of proper consistency. Bake slowly (300° F.) for 30 to 45 minutes.

¹ Published through the courtesy of Miss Christine Laird, University of California Hospital.

Ginger snap

$\frac{1}{3}$ cup taro flour	$\frac{1}{4}$ cup vegetable oil
$\frac{3}{8}$ cup cornstarch	$\frac{1}{2}$ tsp. salt
$\frac{1}{4}$ cup rice bran	1 tsp. ginger
$\frac{1}{3}$ cup molasses	$\frac{1}{4}$ tsp. soda
3 tbsp. white sugar	

Mix dry ingredients together. Mix molasses, oil, and about $\frac{1}{3}$ cup water together. Combine wet and dry ingredients. It may be necessary to add 1 or 2 more tablespoons of water for dough of the desired consistency.

Taro crumbles

(Cereal substitute)

$\frac{1}{2}$ cup taro flour	1 tbsp. sugar
$\frac{1}{2}$ cup rice flour	2 tbsp. molasses
2 tbsp. vegetable oil	$\frac{1}{3}$ tsp. salt
$\frac{1}{3}$ tsp. soda	

Mix dry ingredients, and add molasses and oil. Add just enough water to combine ingredients, mold into small loaf, and hold in refrigerator overnight. Next day crumble and spread crumbles out on flat baking sheets. Bake until dry and crisp. (If not dry and crisp when cool, return to oven and complete the process.) When dry and crisp, roll with rolling pin for a uniform crumb. Rice bran may also be added to the above recipe (4 tbsp.) without changing proportions of other ingredients. The cereal is similar to grapenuts, and may be eaten with fruit juice; if milk is not restricted, however, it is preferably eaten with milk.

Spice cookies

$\frac{1}{4}$ cup taro flour	1 tbsp. molasses
$\frac{1}{2}$ cup soybean flour	4 tbsp. vegetable oil
$\frac{1}{2}$ cup cornstarch	$1\frac{1}{2}$ tsp. cinnamon
7 tbsp. brown sugar	$\frac{1}{4}$ tsp. nutmeg
$\frac{1}{3}$ tsp. salt	

Measure and mix all dry ingredients. Combine oil, molasses, and water (begin with $\frac{1}{2}$ cup water and add more if needed). Add liquids to dry ingredients and beat well. Bake in a slow oven.

PATENTS

No. 2105977, issued to Gaston J. Ley, John H. Payne, and George Akau, for the free use of the People of the United States, for :

"1. A method of rendering cooked taro non-viscous, which comprises subjecting cooked taro to a temperature slightly above freezing for a period of substantially 30 hours.

"2. In the preparation of taro flour, the process which comprises cooking, peeling and washing taro corms, thence subjecting the cooked taro to a temperature slightly above freezing for a period of substantially 30 hours, thence slicing, drying, grinding and sifting the material."

No. 2108897, issued to Gaston J. Ley, John H. Payne, and George Akau, for the free use of the People of the United States, for :

"The method for producing taro meal so that it will not revert to an amorphous viscous mass when hot liquid is added, comprising subjecting dry taro meal to the action of heat at substantially 250° F. for approximately 30 minutes, thence raising the temperature to approximately 300° F. for approximately 15 minutes, thence raising the temperature to approximately 350° F. for a period ranging from 5 to 15 minutes, the while agitating the mass."