THE SWEET POTATO IN HAWAII

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When the Station produced the high-quality baking sweet potato Onolena, cuttings were widely distributed to growers; demonstrations of root appearance and baked-potato quality at leading markets created an immediate demand for more. The armed services arranged for supply with several growers. Soon, however, farmers' lots began appearing on the market in an uncured and ungraded condition. Dealers looked at the unsound and occasionally weevil-infested offerings and set their price 5 to 10 cents per pound below that for imported California varieties, which had been cured and graded. Now farmers are asking for a much inferior substitute variety, Kona B.

Conferences between wholesale and retail merchants, together with Station workers, showed that despite the high quality of Onolena, it cannot compete on equal terms with California imports unless it is cured and graded for quality and freedom from weevils.

Why was the first appeal so successful? The answer is that the demonstration lots, grown on University plots, were cured before being marketed; the growing crop was given the minimum care needed, which included precaution against weevil infestation. If the potato is cured before bagging, the outer skin-layer has time to toughen and will permit handling without nicking and introducing disease germs. Cured potato roots are solid and have no wilted root ends; they can be held in storage for several months if necessary. Curing and grading furnishes good initial appearance on the market, and, what is still more important, the good appearance continues because once cured there is no withering of flesh or nicking of skin.

CULTURAL PRACTICES

Hawaii soils and climatic factors are too variable for recommendation of rigid cultural practices suiting all conditions. But some suggestions for general consideration can be made: (*a*) If the soil is low in potash, a complete fertilizer is needed; (*b*) in any event, a good supply of nitrogen and phosphorus is needed, hence we recommend a fertilizer formula offering about 12 N, 30 P, 6 K, where there is doubt of potash (K) sufficiency, or 4–12–8 after 3 weeks followed by a side dressing of 11–48–0 (alternate 16–20–0) three weeks later; (*c*) apply the complete fertilizer as a side dressing at the rate of about 700 pounds per acre, and the ammophos at 300 pounds.

In Hawaii, the sweet potato requires less care to grow than on the Mainland because, in the first place, there is no need to overwinter a "seed crop" in a heated storehouse. Secondly, there are periods of the year in Hawaii when all regions have temperatures which favor natural curing and storing. Island farmers have found the crop so easy to grow that they have never tried to improve their practices so as to permit competitive marketing. We are most deficient, therefore, in two important respects: roots are not cured before handling for market, and the crop is not graded. As long as these two most fundamental points are neglected, we cannot compete with the cured and graded roots from California, which need not be imported to Hawaii in the first place.

For maximum yield of grade-A roots, hills should be spaced at 6–8-inch intervals. Wider intervals induce jumbo root formation and, of course, lower total yield. Since stem cutting is the invariable local planting practice, there is no argument for wider spacings on the grounds of economy.

Maximum crop yields are obtained from plantings set to the field between the end of March and the middle of May, and harvested in 4½–5 months.

Table 1. Average tonnage for the combined yields of 4 varieties at Poamoho (600 feet elevation).

Plot	*Season*	*Tons per acre*
A.	November-June	4.8
B.	January-July	6.4
C.	February-August	7.4
D.	March-September	9.0
E.	May-November	11.7
F.	July-January	7.2

Farmers who wish to supply the market for the moist, high-sugar baker should plant Onolena, or those varieties erroneously called "yams," such as the Porto Rico, or a selected strain of Nancy Hall. To supply the dry boiled-or-fried market, we recommend McBryde (many other synonyms: Laupahoehoe, Tantalus, etc.) and HSPA 3. Curing can be done under controlled heat of 80–85° F. for 7–10 days, or for the same interval at prevailing room temperatures from June to November, and for about 14–20 days the rest of the year; but such temperatures are *not for storage.* The bakers are good keepers if first cured; they can then be stored at 55–70° F., or room temperatures prevailing from November to March. The dry-flesh types are poor keepers and will not store well. But both types should be harvested and graded in wood containers in the field, and cured (in the same containers) before being handled for market. Freshly dug roots are very tender and may be sunscalded after 30 minutes of direct midday sun; therefore they should be covered with vines until removed for curing.

If weevils are present, the cuttings should be dipped in a solution of 5 tablespoons wettable DDT (50% strong) per gallon of water. If weevils persist in the vicinity, the crop should be sprayed again at least twice before harvest.

ONOLENA: HAWAII ADAPTED BAKER

Variety and seedling trials at substations have shown that Onolena, under Hawaii conditions, combines more desirable characteristics than any imported variety thus far tried. It ranks high in total and grade-A root yield, bakes well, and stores well. Table 2 shows results of scoring the ten leading entries in the last two experimental tests conducted at the University. The results from baking tests are from data furnished by the HAES Department of Foods and Nutrition.

Kona B, the inferior variety which several farmers have asked for, is shown to rank eighth out of ten, and to be lower in baking quality, total yield of roots, as well as of grade-A roots, and it will not keep well in storage. On the produce market, its showing will be comparable to its trial performances. The manager of a Honolulu produce exchange brought us some excellent imported California roots, which, of course, had been cured and graded, and asked why we didn't have a variety that looked that good. His sample was taken, increased, and grown under trial with some of our better seedlings. One inspector, on viewing the harvest and learning the story said, "You never know how your children do when away from home." We immediately dropped the California variety as being inferior when grown in Hawaii. Notice the inferior ranking in table 1 of Allgold, one of the leading commercial varieties in the southeastern states. It ranked seventh, only a trifle better than Kona B, in overall performance. Varieties bred for performance in one region cannot be expected to be as well adapted elsewhere.

WHY CURE ROOTS?

What happens when cured and uncured roots are treated in the customary ways? The question may be answered by giving the cooking measurements with Mainland and Hawaii roots cured from 7 to 10 days at average temperatures between 80–85° F., and with the following:

1. Curing increases the total sugar content and improves the flavor.
2. Curing permits even solidification of flesh and toughening of skin to prevent introduction of storage diseases.
3. Curing improves the market-shelf length of life, or the ability to maintain good health pending storage in the warehouse until a favorable price is offered.

EFFECT OF CURING ON STARCH AND SUGARS

The percentages in figure 1 represent actual measurements made by United States Department of Agriculture chemists in Washington, D. C., of the sugars—sucrose, maltose, and dextrin—and starch in four varieties of sweet potato before and after curing, and before and after cooking. Two of these varieties are the dry-flesh kind, to which belong all native Hawaii varieties (such as HSPA 3 and McBryde) and the "Jersey" types from the northern states; two are the moist-flesh kind (erroneously called "yams") typified by the standard baking varieties Porto Rico, Nancy Hall, and the new Onolena. All sweet potatoes have an enzyme, *beta amylase,* which when heated will convert starch into the sugars, maltose and dextrin. The temperatures of curing, 80–85° F., are sufficient to convert much of the starch, but the temperatures of cooking, if reached slowly, are even more effective in converting the remaining starch.

Table 2. Six leading new seedlings compared with four previously tested varieties for weight in pounds, grade A roots, keeping ability, and baking quality.

VARIETY	TEST I: POAMOHO			TEST II: MANOA			PRODUCT SCORE†
	Weight	*Keeping*	*Baking**	*Weight*	*Keeping*	*Baking**	
1 Onolena	132	5	325	181	5	229	44,454
2 14 A_2	85	4	382	180	3	320	22,443
3 14 S	117	4	177	206	5	127	10,836
4 PR F	99	4	169	148	5	216	10,697
5 14 I	115	4	114	157	4	279	9,188
6 14 P_2	108	4	167	146	5	161	8,479
7 Allgold	64	5	239	91	4	188	5,234
8 Kona B	125	3	127	147	2	173	2,422
9 171	129	2	58	151	2	75	678
10 HES 8	208	1	31	147	1	50	47

* Baking index based on tests performed by the HAES Department of Foods and Nutrition, and scored by 12 jurors for color, moisture, flavor, and fiber.

† Product of six ratings divided by 1,000,000.

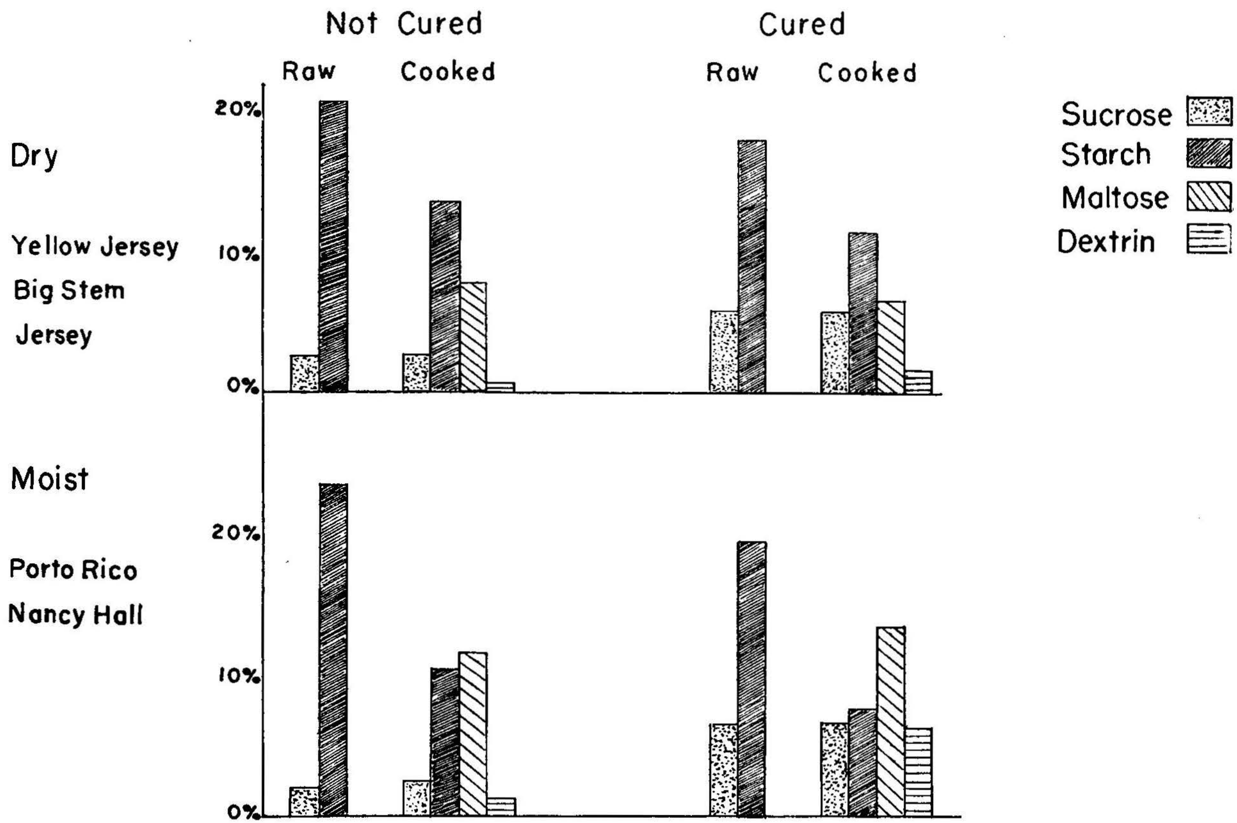

Figure 1. Effect of curing and cooking on starch and sugars of dry and moist types of sweet potato. (From Culpepper and Magoon, 1926.)

Notice in figure 1 that sucrose is unaltered by cooking uncured roots, but that curing converts some of the starch to sucrose before cooking. Both dry and moist varieties have about the same initial composition of sucrose and starch (there is a trifle more starch in the two moist varieties here considered) but heat of cooking or curing breaks down this starch into the sweeter maltose and dextrin. Cooked and cured moist varieties, reported in this experiment by Culpepper and Magoon, are seen to contain less starch, twice as much maltose, and about 4½–5 times more dextrin than the cooked and cured dry types. The difference between the two flesh types in sucrose content is not large, but after treatment with heat there is a larger amount of maltose and dextrin in the moist-flesh varieties.

EFFECT OF CURING ON KEEPING QUALITY

For discussion purposes, points 2 and 3 may be considered together, since keeping-ability largely results from disease resistance. Disease resistance itself stems largely from the fact that the skin and outer flesh-layer toughen up after curing and thus permit market handling without damaging the skin while it is tender.

Three new high-yielding seedlings produced in Hawaii since the war include HSPA 3, which is a very good dry-flesh Hawaii type produced by the Hawaiian Sugar Planters' Association, and two moist-flesh types, Onolena and HES 12, produced by the Station from a cross between Porto Rico and Nancy Hall. All three of these seedlings were tested for storage quality in comparison with the standard baker, Porto Rico. All four varieties were planted six seasons of the year: A, November-June; B, January-July; C, February-August; D, March-September; E, May-November; F, July-January. During the last four seasons, storage data were kept for the first six weeks after curing, but in the last two seasons, storage data were kept for 18 weeks.

All plots were grown and cured at the Poamoho Farm. The roots of plots C, D, E, and F were divided into three lots; one was stored in the quonset hut at Poamoho, the other two on the University campus at (*a*) room temperatures, and (*b*) in a cold storage reefer at about 55° F.

For plots C and D, roots were transferred from the harvesting field to the curing shed in burlap bags, and for plots E and F, in shallow wooden crates, and not disturbed until curing was completed. In this way, plots C and D formed a class which was roughly handled before curing, whereas E and F were a class which was cured before being handled for market. Striking differences in the percentage of sound roots after the first six weeks were observed from these two methods of handling, as is shown in table 3 and figure 2.

Table 3 shows that the loss from rough handling was affected by three factors:

Table 3. Percentage of sound roots after 6 weeks of storage, distributed for two methods of transferring from the harvest field.

HARVEST METHOD	VARIETIES				AVERAGE
	Porto Rico	*Onolena*	*HES 12*	*HSPA 3*	
Bagged uncured	73.7	74.7	34.5	32.8	53.9
Cured first	93.7	94.2	91.5	92.7	93.0
Average	83.7	84.4	63.0	62.8	

Figure 2. Number and condition of sound roots remaining after 6 weeks in cold storage (upper row) and at room temperature (lower row).

(1) Before curing, two varieties, HES 12 and HSPA 3, were more damaged by rough handling than were Porto Rico and Onolena. (2) After curing, all four varieties were equally resistant to rough handling. (3) All four performed significantly better when cured first.

On the average, there was three times more damage from rough handling before curing than after curing.

Even more striking results from this storage experiment may be seen in a distribution of the percentage of sound roots according to place of storage (table 4). The burlap bag handled potatoes rotted in storage so rapidly that the tests were discontinued after six weeks. Plot D, raised and harvested during a warmer season, rotted faster than plot C. But plots E and F were stored for a total of 18 weeks, and in addition, these room-stored lots were in better condition after 18 weeks of natural temperatures than were the reefer lots stored for the same period. Results were almost identical at the University and at the Poamoho quonset hut.

Table 4. Percentage of roots still sound after 6 weeks in four cropping seasons, compared as to type of storage. Seasons C and D bagged uncured; E and F cured before bagging and observed in storage for at least 18 weeks.

TYPE OF STORAGE	FEBRUARY-AUGUST C		MARCH-SEPTEMBER D		MAY NOVEMBER E		JULY-JANUARY F		GRAND AVERAGE	
	6	18	6	18	6	18	6	18	6	18
Room	52.5	—	50.0	—	84.0	67.0	100.0	94.0	71.6	80.5
Reefer	83.5	—	53.0	—	100.0	64.5	99.5	66.0	84.0	65.3
Quonset	53.0	—	31.3	—	79.7	44.3	94.8	92.0	64.7	68.2
Grand average	63.0	—	44.8	—	87.9	58.6	98.1	84.0		

Table 4 may be summarized as follows:

a. Roots must be cured with as little handling as possible between harvest field and curing shed. Shallow wooden trays, as illustrated in figure 2, offer a practical solution.

b. The quonset hut proved effective for curing roots harvested in all six seasons; but for storage of roots it was (1) inferior to cold storage for the November-harvested crop, and (2) superior to cold storage for the January-harvested crop.

c. Storage at natural room temperatures can only be well done between December and April. At other times, roots may be stored for several months in artificially cooled rooms *if* (1) ventilation is provided, or the relative humidity of the reefer is low enough to prevent "sweating"; (2) roots are stored in trays or boxes. Roots stored in bags (even meshed onion bags) will sweat and disintegrate within a month.

d. In deciding the best months for both growing and storing, the data in table 5, although not comprehensive, show that those cropping intervals which are harvested from November to January are very satisfactory. They may be expected to repay the warehouseman who wishes to hold a good keeper until March and April, when market prices will be better.

Results of the natural curing and storage facilities of the quonset hut at Poamoho are given in table 5. Yield is distributed for four storage periods, four varieties, and the last two seasons, in tons per acre of sound roots remaining after 0, 6, 12, and 18 weeks.

It will be seen that in each season, Onolena, on the average, yielded the most tons of marketable roots, and retained 78 percent of its original tonnage in plot E and 98 percent in plot F for as long as 4½–5 months after harvest. Rats showed a decided preference in plot E for roots of HES 12. But in plot F, after eradication of rats, HES 12 retained 99 percent of its original tonnage after 18 weeks of storage. For the best yielding period, May-November, Onolena had more sound roots (78%) in February in the quonset hut than remained (64.5%) for all varieties in cold storage (table 4). The value of Onolena as a good keeper cannot be overemphasized if moist-variety performance in Hawaii is to compete with California on the Honolulu market.

CONSUMER PREFERENCES DIFFER

One of our investigations during the past year has shown that when new-bred varieties of sweet potatoes are subjected to baking tests to learn which are more suitable as bakers, the varieties which received the highest rating made a different appeal according to the food habits of the geographic sector from which the jurors arose. The sweetest varieties, those which are sometimes erroneously called "yams," are rated higher by jurors who are used to yams than by jurors who are accustomed to the starchy, dry type of sweet potato. Those from the northern Mainland states usually preferred, but not always, the sweet, baker types; those from the south always preferred the baker. Bakers were once referred to locally as Nancy Halls, but are now unfortunately referred to as "yams."

The tabulation below gives the average "flavor" scores from tests by the Foods and Nutrition Department for eight varieties (four with higher averages, four with lowest), eight jurors (four with Mainland background, four with Island background). The eight varieties were grown in two separate experiments (table 2), each baked and judged four months apart. The highest possible score was 5.

Table 5. Tons per acre of sound roots during four storage periods at Poamoho quonset hut.

STORAGE PERIOD	VARIETIES								GRAND AVERAGE	
	Porto Rico		*Onolena*		*HES 12*		*HSPA 3*			
	E	F	E	F	E	F	E	F	E	F
0	11.13	7.26	12.33	7.37	11.20	6.99	12.28	7.09	11.74	7.18
6	9.46	6.46	10.48	7.22	6.50	6.92	11.17	6.59	9.40	6.80
12	7.79	6.24	9.62	7.22	3.29*	6.92	9.70	6.31	7.60	6.67
18	2.56†	6.03	9.62	7.22	2.54*	6.92	9.33	6.24	6.00	6.60
Grand average	7.73	6.50	10.51	7.26	5.88	6.94	10.62	6.56		

* Excessive rat damage.

† Probable rat damage at end of test.

The average flavor scores for the eight varieties were:

Variety	*Average Score (16 samples each)*
41 A_2	4.1
HES 167	3.7
Onolena	3.7
Porto Rico F	3.2
HES 173	2.5
14-S	2.5
HES 168	2.9
HES 169	2.8

The average geographic background scores were:

High-score Mainlanders	4.0
High-score Islanders	3.3
Low-score Mainlanders	2.7
Low-score Islanders	2.7

Significant difference at odds of 99 to 1 = 0.3

POTENTIAL USES FOR SWEET POTATO

In regions of the United States where the sweet potato is raised on a large scale, the crop has two uses; (1) industrial starch manufacturer; (2) human food and feed for cattle.

At present, some attention is being given by Hawaii industrialists to the possibilities of expanding Hawaii's economy through agricultural products. If Hawaii follows Mainland trends, the sweet potato will in time receive more attention than it does now. It is pre-eminently a warm-country crop, adapted to the needs of local farmers and consumers; there now are a number of varieties of both the dry and the sweet types developed for Island conditions capable of fitting into the two Mainland uses. Moreover, the majority of Hawaii consumers are more accustomed to the sweet potato as food than are most Mainlanders. A wide range of types can serve as the basis for industrial starch and yeast manufacture, for confections such as taffy and jelly, and satisfy preferences for the dry or sweet types of this vegetable.

STOCK FEED

The greatest market for sweet potato up to the present time has been for the yellow or orange dry types as stock feed. The product is prepared by drying disintegrated sweet potato roots after they have been shredded with beet knives and rapidly dried in the sun. According to the 1950–51 Yearbook of Agriculture (U. S. Dept. of Agri.) dehydrated sweet potato pulp—stored, handled and distributed like corn—is nearly equivalent to corn in feed value. Feed tests by the animal husbandry department of the University of Hawaii have shown that sun-dried pulp is a good substitute (plus a small addition of soybean meal) for barley in dairy cow rations.

SUMMARY

1. To raise and market a good crop of sweet potatoes, dry or moist flesh, the crop should be graded and packed in shallow wooden crates in the field, and not repacked until cured.

2. Before transfering the crates to the curing shed, the crates must be sheltered from direct sunlight between 10:00 A.M. and 2:00 P.M. by covering them with cut vines. Sunscald promotes black rot and other storage diseases.
3. Roots must not be rehandled until they are cured for 7–10 days between 80–85° F. or for about 10–14 days at room temperatures all year.
4. After curing, the roots may then be bagged or repacked for direct market or stored in a warehouse for suitable market price. Storage temperatures must be lower than curing temperatures: 55–70° F. during the summer, or room temperatures between November and April.
5. When cured roots of a good keeping variety, such as Onolena or Porto Rico, are properly stored, the product may keep in sound condition for four or five months.
6. Cured and graded crops of a superior baking variety, thus stored, could be exported to the Mainland during off seasons if the wholesaler or co-operative dealer so wished.
7. The heaviest yielding cropping seasons are between April and November; and the most economical storage seasons during which room storage is more effective than refrigeration are May-November to July-January; however, the last gives such inferior tonnage yields that the April-November growing season is ideal for the Territory with respect to yield and economical storage.

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