NP--3901572

DE83 901572

UTILIZATION OF GEOTHERMAL HEAT

IN

TROPICAL FRUIT-DRYING PROCESS

By

Bill H. Chen, University of Hawaii at Hilo
Louis P. Lopez, Research Corporation of U. of H.
Robert King, University of Hawaii at Hilo
Jack Fujii, University of Hawaii at Hilo
Melvin Tanaka, Okahara, Shigeoka & Associates

October, 1982

Funded by

Department of Planning & Economic Development

State of Hawaii

DISCLAIMER

DISCLAIMER

EXECUTIVE SUMMARY

Purpose

This project was developed to encourage and demonstrate the use of geothermal direct heat applied to fruit drying. A study was prepared with Foremost-McKesson investigating the feasibility of their investing in a pilot papaya drying facility at the State geothermal site.

Discussion

Along with Foremost-McKesson management, the project team collected and evaluated data relevant to the feasibility of investing in the production and distribution of dried Hawaiian papaya. Initially a pilot plant was considered. Later Foremost-McKesson decided a pilot facility was not needed and a commercial venture became the focus of consideration. Indeed, the company's management thought that production procedures were sufficiently established and demand for dried papaya substantial enough to allow the "economical" production of 1-2 million pounds of dried papaya annually.

It was determined that a commercial plant is only marginally feasible if it can operate at the 1-2 million capacity and if the 10-20 million pounds of processing papays required could be purchased at 12¢ per pound. Twelve cents is considered to be the farmers cost of production.

While it is true that much of the processing-type papaya can be purchased at less than 12¢ per pound (probably 5-7¢), sufficient continuous supply can not be guaranteed. For example during the industry's peak production year (1979) approximately 80 million pounds of usable papaya was produced in Hawaii. Of this about 16 million pounds were available for processing at the lower price rate. Of this, puree processing takes a substantial amount. Recent production has fallen short of this peak year due to weather and disease.

The amount of lower-priced processing fruit available is a function of total papaya production. Total papaya production is currently limited by the demand for fresh papaya on the high side and variable weather and disease conditions on the low side. Since the Papaya Administrative Committee, industry marketing and self regulating organization, at present feels thate is limited demand, it is doubtful that total production of papaya will exceed 100 million pounds in the near future. But even at this production level the amount remaining for processing would be at a marginal 10-20 million pound level. The probability of lower production is quite high.

During times of low production two things work against guaranteeing a continuous supply of low-cost processing fruit. First there is less fruit available not only due to lower production, but also due to allowing a greater proportion of processing-type fruit to pass as fresh in order to fulfill demand. Secondly, the demand places pressures upon prices to increase. It would be economically difficult to supplement deficiencies in the required amounts of processing fruit with high-priced fresh.

The risks associated with a consistent supply cause this project to be considered unfeasible at the present time. Only structural changes in the papaya industry can change this condition.

Conclusion

A commercial papaya drying plant is not feasible at this time. It is possible that combining papaya drying with the drying of other tropical fruits may make a plant feasible. but further research is required.

Because private industry is reluctant to invest in a pilot food processing plant, it is possible that a cooperative venture, perhaps including the fruit industries, Governments, and a private firm could provide a stimulus to involve more use of geothermal direct heat in food processing.

CONTENTS

Contents (continued)

INTRODUCTION

With the dedication of HGP-A Wellhead Generator Plant in July, 1981, the geothermal development in Hawaii has marched into a new era of commercialization. The power plant is currently producing approximately 1,780,000 KWH of electricity every month and supplies 4.3 percent of the total energy consumption on the Big Island.

However, the power plant utilizes only the steam portion of the HGP-A well production. There are approximately 50,000 pounds per hour of 360°F water produced (approximately 10 million BTU per hour) and the water is currently not used and is considered a waste. This tremendous resource could very well be used in applications such as food processing, food dehydration and other industrial processing that requires low-grade heat.

This report examines one of the applications, namely the drying of tropical fruits particularly the papaya. The papaya was chosen for the obvious reason that it is the biggest crop of all fruits produced on the Big Island.

This report also includes a conceptual design of a pilot plant facility capable of processing 1000 pounds of raw papaya per day. This facility is designed to provide a geothermally heated dryer to dehydrate papayas or other tropical fruits available on an experimental basis to obtain data such as drying time, optimum drying temperature, etc.

OVERVIEW OF THE HAWAIIAN PAPAYA INDUSTRY

In 1980, growers in the State of Hawaii produced 48,916,000 pounds of papaya utilized for fresh markets or processed fruit. This represented a value of $9,979,000 or 1.8% of the value of all Hawaii crops. As a crop, papaya ranked 4th in production, behind sugar, pineapple and macadamia nuts.

Production in 1980 showed a 19% increase over the 1979 year when a severe storm affected yields. Total production in 1981 was up 31% over 1980 as recovery from the storms and plantings in new acreage continued. Another long storm in early 1982 caused another setback in the State's production of papaya. Most of the effects were felt on Kauai, Oahu and Maui where phytophthora damage caused a reduction of 30-60% during the first few months of 1982. Due to the exceptional soil drainage, the Island of Hawaii was able to actually increase production during these same months by about 2%. The Papaya Administrative Committee projects the production, marketing and prices of fresh papaya (that sold at the fresh produce section of a supermarket) as indicated in Table 1.

In April, 1982 the state's total acreage in papaya crop was 3,035 acres as compared to the 1979 high of 3,245[3]. The center of the papaya industry resides in the Puna district of the Island of Hawaii and maintains 75-80% of the state's productive capacity. This status is expected to continue since Maui's Princess Orchards operation is phasing out and Oahu's orchards are used mainly for supplying the Oahu market. Kauai is developing a papaya industry rather rapidly, but the 75% production on the Big Island is expected to continue. The Puna Papaya farmers attempt to bring 10-15% of new acreage under production each year.

Current Problems

The Papaya Administrative Committee summarizes the findings of its 1975-1979 financial analysis of the Hawaii Papaya Industry[4] as follows:

TABLE 1

FRESH PAPAYA PRODUCTION, MARKETING, PRICES AND INCOME

1974 - 1984

(PRODUCTION IN MILLIONS OF POUNDS)

		EXPORTS						
	LOCAL	FOREIGN[1]	MAINLAND[2]	TOTAL	TOTAL FRESH	PERCENT EXPORTED	FRESH PRICE (¢ PER LB.)	FRESH SALES (Millions of $)
1974	13.1	3.0	18.5	21.5	34.5	62.3	13.9	4.0
1975	12.2	3.3	19.5	22.8	35.0	65.1	15.8	5.5
1976	12.7	3.9	27.0	30.9	43.6	70.9	13.5	5.9
1977	13.2	4.6	36.2	40.8	54.0	75.6	13.2	7.1
1978	14.8	7.1	33.7	39.8	54.6	72.9	14.4	7.9
1979	10.2	6.3	20.0	26.3	36.5	71.1	25.6	9.3
1980	11.0	7.0	27.0	34.0	45.4	75.6	21.7	10.2
1981					59.3		20.8	
1982*	13.2	10.0	41.5	51.5	65.0	79.2	21.5	14.0
1983*	14.0	11.0	45.0	56.0	70.0	80.0	23.0	17.0
1984*	14.5	12.0	48.5	60.5	75.0	87.0	24.0	18.0
1985*	15.0	13.0	52.0	65.0	80.0	81.2	25.0	20.0

*1982-1985 Projected by PAC

1/ Includes direct sales to Japan, Canada and other foreign destinations.

2/ Includes direct sales to Canada.

Source: Papaya Administrative Committee Reports

1. During 1979, inflation returned to double-digit levels (15.1%) after declining to only 5.0% during 1977. Since 1974, papaya production costs have increased by a substantial 54.0%

2. After experiencing a negative growth rate during 1977, the industry re-bounded to a 1.7 percent growth during 1979 - however, a rate well below the recommended (historical) 8% annual increase.

3. Farm income (fresh and processing sales) totaled $9.5 million during 1979 - the highest on record.

4. Net farm income reached a record $1.8 million during 1979 - up sharply from the less than $400,000 profit levels during 1975 and 1976.

5. Papaya production dropped substantially during 1979, causing sharp increases in papaya prices and resulted in record low yields, which in turn resulted in a record high production cost of 18.5¢ per pound - an 83.1% over 1978.

6. In spite of an 8.5¢ per pound increase in production costs caused by inflation and low production levels during 1979, net profits to farmers increased 4.9 per cent over 1978 as a direct result of a 10.2¢ per pound price increase in papayas from prior years received during the year - the largest year-to-year price increase on record.

A financial analysis further shows the income, expenses and profits for a hypothetical 15-acre farm:

Hypothetical 15-Acre Farm[1]/ Income, Expenses & Profits: 1975 1979

	DOLLARS			CENTS PER POUND		
Year	Farm Income[2]	Farm Expenses	Net Profits	Income	Expenses	Net Profit
1975	$30,790	$25,350	$5,440	14.2¢	11.7¢	2.5¢
1976	31,890	27,000	4,890	12.3	10.4	1.9
1977	35,010	28,300	6,710	11.9	9.6	2.3
1978	37,990	30,850	7,140	13.0	10.6	2.4
1979	42,660	35,500	7,160	23.2	19.3	3.9

1/ Hypotehtical farm consisting of 15 acres - 5 acres planted earh year, 5 acres harvested in their first year of bearing and 5 acres harvested in their second year of bearing.

2/ Farm income based on industry average total production yields of each year.

Source: A Financial Analysis of the Hawaii Papaya Industry 1975-1977, Papaya Administrative Committee, Honolulu, Hawaii 96814, p. 17.

Notice that much of 9.3¢ increase in the per pound expense is due to the cost of recovering from the 1979 set back.

The Papaya Administrative Committee indicated in its September, 1980 conference that for the 1980 year:

> "...farm income is expected to total $10,650,000, representing an increase of 14.3 percent over 1979, and the Production Cost Index is expected to increase 11.0 percent for the year, giving the farmers a net increase of 3.3 percent in income after taking inflation into account."

A copy of an article developing an economic analysis of the 10-acre farm is found in the appendix of this report.

Further problems of the Hawaii Papaya Industry were summarized in a presentation to the Agriculture Coordination Committee for the State of Hawaii on March 21, 1979. These problems or bottlenecks are listed in the order of importance as indicated by Dr. N. Kefford and Mr. W.T. Harada of the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa:

1. There is a lack of an economically acceptable alternative to EDB (ethylene dibromide) for fumigating papaya for export.
2. There is inadequate air-lift for exporting papayas and for shipping papayas from Hawaii and Kauai to Oahu for trans-shipment to export markets.
3. There is a lack of adequate control measures for post-harvest diseases and the lack of a full understanding and control measures for preventing the rapid deterioration of papayas after they arrive on the mainland.

4. There is inadequate market development for fresh papaya and papaya products.

5. Papaya mosaic virus continues to be a threat to the papaya industry.

6. Adequate weed control does not exist.

7. Papaya marketers stress the problems of a lack of continuity and reliability of supply.

8. Lack of freezing technology for papayas and inadequate information of aseptic packaging of papaya puree for overseas shipping.

9. Farmers cannot get the quantity and quality of people they need.

10. Methods to overcome the yield decline problem and the magnitude of the problem are not known.

11. Cultivators with resistance to papaya mosaic virus and fruit and root diseases are not available.

12. Lack of adequate control methods for powdery mildew.

13. Insufficient research on market potential and market development.

14. Insufficient information on what effect irrigation has on yield in Puna, Hawaii, and yield, fruit quality, fruit set, and sterility in Moloaa, Kauai.

15. Lack of adequate containers for surface shipments.

16. Lack of current costs and returns and profitability of papaya production.

17. Critical nutrient levels for trees up to 12 months of age and for trees over 30 months of age are not known. Minor and micro-element needs for trees older than 30 months are not known.

18. There seems to be a lack of understanding and specific information exchange between lenders and borrowers (farmers) on financing papaya farms.

19. Lack of adequate packaging and packaging systems for shipping papayas by air and surface.

20. Costs of ownership and operation of alternative mechanical harvesting methods for various-sized farms are not known.

21. Lack of an effective, registered chemical to control mites in dry production areas.

22. Many public rules and regulations put unnecessary burden on farmers.

It would seem that even though the papaya industry in Hawaii has existed since the 1940's, it is still in the infancy stage of sophistication in production and marketing technology. Although some of the problems listed above have been solved, most of the problems still remain.

PAPAYA PRODUCTS AND THEIR MARKETS

The U.S. Market

Three final products are common for the Hawaii papaya industry: Fresh papaya, papaya puree and dried papaya. At present, only fresh and puree papaya have developed a significant market. In 1981 approximately 48 million pounds of fresh papaya were packed and marketed, while approximately 1.6 million pounds of puree were processed from sub-standard papaya and marketed. This study concentrates on the mainland U.S. market.

The following sections examine the primary demand trends for fresh, processed and dried fruit, as well as their existing and potential markets for papaya products. Further, an examination will be made of the papaya industry's price, channels, promotion and product development strategies.

Per capita consumpiton of noncitrus, fresh fruit in the U.S. has been generally increasing since 1975.

Dried fruit consumption had generally decreased since 1960, but recently has demonstrated a positive trend.

The reasons for the increase in fruit product consumption per capita, and in total dollars of production, is due to changes in the values and attitudes of consumers. Essentially, these trends are as follows:[7]

1. There is a trend toward increased total family income, along with smaller households that increases family disposable and discretionary income. Today people can better afford to purchase those things they want most.

2. Households are generally younger and willing to try new things, such as eating ethnic type foods.

3. People are eating out more. Eating away from home is up 50% per capita, and restaurant sales account for about 35% of this increase.

4. People are losing their "sweet tooth" and becoming more nutrition conscious. A recent survry by Women's Day Magazine indicated that 71% of their women respondents said that nutrition was their primary concern when planning meals. 77% of those surveyed, indicated that this interest in nutrition had mushroomed within the last few years.

These favorable demand and attitude trends could be seized by the papaya industry in their efforts to expand to new markets. Especially significant, is the new consciousness of nutrition. Papaya is considered an exceptionally healthful food. In 7 ounces of papaya are contained 3,500 units of Vitamin A, 112 mg. of Vitamin C, 468 mg. of potassium and a significant amount of calcium. All of this, with less than 80 calories.[8]

Women's Day Magazine predicts:

> ...the whole new world of nutrition would prompt supermarkets to introduce more products and advertising tied in with physical fitness, to emphasize healthful snacks for those who have foregone meals, to develop more attractively packaged and easy to serve takeout foods, to emphasize more fresh fruits and vegetables and the balanced whole day diet.

The papaya industry should be ready to expand within these trends, introducing their products to an increasingly interested market while primary demand trends are favorable. Once a sizeable share of the fruit products market is attained, it is easier to maintain that share even in the face of less desirable trends.

Market development of all papaya products is considered an important priority among industry members. At present, little development is occurring. The Papaya Administration Committee is about the only agency responsible for market development. In 1980, they budgeted approximately $230,000 for promotion. Of this amount, the Japan market received $80,000, and the Hawaii market received $5,000. This leaves $145,000 for the large mainland market, or approximately 0.725% of fresh sales revenue for market development. This is well below the industry averages for all fruits which is approximately 1-5% of sales. When you consider that other fruit industries are maintaining markets, not developing them, the 0.7% of the papaya industry seems quite low. Additional investments in market development are required, if the industry expects to have any control over its growth.

The lack of effort can be partially explained by the industry's unfortunate past experiences in market development when primary demand trends were down. Indeed, many of the industry's most influential people seem genuinely afraid of their markets. This is due to a lack of understanding of the markets from a lack of information about these markets. Marketing research and development should be considered an investment in the future, just like a new growing process, or a new piece of equipment.

The Hawaii Market

Discussions with local retailers indicate that Kaamania Distributors is considered the best health food wholesaler in the state. They are located at 4025F Kulamana Street, Honolulu. An interview with Terry Hey, its president, provided valuable insight into the State's potential demand for dried papaya.

Kaamania Distributors normally sells in bulk to health food stores and/or departments for their own packaging. He did indicate an interest in distributing a prepackaged product. At present his papaya supply comes from Taiwan or the Phillipines via a California wharehouse. He distributes to about 150 outlets statewide (approximately 120 are health food stores).

The landed costs of the bulk dried papaya in Los Angeles is $1.20 a pound with a wholesale price around $1.65. The retail price ranges around $2.50 - $2.60 per pound in bulk.

The demand for bulk dried papaya is about 700-800 pounds a week and is slightly less than dried pineapple. Mr. Hey thought that the demand for prepackaged dried papaya could be 10 times that of bulk.

Kaamania Distributors indicated an interest in this pilot project and stated that they could sell to wholesalers in California.

Papaya Product Characteristics

The primary product of the papaya industry is the fruit sold fresh to the retail consumer through grocers and restaurants. These papayas provide the grower with most of his income. The farm price for papaya has been quite sensitive to the quantities produced and has ranged from 12 to 41 cents per pound with 20 to 30 cents being normal. Thr puree and dried papaya must be considered by-products of the industry since papaya used in processing provides the farmer with as little as 3¢ per pound.

Fresh Papaya

The Papaya Administrative Committee provides a market order for the industry. It established quality standards for the marketing of fresh papaya. These standards, to some degree, determine the proportion of total production that is available for the fresh and process markets. Some lowering of standards occur during times of short supply and elevating of standards during times of "excess" production. For example, with current production at 75% of expected, "culls" represent only 5% of total fruit. Normally the substandard papaya represent 15-20%.

Disagreement has surfaced as to the necessity of using USDA inspectors. Some packers feel this cost of continuous inspection (.005¢ per pound) is too high relative to the benefits. Certain packers have dropped the U.S. grading standards and are using Hawaii State Department of Agriculture standards. State inspectors spot check at no cost. The feeling is that packers do a good job of quality control with or without inspection. As long as all packers do a good job, few problems will probably occur in the market channels. However, if just one packer slips just a few times, the reputation of the papaya industry among retailers and their customers may decline. In the fresh fruit market, quality standards are essential and some control is needed.

Papaya Puree

The market for canned fruit nectar is expanding rapidly as people turn from sweet sodas, to more natural and healthful fruit juices. Companies like Kerns and Meadow Gold have demonstrated the ability to market the nectars of exotic fruits as well as common juices.

Although there has been more success in the retail marketing of canned juice drinks as opposed to frozen puree, some prospects of concentrated products look encouraging. The "aseptic" process of producing nectars allows a company to package individual cans that can be stored at room temperature. Since much of the world does not use frozen foods regularly, this new process provides a natural differential advantage to frozen juices.

Quality standards need investigation. One study of papaya puree marketing, for example, noted that test products were sweetened to Hawaii tastes and this was too sweet for most Mainland customers.[9] Other factors such as taste, smell and texture must also be considered. It is recommended that as market development is occuring, part of the effort be devoted to matching product characteristics to various markets' tastes.

Dried Papaya

Some dried papaya is presently sold in health food stores and included in "trail mixes". It is of very limited quantities at present, however, with most of the dried papaya being imported from Tiawain and the Phillipines.

In general, dried fruits and nuts are among the most common and best selling areas of many supermarket chains.[10] Some authorities estimate this segment is growing at 6% a year - twice that of other grocery products.[11]

Product Positioning

Most people knowledgeable of the industry consider orange juice, grapefruit and other breakfast fruit and juices to be papaya's most direct competition. These people assume that final consumers consider papaya a breakfast fruit. While this may be true of many of the current consumers, many other potential consumers do no know that papaya is only for breakfast.

With caloric consumption a concern among consumers, fresh papaya may be positioned along with cantaloupe as a desert. Similarly, the fresh and dried papaya may be considered a nutritious and healthful snack. The puree may be developed as the base for an all-day, refreshing and healthful drink as well as a base for use in cakes, yogurts and ice cream.

In any case, the industry along with each firm's marketing arm should promote the idea that all papaya products are nutritious, healthful and natural and can be used with any meal or as an in-between refreshment and snack.

Channels of Distribution

Channels Members

Generally, papaya packers sell 75% of their production direct to retailers or through a major marketing arm. These marketing arms may be organizations closely associated with the packers such as Mr. Papaya's Puna Processors or totally independent such as Puna Papaya's Californian Avocado Cooperative (Calavo). It would seem that each packing organization and each processor has a different marketing arm. This can pose problems in some cases. Castle & Cooke in 1977 proposed to the industry that they be allowed to distribute a significant majority of the fresh papaya grown in Hawaii. Their logic was that Hawaiian Papaya was competing against itself in the major markets. To some degree this is considered a true situation by industry members. On the other hand, some people feel that tying all output to one distributor has disadvantages in terms of channel control. By developing carefully worked-out agreements within an environment of cooperation, many industry gains could be had by consolidating the efforts of various packers and processors. If an attitude of trust cannot be maintained, packers and processors should carefully and continuously evaluate their major distributors. During the market development stages, this evaluation should include identification of channel members who distribute in areas presently under-supplied with fresh papaya and who are willing to strategically and financially cooperate with the firms' market development plans. Currently there seems to be some small movement in this direction.

Restaurants too provide a potential market for fresh papaya and papaya puree. While this channel of distribution may not provide the volume of other channels, this can serve to introduce new customers to papaya products. Consumers are eating away from home more today and they are trying new types of food, especially if it is ethnic or exotic and healthful. This trend, coupled with a promotion effort that cooperates with restaurant chains can develop a whole new market (restaurants) as well as stimulate demand in the grocery channels.

Physical Distribution

At present, the major U.S. Mainland destination points for fresh papaya are listed in the order of the quantities received as follows:

1. Los Angeles
2. San Francisco
3. Seattle
4. Portland
5. New York
6. Chicago
7. Detroit
8. Minneapolis
9. Boston
10. Washington, D.C.

Other major markets include Japan and Canada (Toronto and Vancouver).

Most of the fresh papaya reaches restaurants and grocers close to these major air transportation centers. The East Coast, Southern and Midwest states do not find much quality papaya available. Indeed, adequate marketing research can identify profitable pockets of customers within these areas who would enjoy consuming papaya and are willing to pay a fair price.

Markets outside the United States are also "ripe" for development. Many countries of the world are following trends similar to those in the U.S. A creative marketing and product development strategy can be devised to identify and open up new opportunities. While some effort has been made to enter the Canadian and Japanese markets, the efforts seem too weak relative to the results expected or relative to the potential that could be developed if more effort were provided.

Increasing transportation costs and overseas transportation availability uncertanties are definite concerns of the papaya industry in Hawaii county. The basic transportation alternatives for the Big Island to points within the United States are shown in Appendix D. As one may note, these alternatives are limited to air and ship transportation.

It is expected that both Matson and Young Brothers will continue servicing the Hilo Port indefinitely. While a ship is generally a low cost form of transportation, it takes from 7 to 10 days to reach the mainland U.S., the largest market for the Papaya Industry. This low cost and length of time may be useful in shipping puree and dried papaya in that a low cost storage function can be performed at the same time movement is occuring. For fresh papaya, however, speed of transportation is important since the shelf life of papaya shipped 1/4 ripe is approximately 10-14 days. The short-life and long transport time accounts for the 20% damage and over ripe rate during surface transportation.

As more and more mainland passenger airlines move out of the Hilo air terminal, alternative air routes to the mainland become increasingly limited. Papaya shippers interested in speed must investigate trans-shipping their merchandise via air to Honolulu. This increases the time to the mainland from 1 to 2 days. While this time period is reasonable, the cost of transporting by air is quite high. There seems to be no solution to the air transport problems in the near future.

Considering the fact that the aseptic process producing a puree requires no refrigeration, the lowest cost transportation alternative should be utilized. The dried papaya products requires no refrigeration and should also use the lowest cost for the transportation. The alternative transportation forms, along with their approximate cost per pound of puree or dried papaya, is summarized in the Appendix D of the pilot plant operations.

Promotion

Most of the promotion activities of the Hawaiian Papaya Industry have been left up to the Papaya Administrative Committee and the major distributors. Very little of this effort seems coordinated at present.

One study of the disappearance rate of fresh papaya at grocery stores[12] concluded that the major factors affecting this rate were:

1. its availability (channel member developed)
2. its appearance (product development)
3. quality of control carried from farm to retail outlets (product standardization and physical distribution)
4. attractiveness of the display (channel member cooperation)
5. the degree of in-store promotion and of store-identified newspaper advertising.

The last factor indicates the need of the industry's packers and processors to coordinate and cooperate with distributors and retailers in developing markets. Once supply quantities and quality standards are guaranteed within a market area, retail grocers will be ready to assist in stimulating demand for papaya. One study indicated that grocers would be willing to promote papaya at substantial discounts (perhaps below cost) to develop store traffic[13] as well as help introduce papaya to new customers. Another study concluded that television promotion of papayas was not as effective as newspaper advertising emphasizing special papaya prices in developing demand.[14] Special introductory prices have the effect of reducing the pre-decision risk for people trying a new product. This type of introductory strategy might be quite effective in times of excess papaya production. Instead of dumping supplies on established markets forcing prices downward, direct excess production to new markets and consider the cost of production a market development expense. During a recent excess production period, the "surplus" was dumped in the garbage.

In any case, it is essential that the selling and market development budget be wisely spent, concentrating on developing one or a few markets at a time, and gaining the cooperation and assistance of all channel members.

While developing the market for fresh papaya will help develop the market for dried and puree by-products, reverse strategies may also be utilized. If processed papaya can be incorporated into other products, such as desserts, trail mixes, exotic drinks, consumers can be introduced to the papaya taste while consuming more familiar products.

Prices

Prices of fresh papaya vary considerably from year to year and season to season. Much of this variation is due to the total supply of fresh fruit in the market. Another consideration is when consumers normally eat fresh fruit. Since 1978 the annual average farm prices of fresh papaya shipped to the Mainland varied from 12¢ per pound to 25¢ per pound. In 1980, the price packers receive varied similarly to the farm price but averaged to about 40¢ per pound. As noted in Table 2, monthly average prices vary dramatically.

Much of the price variation can be reduced through effectively matching the supply with demand. In times of excess supply relative to established market demand, firms in the industry can

1. Channel fresh fruit to market development areas for special promotions with retailers.
2. Channel some fresh fruit to the product production of puree and dried papaya. In this way, excess papaya can be stored in another form. When demand is high, channel less into the by-product area and sell off the stored inventory.

Also, the prices of all papaya products may be made more stable through proper product positioning. By developing a papaya product image of a nutritious, healthful, exotic, fruit, it becomes more compatible with the attitudes and desires of the current market. If the product image is accepted and believed, a more inelastic price will result. This provides the industry with more price control and with a stronger position from which to negotiate and cooperate with channel members.

TABLE 2

PAPAYAS: Monthly average fresh papaya farm price per pound, by place of sale, State 1980-81

Year and place of sale	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
						Cents							
1980 Local......	34.0	39.0	43.4	44.7	36.8	31.3	28.8	23.8	22.4	22.6	21.8	21.4	29.3
Mainland...	23.0	34.2	38.0	37.9	21.2	21.4	16.2	20.2	14.7	9.5	13.6	11.2	18.6
Foreign....	18.5	18.0	25.6	26.5	24.4	24.7	21.8	18.5	18.0	18.5	17.9	17.5	20.7
All........	25.2	32.8	37.4	38.1	25.7	24.5	20.2	20.9	17.1	13.6	16.3	14.6	21.7
1981 Local......	20.9	25.8	28.4	26.8	25.9	25.0	20.6	25.4	26.4	19.2	16.6	21.4	23.5
Mainland...	16.1	26.4	24.7	23.4	23.8	25.8	21.6	25.4	19.7	11.4	12.4	13.1	20.5
Foreign....	18.2	18.5	21.5	20.9	21.2	19.7	18.7	16.6	17.9	10.1	14.2	14.8	18.1
All........	17.6	25.1	25.1	23.8	23.8	24.7	21.0	24.1	20.7	13.2	13.6	15.5	20.8

Source: Papaya Administrative Committee Monthly Report

Because of storage function feasibility, dried and pureed papaya have less price fluctuations. Pureed papaya average at 30¢ per pound, FOB-Destination. The negotiation for better terms should be possible as the market for all papaya products increase. The retail price of dried fruit now ranges between 1.59¢ per pound to $4.00 per pound in bulk. Since papaya is an "exotic" fruit, it is expected the $4.00 price is attainable.

SUPPLY OF PAPAYA PRODUCTS

In 1978, the industry's peak year of production, over 83 million pounds of papaya were produced with approximately 5% being unusable. Of the remaining, approximately 54 million was sold as fresh papaya and 9 million used in puree production. Over 15 million pounds of papaya was not used or sold by the farmer. Also in 1978 growers yielded 29,200 pounds per acre. A technical description of the papaya fruit industry, cultivation and composition is included in the "Fruits available for Processing" section.

Considering the fact that approximately 2900 acres of Big Island land is under the control of papaya growers, it is possible that over 80 million pounds of usable papaya could be produced by the Big Island alone. Another 10-20 million can be produced on the other islands. This represents the short-run potential.

Additional land is available in the Puna District for papaya production. The State of Hawaii has approximately 1080 acres of land available for lease that could be used. Additionally, the Hawaiian Homes Commission and private individuals have acreage not otherwise being used. The State's acreage alone represents a possible 30 million pounds of new papaya production. Additional acreage has become available due to the closing of AmFac's Puna Sugar operation.

Supply is not a problem. If farmers can be shown that it will be profitable it is assumed they will increase production. Growers are cautious because it costs $1200 to $2000 an acre to prepare new land for planting.

The supply of fresh papaya (the farmers money crop) is dependent upon expected prices which is dependent upon demand. The supply of sub-standard papaya for processing into puree or dried papaya is dependent upon how much fresh papaya growers are willing to produce.

To compete in the market for puree and dried papaya, low cost sources of papaya are necessary. Because of the low price paid to farmers for their "culled" papaya, the pureed and dried papaya must of necessity be considered a by-product of fresh papaya production. It should be noted here that some research is being performed to develop a low cost, large "melon-type" papaya for processing purposes. To date no such product is on the market.

A potential supply problem may exist for both puree and dry processors if they rely totally on substandard papaya. Table 3 examines papaya production yields and the type of utilization from 1970-1980.

One may note the effects of poor production years on the fruit available for processing. It is possible that high demands for processed fruit during bad production years could force the price of substandard fruit up from its exceptionally low average of 3-5 cents per lb.

Fresh Papaya Packing

There are five major companies that pack and process papaya. These organizations along with the number of acres from which their papaya come and the total number of acres each has available for production are as follows:

Company	Total Acres Available	% of Total
Puna Papaya	1255	43%
Mr. Papaya	750	26
Ono Pac	400	14
Diamond Head	300	10
Del Monte	200	7

TABLE 3

PAPAYAS: Number of farms, acreage, yield, utilization, price, and value, by islands, 1976-80

Year	Farms[1]	Acreage harvested[1]	Yield per acre	Utilized production	Utilization		Price per pound			Value of utilized production
					Fresh	Processed	Fresh	Processed	All	
	Number	Acres	1,000 pounds				Cents			1,000 dollars
					STATE					
1976	178	1,930	25.9	50,037	43,588	6,449	13.5	3.8	12.3	6,134
1977	186	2,155	29.5	63,548	53,987	9,561	13.2	2/ 4.7	11.9	7,565
1978	183	2,190	29.2	64,000	54,624	9,376	14.4	2/ 4.6	13.0	8,304
1979	194	2,210	18.6	41,015	36,446	4,569	25.6	2/ 4.0	23.2	9,510
1980	197	1,950	24.9	48,916	45,360	3,556	21.7	2/ 3.4	20.4	3/ 9,979
					HAWAII					
1976	116	1,670	23.7	39,548	37,652	1,896	12.9	3.5	12.5	4,923
1977	113	1,745	24.1	42,000	40,479	1,521	12.7	2/	12.3	5,186
1978	108	1,740	25.2	43,860	41,656	2,204	13.6	2/	13.1	5,738
1979	112	1,820	16.8	30,565	27,129	3,436	24.2	2/	21.9	6,680
1980	108	1,665	24.5	41,255	37,947	3,308	21.1	2/	19.7	8,127
					KAUAI					
1976	32	100	26.2	2,624	2,621	3	17.6	4/ 4.9	17.6	461
1977	32	155	40.0	6,196	6,195	1	5/ 13.2	2/	5/ 9.9	5/ 2,000
1978	28	135	39.0	5,263	5,117	146	5/ 15.4	2/	5/ 11.4	5/ 2,094
1979	32	160	35.4	5,672	5,413	259	5/ 27.8	2/	5/ 25.4	5/ 2,422
1980	37	200	30.5	6,096	5,967	129	5/ 20.8	2/	5/ 20.5	5/ 1,286
					MAUI/MOLOKAI					
1976	6	110	58.5	6,432	1,885	4,547	11.7	3.9	6.2	398
1977	5	210	66.4	13,939	5,919	8,020	5/	2/	5/	5/
1978	5	260	50.6	13,167	6,152	7,015	5/	2/	5/	5/
1979	7	165	23.4	3,866	3,035	831	5/	2/	5/	5/
1980	4	10	17.6	176	176	0	5/	2/	5/	5/
					OAHU					
1976	24	50	28.7	1,433	1,430	3	24.6	4/	24.6	352
1977	36	45	31.4	1,413	1,394	19	27.1	2/	26.8	379
1978	42	55	31.1	1,710	1,699	11	27.8	2/	27.6	472
1979	43	65	14.0	912	869	43	46.7	2/	44.7	408
1980	48	75	18.5	1,389	1,270	119	44.7	2/	41.1	571

1/ Average of monthly estimates.
2/ Island data not shown separately to avoid disclosure of individual operations but combined and included in the State total.
3/ Sum of island estimates may not add to State total due to rounding.
4/ Kauai and Oahu processed combined to avoid disclosure of individual operations
5/ Kauai and Maui combined to avoid disclosure of individual operations.

SOURCE: Statistics of Hawaiian Agriculture 1980

These figures provide an indication of the potential supply of papaya available to each packer at the present time. It should be noted that Puna Papaya, and AmFac company, now produces 36% of the Island's papaya. With the acreage under its control, and its more aggressive marketing plans, Puna Papaya is expected to produce about 43% of the papaya by 1985. This assumes the industry will grow at a 8-10% rate per year and no change in marketing technique of the other packers will occur. The current papaya acreage utilization is shown in Table 4.

At the present time, Puna Papaya is the only company that culls the papaya at their plant. The farmers who sell and distribute through Mr. Papaya, Diamond Head, and Ono Pac, do most of the culling in the field and bring the rest to these distributors which in turn do their own culling and sell the rejected fruit to Suisan Fruit Processing or Hawaiian Fruit Flavors for puree processing.

TABLE 4

PAPAYAS: HARVEST acreage and fresh utilization with comparisons, May 1982

Island	Total acreage in crop		Acreage harvested		Acreage for harvest	Fresh utilization		Expected fresh utilization
	Apr. 1, 1981	Apr. 1, 1982	May 1981	April 1982	May 1982	May 1981	April 1982	May 1982
			---Acres---			---1,000 pounds---		
Hawaii........	2,630	2,680	1,720	1,950	2,010	4,094	3.430	4,160
Kauai.........	340	225	250	140	125	741	245	250
Maui/Oahu[1]....	120	130	75	90	90	135	85	90
State	3,090	3,035	2,045	2,180	2,225	4,970	3,760	4,500

1/ Combined to avoid disclosure of individual operations.

Source: Papaya Administrative Committee monthly report.

PAPAYA PROCESSING

If PAC projections are correct and assuming 20% of fresh papaya are considered culls, by 1985 approximately 16 million pounds of papaya can be available for processing pureed or dried fruit.

At present, there are three major companies making puree, Puna Papaya, Suisan Fruit Processing and Hawaiian Fruit Flavors. Puna Papaya deals solely with papaya while the others process guava and passion fruit as well. The Big Island's total production capacity devoted to papaya is estimated at 5000 to 6000 pounds per day. Except for Puna Papaya, the demands of puree processors for guava and passion fruit is increasing.

La Malo'o, a new papaya drying operation, produces approximately 500 lbs of dried papaya a month using an experimental solar heat process. The product is good, a bit sticky and tastes much like apricots. If 10 million pounds of papaya were available for processing, it is estimated that approximately 800,000 pounds of dried papaya would result.

The following describes the production technology required in the packing and processing of papaya products.

Fresh Papaya Packing

In the typical packing plant, the papaya is received in field boxes. These boxes are dipped in 120°F water for 10 minutes to kill any larvae on the skin. The boxes are then sprayed with cold water to prevent over-heating of the fruit. After heat treatment, the papaya is fumigated with ethylene dibromide and is ready for packing.

In the packing plant, the papaya is sorted by its ripeness and size. They are then packed into different size boxes for shipment. Refrigeration of the packed boxes is needed until actual shipment.

Puree Processing

The typical puree processing plant, washes the papaya before entering a slicer. The sliced papaya are then mashed, and seeds and skin separated from the pulp through a rotating sieving system. The juice is then chilled and pH of the juice adjusted. The chilled juice is packed in plastic bags or drums for shipment. The main disadvantage of this processing is that the juice needs refrigeration throughout the distribution process.

A new process called the asceptic process has been established. In this process the juice is heated to 205°F for a set time and quickly chilled to 80°F and packed under sterile conditions in containers. The advantage of this process is that the finished product need not be refrigerated.

Papaya Drying Process

The papaya drying is normally done by first removing the skin and seeds. Then, the product can be either dried in halves or quarters or in 1"-2" chunks. The optimum drying temperature is between 140-150°F and the drying time is approximately 24 hours depending on the ambient humidity. The finished product can be either 15% moisture apricot-like product or 5-6% dried product.

PILOT PLANT FACILITY

At this time the specific pilot plant design parameters are nebulous, but preliminary evaluation of basic inputs have been considered. The following then describes these factors for an assumed pilot plant operational duration of 12 months.

PLANT DESCRIPTION

A verbal commitment for supplying 1,000 pounds papaya fruit per day has been reached by Dr. Bill Chen of RCUH and Mr. Peter Hauaunio representing papaya farmers of Puna Hui Ohana. It will assure a daily supply of 1,000 pounds papaya, five days a week delivered at the pilot plant site. Price will probably be a function of prevalent market prices at the time of delivery, although fixed rates might also be negotiated. The current price for papaya culls is $0.03 per pound of delivered fruit.

Based on the availability of 1,000 pounds of delivered fruit, the pilot plant capacity was selected to be 1,000 pounds per day, operating 5 days per week. Figure 1 shows a tentative plot plan of the pilot plant facility at the HGP-A power plant site. Specific information regarding the pilot plant are listed below.

1. Building (Figure 2)
   a. A standard pre-engineered metal frame building (20' x 30') houses the papaya receiving, fruit preparation and packaging, dryer product storage, and administrative/office functions.
   b. A concrete floor slab is utilized throughout building.
   c. Office preparation and dryer areas are screened for insects but have no ceiling.
2. Utilities and Resource
   a. Geothermal brine is available via an existing 3" diameter pipeline

running within 50 feet of the building. A one inch tap-off is assumed for the pilot plant facility. Total flow in the 3" pipe is not less than 100 gpm at 160 psig (±), saturated.

b. Electricity is available at $0.054 per kWh from the HGP-A power plant for pilot plant work. Any follow-on commercial venture would be subject to regular HELCO rates. Depending on the actual consumption of such a venture, rates could be considered under any of several schedules G, H or P, included in Appendix A. The fuel adjustment rate referred to in each schedule was $0.0415825 per kWh as of June 1, 1982.

c. Potable water is available from two sources. The first is from the power plant system and the other is directly from the County water main. Each source ultimately is tied into the County system. The assumption for the pilot plant has been that water would be made available from the power plant and metered at the pilot plant. Should a tap directly into the County 8" main be required, an estimated $2,250 charge is anticipated for a 1" meter (60 gpm) or $7,000 for a 2" meter (160 gpm). Assurances have been verbally made by the Department of Water Supply for granting a 1" meter. A 2" meter hook up approval, however, is subject to system supply evaluation at the time of application. Water is presently being charged at $0.82 per thousand gallons, with a nimimum charge of $6.50/month.

d. Service air will be available to the pilot plant from the power plant at 100 psig if it is required. No provision has been made in the cost estimate to pipe this air to the pilot plant.

e. Instrument air has been assumed to be generated by a pilot plant compressor. Alternatively, power plant service air can be utilized after filtering and dehumidification.

f. Hot water is assumed generated by an electric hot water heater at the pilot plant.

g. Wash down waste water is assumed to be handled by a separate cesspool near the building. The cost of the cesspool is reflected in the cost estimate for the pilot plant. There is no sewer system servicing the general area of the HGP-A site.

To determine the process flow requirements of the papaya system, 14 papayas were picked at random from the Del Monte packing facility in Hilo on June 2, 1982. The ends of the fruit were cut off, then the fruit peeled, and de-seeded. Measurements and weights were recorded. Table B-1 shows the test data, indicating feed stock to the dryer will be about 70% of raw fruit weight. While the sampling is relatively small, it does indicate ball park numbers, and was deemed sufficient for the present purposes. Figure 3 shows a process flow diagram of the pilot plant.

Further testing of the fruit to determine more exact process flow streams is recommended prior to any pilot plant design. More samples of actual culls from Puna Hui Ohana should be used as well as informational input from Foremost McKesson on process requirements, to determine a statistically definable test.

Figure 4 describes in general, the possible utilization of geothermal waste heat for the pilot plant. One option is to use the geothermal brines directly while the other option utilizes a cleaner flashed steam at a lower pressure. The preliminary control scheme of the dryer is presented in Appendix C. The proposed controls allow for unattended operation of the dryer during the evening hours.

The operation of the pilot plant then involves receiving and preparation and loading of the fruit during the day. Drying would commence in the afternoon and continue unattended overnight. The dried batch of papayas is removed from the dryer the following day and packaged and a new batch of papayas is loaded for drying. Five batches are processed per week, necessitating a Monday through Saturday operation.

MANNING REQUIREMENTS

Projected staffing for this project are three operators and an on-site program manager. The program manager will coordinate all work including test programs. Compilation and evaluation of data will also be part of the manager's function. Work assignments of the three operators are listed in Table 1. Work hours will be 7 hours per day Monday through Friday and 5 hours on Saturday.

CAPITAL COST REQUIREMENTS

Capital cost of the facility is estimated to be $200,000, which includes a building, dryer, office, preparation area, and all piping and equipment. Table 2 shows the capital cost breakdown of the base test facility. Table 3 reflects a cost additive should the cleaner steam system of Figure 4 be incorporated.

PILOT PLANT PROGRAM COST

Total predicted pilot plant program cost is $300,000 for the twelve month test program. Plant construction and engineering contributes $200,000 of this cost, while O & M will cost $100,000. In the predicted cost above, there is no allocation for expenses and labor to be incurred by Foremost McKesson and RCUH.

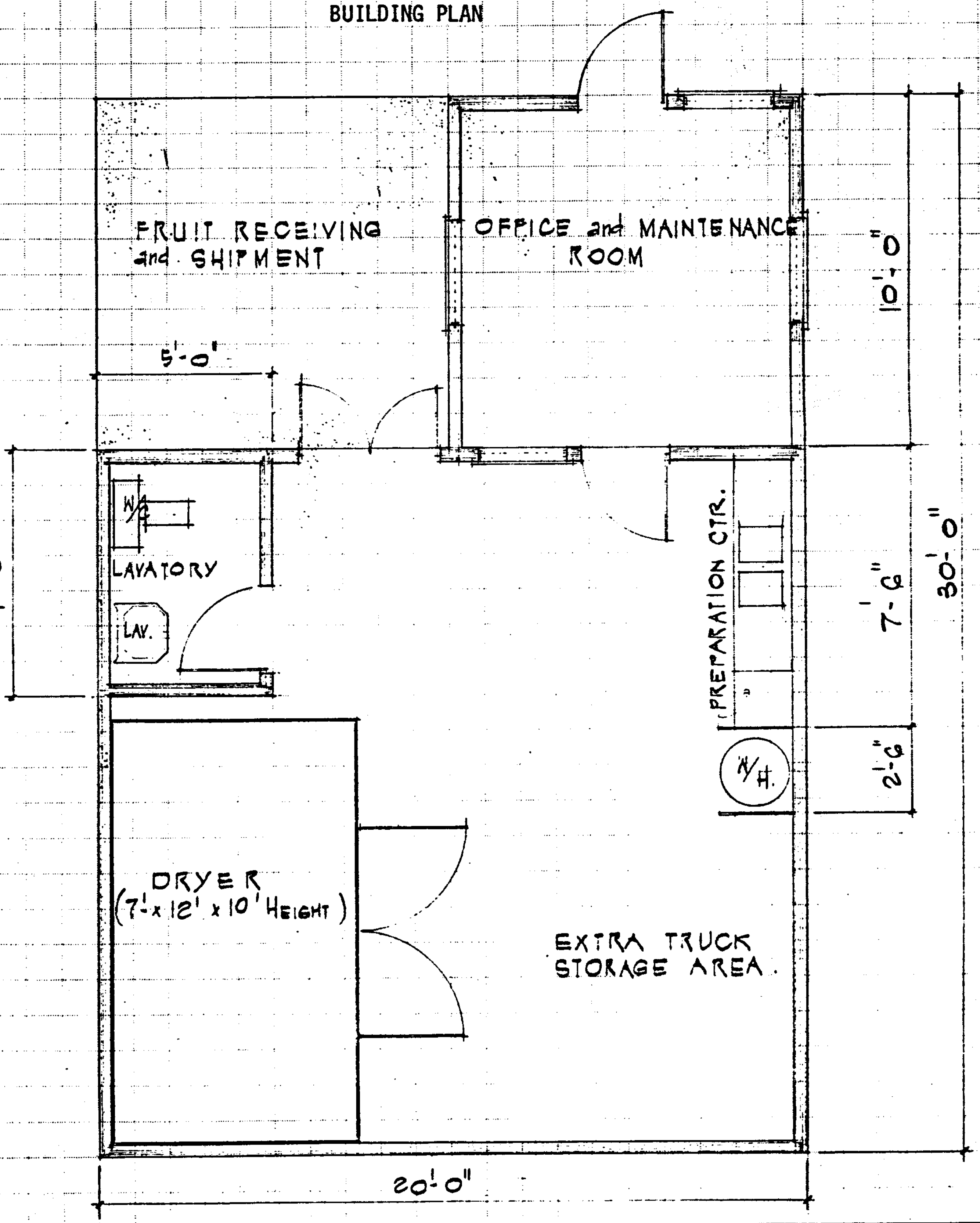
OKAHARA, SHIGEOKA & ASSOC. INC.
Engineering & Planning Consultants
200 Kohola Street
HILO, HAWAII 96720
(808) 961-5527

JOB ______
SHEET NO. ______ OF ______
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

FIGURE 2

PAPAYA DRYING TEST FACILITY ~ PLAN

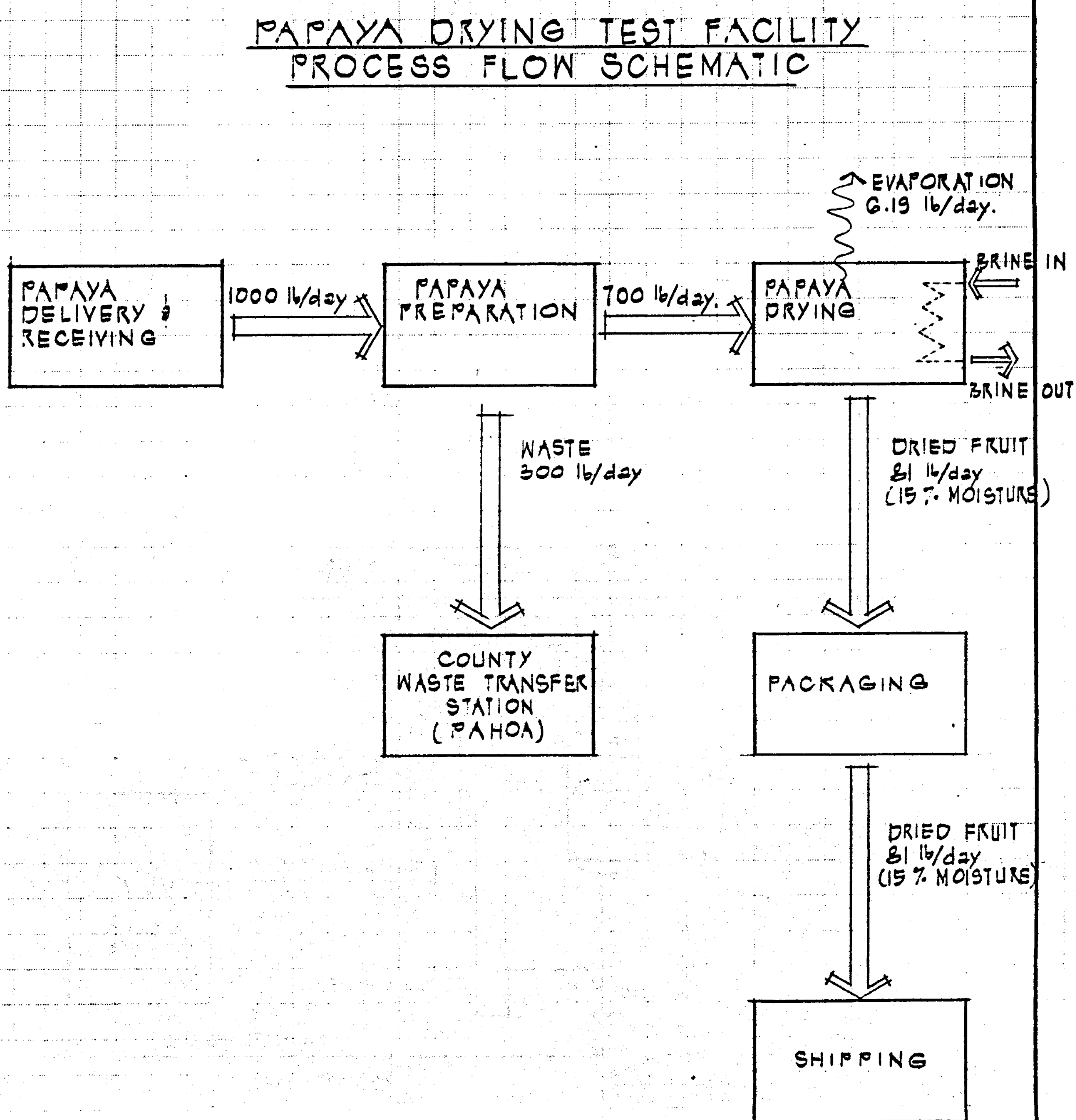
BUILDING PLAN



OKAHARA, SHIGEOKA & ASSOC. INC.
Engineering & Planning Consultants
200 Kohola Street
HILO, HAWAII 96720
(808) 961-5527

JOB
SHEET NO. OF
CALCULATED BY DATE
CHECKED BY DATE
SCALE

FIGURE 3



OKAHARA, SHIGEOKA & ASSOC. INC.
Engineering & Planning Consultants
200 Kohola Street
HILO, HAWAII 96720
(808) 961-5527

JOB 0224
SHEET NO. ______ OF ______
CALCULATED BY WW DATE 5/2/82
CHECKED BY ______ DATE ______
SCALE ______

FIGURE 4

PAPAYA DRYING TEST FACILITY
BRINE FLOW SCHEMATIC

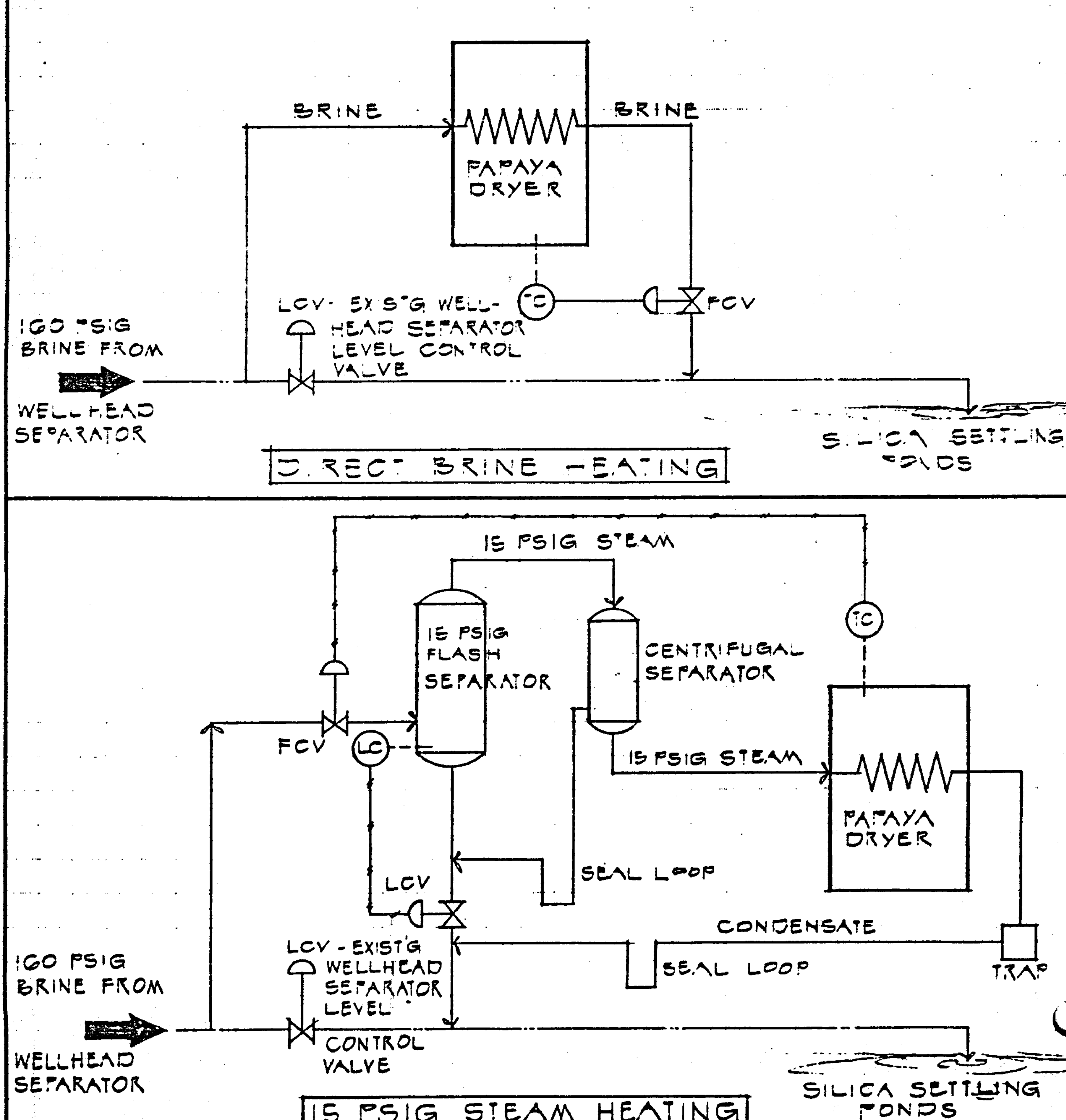


TABLE 1

PAPAYA TEST FACILITY

PROPOSED WORK SCHEDULE

	FUNCTION	PERIOD		MANHOURS
1.	Remove trays, package, label, box	Mon - Fri		6.0
2.	Prepare fruits @ 45 seconds per fruit, 800 fruits @ 1.25 pounds	Mon - Fri		10.0
3.	Stack fruit on trays	Mon - Fri		1.0
4.	Wash down and sanitation	Mon - Fri		1.0
5.	Waste disposal @ Pahoa	Mon - Fri		1.0
6.	Miscellaneous work and personnel	Mon - Fri		2.0
			SUBTOTAL	21.0
7.	Remove trays, package, label, box	Sat		6.0
8.	Deliver product for shipment	Sat		4.0
9.	Miscellaneous R & M, personal	Sat		5.0
			SUBTOTAL	15.0
		WEEKLY GRAND TOTAL		120.0

TABLE 2

PAPAYA DRYING TEST FACILITY

COST ESTIMATE

ITEM		COST
1. SITE WORK		$ 5,500
A. Mobilization, L.S.	500	
B. Grading, L.S.	1,000	
C. Paving, $10/SY	4,000	
2. BUILDING (20' X 30')		37,200
A. 4" Slab and Foundation, $400/CY	3,200	
B. Structure, including painting, $30/SF	18,000	
C. Electrical, including dryer fans, L.S.	11,000	
D. Office/Maintenance furniture, equipment, L.S.	5,000	
3. DRYER		31,700
A. Base price ($25,000), plus 10% freight and insurance (National Dryer)	27,500	
B. Ductwork, L.S.	1,000	
C. Installation, L.S.	3,200	
4. DRYER INSTRUMENTATION		41,275
A. Recorder, Doric Digetrend 235	5,500	
B. Temperature Controllers (2) Fisher 5190 Series	2,200	
C. 1" Brine Control Valve, Fisher GS with Fisher 513 Actuator	400	
D. Damper Actuators (2), Fisher 656 Long Stroke Spring and Diaphragm	500	
E. Relative Humidity Transmitters (2) Yellow Springs Instrument Co. YSI	1,000	
F. 1" Brine Flowmeter, Hershey with Transmitter, Register and Pulse Output	950	
G. Temperature Sensors (7), Resistance Temperature Detector (RTD) Type	525	
H. Pressure Sensors (6), with Analog Converter	3,000	
I. Infrared moisture sensor, same model as used in commercial peach and pear drying, Moisture Register Co.	14,000	
J. Miscellaneous Instrumentation, Supplies, Piping, L.S.	6,000	
K. Installation, 3m X 6d X $50 X 8	7,200	

Table 2
Page Two

5.	PROCESS PIPING AND INSULATION		$15,600
	A. Materials, PVF, L.S.	6,000	
	B. Installation 3m X 8d X 50 X 8	9,600	
6.	PORTABLE WATER		3,200
	Assume 4 fixtures at $800 each		
7.	SANITARY WASTE		4,500
	Cesspools, L.S.	3,000	
	Plumbing, L.S.	1,500	
8.	ENGINEERING		20,000
9.	SUBTOTAL		158,975
10.	CONTIGENCY, 20%		31,975
11.	SUBTOTAL		190,770
12.	STATE GENERAL EXCISE TAX, 4%		7,630
13.	GRAND TOTAL		$198,400
		SAY	$200,000

TABLE 3
PAPAYA DRYING TEST FACILITY
ADDITIVE COST ESTIMATE
FOR 15 PSIG STEAM SYSTEM

1.	Flash Separator with Level Controller		$12,000
	a. Separator, L.S.	$11,000	
	b. Shipping & Insurance 10%	1,100	
2.	Centrifugal Separator		2,200
	a. Anderson	2,000	
	b. Shipping & Insurance 10%	200	
3.	Instrumentation		400
	1m X 1d X 50 X 8		
4.	Process Piping		2,900
	a. Materials	500	
	b. Labor 3m X 2d X 50 X 8	2,400	
5.	Insulation		6,800
	a. Materials	2,000	
	b. Labor 3m X 4d X 50 X 8	4,800	
6.	Engineering		2,500
7.	Subtotal		26,900
8.	Contingency		5,380
9.	Grand Total		32,280
		SAY	$35,000

TABLE 4

PAPAYA TEST FACILITY

PREDICTED 12 MONTH PLANT OPERATION AND CAPITAL

DESCRIPTION		COST DOLLARS
1. Labor		$ 55,000
a. Manager @ 2,000/mo., 25% fringes	$30,000	
b. Operators, (3), @ $4.00/hr., 25% fringes	25,000	
2. Electricity @ $0.054/kWh		2,100
a. A/C @ 1kw, 44 hr/wk	2,288 kWh	
b. Fans, Circulation & Exhaust, @ 5 kw total connected, 80% utilization, 20 hr/day, 5 day/wk	26,000	
c. Lights @ 1kw, 44 hr/wk	2,288	
d. Hot water, 70°F to 120°F, 100 gal/day, 5 day/wk	3,170	
e. Miscellaneous uses, hot pad, oven, compressor, instrumentation, 2kw, 44 h/wk	4,576	
	38,322 kWh	
3. Potable Water, L.S. @ $10/mo		100
4. Shipping (products)		1,700
a. Truck delivery @ 45 mi per day, 1 day/wk, @ $15/mi	350	
b. Ship delivery to West Coast @ freight rates per Appendix D, @ 35 pounds per cubic feet, 81 x 5 = 405 pounds/wk	1,355	
5. Transportation (personal & waste)		4,400
pick up truck rental @ $300/mo., 12 mo	3,600	
Mileage, 5,000 mile/yr., @ 0.15/mile	800	
6. Tradesperson callout		10,400
Repair and adjustment of equipment 8 hr/wk, $50/hr., 1/2 yr.		

Table 4
Page 2

7.	Fruit purchase @ $0.03/LB., 1,000 pounds/day, 5 day/wk.		7,800
		SUBTOTAL	$ 81,500
8.	Contingency, @ 20%		14,700
		SUBTOTAL	96,200
9.	Round Off	SUBTOTAL	100,000
10.	Plant Capital Cost		200,000
		GRAND TOTAL	$300,000

Hawaiian Fruits Available for Processing

Included in this section is a brief description of the cultivation and chemical and nutrient composition of fresh fruits produced in the State of Hawaii. These can be available for processing and include Banana, Guava, Mango, Papaya and Pineapple. Annotated Bibliographies for each is found at the end of this report.

BANANA

Banana, Musa spp., (Musaceae) are native to the tropics of the old world and are now common in tropical America and Asia. Bananas require about 6-7 inches of rain monthly, a temperature range between 70°-85° F with gentle trades to provide air circulation within the orchard. Plants should be planted where they receive full sun and in soils that are well drained and aerated. Banana plants are propagated vegetatively by means of suckers. The planting space will vary from 8' x 10' to 18' x 18' depending on the variety to be planted.

Dried banana products come in several forms. Banana "figs" are whole or half dried bananas and have been known since the 11th century. Prior to modern technology, banana figs were dried in the sun. Currently they are dried in a forced draft oven or a tunnel dryer to 17-20% moisture content. Freeze and osmo-vac are other methods of drying bananas. Banana puree may be placed in a drum dryer to form banana flakes.

Nutritionaly, half ripe bananas consist primarily of starches where as ripe bananas consist of sugars. The composition of bananas (Williams hybrid) per 100 grams of the edible portion are as follows:

Moisture	71.33%	Phosphorous	17.5 milligrams
Food energy	100.0 Calories	Iron	0.49 milligrams
protein	1.08 grams	Vitamin A	88.0 micrograms
Fat	0.13 grams	Thiamine	0.044 milligrams
Total Carbohydrate	26.56 grams	Biboflavin	0.045 milligrams
Fiber	0.11 grams	Niacin	0.690 milligrams
Ash	0.90 grams	Ascorbic Acid	5.1 milligrams
Calcium	5.0 milligrams		

As of 1980 there were 159 banana farms in the State totaling 1,310 acres of which 580 acres were harvested yielding 4,600,000 lbs. For the same year the island of Hawaii had 25 farms totaling 265 acres of which 105 acres were harvested which yielded 1,560,000 lbs.

GUAVA

Guava, Psidium guajava L., (Myrtaceae) is a low evergreen tree or shrub six to 25 feet high, with wide-spreading branches and square, downy twigs, is a native of tropical America. Guava grows in all soil types in Hawaii from sea level to the 3,000' elevation. However the best available land should be used if maximum production is desired. Planting space should be 8' x 24'. This spacing will result in maximum production and profitability in the shortest time. As a rule of thumb, 1 lb (CTA Mac #4 or CTA Mac #8) fertilizer per year per inch diameter of the guava main trunk is recommended to be applied twice a year. The time between flowering and harvesting is 5 to 6 months depending on environmental conditions, and in general there are two harvests per year. After planting, it requires three years before fruits are harvested. Maximum production is generally attained seven years after planting (35,000 lbs/acre).

Guavas trees are propagated by means of grafting to insure the true guava cultivar. Commercial processing cultivars include Beaumont B-30, Ka hua kula No. 097, Puerto Rico No. 2, Pink acid and Patillo. Most commercial growers in Hawaii plant Beaumont B-30 or Ka hua kula No. 097.

Guava is a good source of niacin and vitamin C. The rind portion contain more vitamin C than the pulp and seeds. The composition of guava per 100 grams of edible portion include the following:

Moisture	81.75%	Phosphorous	21.6 milligrams
Calories	65.0 calories	Iron	1.49 milligrams
Protein	0.75 grams	Vitamin A	109.0 micrograms
Fat	0.24 grams	Thiamine	0.037 milligrams
Total Carbohydrate	16.76 grams	Riboflavin	0.053 milligrams
Fiber	6.84 grams	Niacin	1.28 milligrams
Ash	0.50 grams	Vitamin C	70.350 milligrams
Calcium	9.5 milligrams		

The primary use of guava is for jams, jelly, and juice. In some tropical countries a paste is made from guava puree by boiling it. This paste is further dried in the sun as a thin sheet spread on trays forming "leathers." Guava puree can be foam dried

MANGO

Mango, Mangifera indica L., (Anacardiaceae) is an evergreen fruit tree native o Southeastern Asia. Mango is grown throughout the Hawaiian islands. There are more mango trees planted in backyards than those in commercial plantings. There are approximately 300 acres of mango in commercial plantings, most of which are located in Maui. Mangos grow from sea level to about 2,800'. The tree is not difficult to grow and is tolerant to drought and poor soil conditions, but require soils with good drainage. Commercial mangos are grown where the rainfall is less than 60" per year. Best yields are obtained where trees are exposed to continous full sun.

There are many mango varieties, but established varieties include Haden and Pirie. Other varieties include Ah Ping, Zill, Gouveia, Irwin, Joe Welch, Kensington, Kent, Julie, Buchanan, Ono, Waterhouse, Edwards, Pope, Fairchild, Georgiana, Momi K. and Smith. If a particular variety is desired, the plant should be grafted, but the trees may be grown from seed. Trees should be planted 35-40 feet apart. Grafted mango trees usually produce a few fruits by the fourth year in dry lowland areas. Crops of 25-400 lbs/tree can be expected in the 5th to 7th year if flowering occurs. Yields of 200-1,000 lbs/tree can be expected between 8-14 years. Trees over 15 years have been reported to have crops over 1,000 lbs/tree.

Mangos are a good source of provitamin A. The composition of the mango fruit (Haden) per 100 grams edible portion are as follows:

Moisture	84.12%	Phosphorous	10.4 milligrams
Food Energy	56.00 calories	Iron	0.16 milligrams
Protein	0.39 grams	Vitamin A	2813.0 micrograms
Fat	0.07 grams	Thiamine	0.041 milligrams
Total Carbohydrates	15.05 grams	Riboflavin	0.057 milligrams
Fiber	0.54 grams	Niacin	0.30 milligrams
Ash	0.42 grams	Ascorbic acid	15.1 milligrams
Calcium	8.1 milligrams		

Enzymes present in the fruit include peroixdase, catalase and polyhenolase.

Mangos can be processed into puree and can be drum dried to form dried flakes or powder with 3% moisture content.

PAPAYA

Papaya, Carica papaya L., (Caricaceae) is native to tropical America. It is a rapid growing, hollow single stemmed, short lived perennial which can attain a height of 25 feet or more under favorable environments. The principal commercial producing area is Kapoho in the Puna District of the island of Hawaii (up to 300' elevation). There are several varieties which have been developed in Hawaii. They include, Solo (Introduced from Barbados and Jamaica), Line 5, Line 8, Kapoho, Masumoto Solo, Line 10, Sunrise Solo and Waimanalo. These varieties are derived from the Solo papaya.

Papayas are capable of growing in most soils having soil pH of 6.5-7.0 with good drainage. The annual rainfall of papaya growing areas range from 60-100 inches per year. The best temperature range for papaya growth range from 69.7^{o} to 80.8^{o}F. Papaya trees that have well developed root systems can tolerate winds up to 50 mph although wind breaks are recommended in windy areas.

Plants are started from fresh seeds which germinate within 10 to 14 days. Six weeks after germination the seedlings are thinned-out with the exception of two to three of the healthiest seedlings. At five months age, flowers are present, thus enabling the selection of one hermaphrodic or female tree. Trees are fertilized (10-10-10) at a rate of 1 lb./tree/month for continued high production of bearing trees. Fruits are harvested before the end of the first year and in commercial orchards the tree are cultivated for three years. Estimated average potential yield of 38,000 lbs/acre during the first year and 25,000 lbs/acre the second year in the Puna District

The composition of the Solo variety per 100 grams of edible portion are as follows:

Moisture	86.8%	Phosphorous	11.6 milligrams
Food Energy	46.0 calories	Iron	0.19 milligrams
Protein	0.39 gram	Vitamin A	1093.00 micrograms
Fat	0.06 gram	Thiamine	0.027 milligrams
Carbohydrate	12.18 grams	Riboflavin	0.043 milligrams
Fiber	0.58 gram	Niacin	0.33 milligrams
Ash	0.57 gram	Ascorbic Acid	84.0 milligrams
Calcium	29.9 milligrams		

Enzymes that have been reported from papaya fruit are as follows:

Pectin esterase in flesh 0.013 mequiv/min/g.
Papain in latex of unripe fruit
Thioglucosidase 3.2.3.1.
Benzylglucosinolate
Invertase
Papaya calalase
Peroxidase
Nitrate reductase

The composition of the papaya seeds are as follows:

Moisture	71.89%
Fat	9.50%
Protein	8.40%
Ash	1.47%
Total Carbohydrate	9.44%

The characteristics of papaya seed oil are as follows:

Refractive index (40°C)	1.4627
Specific gravity (25°C)	0.9130
Unsaponifiable matter	2.11%
Saponification value	193.4
Iodine no.	74.77
Free fatty acids	1.11%
Viscosity	339.41

Papaya is considered to be low in polyunsaturated fatty acids.

Papaya seed oil fatty acid composition are as follows:

Lauric	0.13
Myristic	0.16
Palmitic	15.13
Stearic	3.61
Oleic	71.60
Linoleic	7.68
Linolenic	0.60
Arachidic	0.87
Behenic	0.22

PINEAPPLE

The pineapple, Ananas comosus (L.) (Bromelliaceae), probably originated in Brazil and has spread throughtout the tropics. The principal commercial variety is the Smooth Cayenne which are grown primarily on the islands of Molokai, Lanai, Maui and Kauai. In Hawaii pineapples grow well at the higher elevations (up to 3,000') and dryer locations. The plants prefer well drained sandy loam with a pH of 5-6. Plants should be spaced from 12 to 18 inches apart. Pineapples are are propagated vegetatively by means of the crown cut from the top of the fruit, slips and suckers. Plants grown from suckers produce frits in approximately 17-18 months, those from slips in 21 to 22 months while those grown from crowns require 23 to 26 months.

The composition of pineapple (Smooth Cayenne) per 100 grams of edible portion are as follows:

Moisture	85.54%	Phosphorous	11.5 milligrams
Food energy	52.0 Calories	Iron	0.26 milligrams
Protein	0.45 grams	Vitamin A	trace
Fat	0.21 grams	Thiamine	0.085 milligrams
Total Carbohydrate	13.51 grams	Riboflavin	0.036 milligrams
Fiber	0.50 grams	Niacin	0.24 milligrams
Ash	0.29 grams	Ascorbic Acid	10.1 milligrams
Calcium	18.4 milligrams		

In 1980 there were 18 commercial pineapple farms in the State totaling 43,000 acres. The total production was 657,000 tons of which 101,000 tons were sold as fresh fruits. The remaining tonage were processed for canning.

ENDNOTES

1. <u>Statistics of Hawaiian Agriculture 1980</u> (Hawaiian Agriculture Reporting Service, June, 1981), p. 16.

2. IBID.

3. <u>Hawaiian Papaya</u> (Agriculture Reporting Service), May 10, 1982.

4. "A Financial Analysis of the Hawaiian Papaya Industry, 1975-1979" (Papaya Administrative Committee, July 1978).

5. "Statistical Highlights", <u>National Food Review</u> (USDA, Spring 1980), p. 35.

6. IBID.

7. For a complete discussion see C. Stowell III, "Where, What and How We Eat," (<u>Advertising Age</u>, April 30, 1979), p. 2+ and "Eating Habits Force Changes in Marketing," (Advertising Age, October 30, 1978) p. 65+.

8. Weiss, S. "Papayas are a Natural for Mainland Menus," (<u>Food Institutions</u>, September, 1978), p. 101.

9. Scott, Jr. F., "Marketing Research on Papaya Products", (Cooperative Extension Service, University of Hawaii, Miscellaneous Publication 140, September 1976).

10. Azzarone, S., "Natural Snacks Up Produce $$," (<u>Super Marketing</u>, September, 1978), p. 1+.

11. "Food: A move to Higher Margin Products," (<u>Business Week</u>, January 1979), p. 34+.

12. Speilmann, H. "Demand Characteristics for fresh and Potentially Gamma-Inactivated Papaya..." (Hawaii Agriculture Experiment Station, Research Bulletin 149, (February 1971).

13. Spielman, H. and R. Souza, "Papaya Marketing on Oahu: Retail Mark-up Analysis and Consumer Behavior Study," (Hawaii Agriculture Experiment Station, March, 1973).

14. Gerrod, P.V. and W. Micklius, "Effect of T.V. Promotion on Development of the Papaya Market on the Mainland," (Hawaii Agriculture Experiment Station, Departmental Paper 43, (1976).

BANANA BIBLIOGRAPHY

Andrade, J.S., V.D. De Carvalho, R. Castro-Gomes and J. Cal-Vidal. 1980. Kinetics of environmental dehydration of "silver" bananas (Musa sp.) at various stages of ripening. Revista Brasileira de Tecnologia 11(1): 23-34.

Anonymous. (no date). Production of banana pulp and its use in the manufacture of food products. Union de Paises Exportadores de Banano. 52 pp.

Anonymous. 1962. Banana flour. Tech. Inquiry Serv., Office of Tech. Ser. IR-28342, Wash., D.C.

This report indicated that apparently the banana powder produced by drum drying has attracted more attention from commercial food processors than have other dried banana products.

Anonymous. 1973. Committee on commodity problems, Intergovernmental group on bananas, 5th session, Bremen, Federal Rep. of Germany, 10-20 July 1973. Competition between bananas and summer fruits: preliminary case studies. Marketing, food and agriculture organization of the United Nations. Food and Agriculture Organization of the United Nations, Committee on Commodity Problems. CCP FAO. BA 73/8: 26 pp.

Anonymous. 1980. A plan for marketing Hawaii grown papayas in Japan. Papaya Admin. Comm. for Calendar year 1980. 10 pp.

Japan is an active market for fresh fruit attested by the large volumnes of imported bananas, citrus fruit and more recently kiwi fruit, cherries and avocados.

Anonymous. 1981. Statistics of Hawaiian Agriculture 1980. Hawaii Dept. of Agric., Marketing & Consumer Serv. Div.

Provides production data for bananas.

Barger, W.R., W.T. Pentzer and C.R. Fisher. 1948. Low temperature storage retains quality of dried fruit. Food Ind. 20: 337.

They showed the relationship between SO_2 loss and change of color of cut dried fruits during storage.

Bates, R.P. 1964. Factors affecting foam production and stabilization of tropical fruit products. Food Tech. 18(1): 93-96.

Banana was among the fruits studied.

Bhatia, B.S., H.D. Amin and G. Lal. 1962. Studies on dehydration of some tropical fruits: Part I. Absorption and retention of sulphur dioxide during sulphuring and sulphiting. Part II. Drying rates as affected by various factors. Part III. Packaging and storage aspects. Food Sci. (Mysore) 11: 63.

Bhatia, B.S., J.V. Parbhakar and G. Lal. 1960. Packaging and storage of deep-fat-fried vegetables. Indian J. Appl. Chem 23: 73.

A deep-fat-fried banana chip product was reported by these authors. These chips were stable for a year or more if the moisture content was kept below 5% and the RH of the environment did not exceed 60%.

Bowrey, R.G., K.A. Buckle, I. Hamey, I. Pavenayotin and P. Sydney. 1980. Use of solar energy for banana drying. Food Tech. in Aust. 32(6): 290-291.

Brekke, J.E. and L. Allen. 1967. Dehydrated Bananas. Food TEch. 21(10): 101-105.

Bananas were dehydrated by airblast drying, drum drying, and freeze drying. The products were evaluated subjectively and by objective moisture and color analyses. Treatment with sulfur dioxide before drying improved the product. Three commercially produced banana products were included for comparison. Stability of the products for a year at 55, 75 and 100°F is reported. No commercial production of air-dried bananas is presently in operation.

Brekke, J.E. and J.D. Ponting. 1970. Osmo-vac dried bananas. HI. Agric. Exp. Stn., UHM, Coll. Trop. Agric. Res. Rept. 182. 7 pp.

Broughton, W.J., B.E. Chan and H.L. Kho. 1979. Maturation of Malaysian fruits. II. Storage conditions and ripening of banana (Musa sapientum L. var Pisang Emas). Mardi Res. Bull. 7(1): 28-37.

Bundus, R.H., P.O. Noznick, and C.F. Obenauf. 1964. Full-flavored, color-stable banana flakes. Food Processing 25(3): 116.

They indicated that one banana flake product, said to be available commercially, has been described as containing less than 4% moisture, having no additives, and is produced by pulping, pasteurizing, and rapid drying of fress banana.

Cabral, A.C.D., M. Okada, R.M. Soler, L.F.C. Madi, D.A. Travaglini, V.L.P. Ferreira and E.E. Mori. 1977. Influencia da temperatura de estocagem, da embalagem e do teor de oxigenio na qualidade da banana desidratada. (Influence of storage temperature, packaging and oxygen content on the quality of dehydrated bananas) (has english summary). Colet. Inst. Tecnol. Aliment. 8: 483-500.

Cheema, L.S. and C.M.C. Ribeiro. 1978. Solar dryers of cashew, banana and pineapple. In "Sun, mankind's future source of energy. Vol. III."

Endlein, U.M. and C.H.W. Flechtmann. 1976. Ocorrencia de Carpoglyphus lactis (L., 1958) (Acari, Astigmata) em bananas-Passa. (Carpoglyphus lactis (L., 1958) (Acari, Astigmata) mites infesting dried bananas in Sao Paulo, Brazil). Cienc. Cult. Soc. Bras. Para Progr. Cienc. 28(3): 932-933.

Goben, R. 1963. Freeze drying of tropical fruits: New markets predicted. Canner/Packer, Western Ed. 132(6): 22.

Freeze drying is such a rapidly expanding field that it is difficult to exclude any freeze-dried product from a list of those of likely commercial interest.

Jain, N.L., J. Nair, M. Siddappa and G. Lal. 1962. Studies to improve the keeping quality of fried salted banana chips. Food Sci. (Mysore) 11: 335.

They reported that deep-fried-bananas chip dusted with a salt-antioxidant (BHA) mixture retained satisfactory quality for 28 weeks at 37°C storage in a hermetically sealed container.

Johnson, A.H. and M.S. Peterson. 1974. Encyclopedia of Food Technology. AVI Pub., Westport, Conn. 993 pp.

Indicated that dried banana products in several forms have been available for many years. Banana "figs" (sun dried); freeze drying; osmo-vac drying; drum drying.

Ketiku, A.C. 1976. Chemical evaluation of the nutritive value of varieties of banana fruits (Musa sapientum, Linn.) grown in Nigeria. J. Assoc. Advancement of Agr. Sci in Africa 3(2): 53-56.

Kodia, A.A., J.L. Irigaray and J. Dejou. 1979. Analytical research of major and oligoelements in bananas, avocados, yams and Ivory coast attieke by 14 MeV neutron activation. France Fruits 34(12): 743-749.

Levi, A., J.R. Ramirez-Martinez and H. Padua. 1980. Influence of heat and sulphur dioxide treatments on some quality characteristics of intermediate moisture banana. J. Food Tech. 15(5): 556-566.

Maia, G.A. and B.S. Luh. 1970. Phenolic and indole compounds in freeze-dried bananas. Chinese Agr. Chem. Soc. J. (Special Issue) 1-17.

Maia, G.A., L.F.F. Holanda, G.S.F. Oliveira, J.A. Moura Fe and C.B. Martins. 1979. Study on the ripening and storage of the Prata banana (Musa sapientum L.). (in spanish). Ciencia Agronomica 9(1/2): 5-9.

Marriott, J. 1980. Bananas--physiology and biochemistry of storage and ripening for optimum quality. CRC Critical Rev. in Food Sci. and Nutrition 13(1): 41-88.

Marriott, J., M. Robinson and S.K. Karikari. 1981. Starch and sugar transformation during the ripening of plantains and bananas. J. Sci. Food and Agric. 32(10): 1021-1026.

Millim, K., L. Ionescu, A. Gherghi, S. Girbu and S. Stanoiu. 1980. Storage and ripening of bananas in specialized storehouses. Horticultura 29(11): 28-32.

Mrak, E.M. and H.J. Phaff. 1947. Recent advances in the handling of dehydrated fruits. Food TEch. 1: 147.

They determined the effect of moisture level on rate of deterioration of dried fruits including banana.

Nakamura, R. and T. Ito. 1979. Storage of bananas packed in polyethylene bags. Sci. Rept. Fac. Agric., Okayama Univ. 53: 11-21.

Nichols, P.F. and H.M. Reed. 1931. What happens in the tropics. Western Canner and Packer 23(5): 11.

Stability of dried fruits in the tropic regions was the subject of an early study by these authors in which they measured changes in dried fruits.

Nury, F.S., D.H. Taylor and J.E. Brekke. 1960. Research for better quality in dried fruits. USDA ARS-74-16.

They worked on stability of retail packs of dried fruits included observations on the effects of time, temperature, and humidity on quality.

Olorunda, A.O., M.A. Tung and J.A. Kitson. 1977. Effect of post harvest factors on quality attributes of dehydrated banana. J. Food Tech. 12(3): 257-262.

Peacock, B.C. 1980. Banana ripening--effect of temperature on fruit quality. Queensland J. Agric. & Ani. Sci. 37(1): 39-45.

Prigge, H., R. Kohlheb and K. Becker. 1980. Investigations on preparation and pressing of banana plants (for suitable energy and protein sources as feed for ruminants). Trop. Ani. Prod. 5(2): 177-181.

Ramanuja, M.N. and K.S. Jayaraman. 1980. Studies on the preparation and storage stability of intermediate moisture banana. J. Food. Sci. Tech., India 17(4): 183-186.

Samish, Z. and B.R. Coussin. 1965. The production of dehydrated flakes as a means of utilizing surplus bananas. Israel J. Agric. Res. 15(1): 49.

These authors showed that stem blanching prior to drying improved the product, and that the addition of SO_2 improved the color. Ananana powder at 2.6% moisture or below were satisfactorily stable at room temp. in vacuum-sealed tin cans. Storage at 35°C for 6 months caused slight browning and clumping. (The drum drying method was used).

Simmonds, N.W. 1970. Bananas, Second ed. Longmans Group Ltd., London. 512 pps.

Simmonds attempts at commercial production of sun-dried bananas in the form of "fig" have achieved little success. He suggests that artificial drying would be essential to production of dried banana slices or halves. Such artificial drying can be done in a cabinet or tunnel

type drier (air driers) or in a freeze drier. As a means of preservation, drying is perhaps the most important. The pulp may be dried as figs, chips (i.e. thin transverse slices), flour or powder and some reference to the preparation of all these products has been made above. They are mostly to be regarded as preparations in their own right rather than as a means of preservation. In Samoa the ripe fruit is oven-dried, wrapped in leaves, band tightly and stored against eventual need. In Uganda dried chips of unripe fruit are stored as a famine reserve food, being used, as we have seen above, by boiling to make porridge. Probably, the preservation of bananas dried in various ways as a food reserve is fairly widespread among banana-eating people in Africa and the Pacific.

Stadtman, E.R., H.A. Barker, V. Hass and E.M. Mrak. 1946. Storage of dried fruit. Influence of temperature on deterioration of apricots. Ind. Eng. Chem. 38(5): 541.

Reported effects of moisture content, SO_2 level, temperature, and oxygen on the stability of dried fruits.

Stadtman, E.R., H.A. Barker, V. Hass, E.M. Mrak and G. Mackinney. 1946. Storage of dried fruit. Gass changes during storage of dried appricots and influence of oxygen on rate of deterioration. Ind. Eng. Chem. 38(3): 324.

Reported effects of moisture content, SO_2 level, temperature and oxygen on the stability of dried fruits.

Terai, H. and S. Mizuno. 1979. Studies on the effect of subatmospheric pressure treatment for storage of fruits and vegetables. 1. Effect of ripening retardation of bananas, tomatoes, and pears. Sci. Rept. Fac. Agric., Kobe Univ. 13(2): 227-233.

Ullah, M. and E. Elahi. 1977. Quality of sundried banana chips influenced by chemicals in storage. J. Agric. Res., Pakistan 15(2): 25-30.

Unten, S. 1974. Market and processing developments. Bananas, situation studies. Univ. Hawaii Coop. Ext. Serv. Misc. Publ. 119: 7.

Von Locsecke, H.W. 1955. Drying and dehydration of foods, p. 49. Reinhold Pub. Co., New York.

Bananas have been sun-dried, drum-dried, spray-dried, and dried in a cabinet dehydrator.

Wenkam, N.S. and C.D. Miller. 1965. Composition of Hawaii fruits. Hawaii Agric. Expt. Stan. Bull. 135. 87 pp.

Yohinori, H., Y. Ueda and K. Chachin. 1980. Effects of high temperature on the change of acid-phosphatase activity during banana fruit ripening. J. Japn. Soc. Food Sci. & Tech. 27(10): 511-516.

Yoshioka, K. 1979. Biochemical studies on changes in quality of postharvest fruits during storage. V. Changes in saccharides and enzymes related to metabolism of saccharides during after-ripening in chilling-injured banana fruit. Nihon Shokuhin Kogyo Gakkai Shi 26(2): 57-64.

Zica, L.F., Y. Carvalho, W.A. Ferrari. 1977. Etiologic aspects of the occurrence of drying of the bunch of the Prata banana cultivar (Musa sp. AAB) in Goias State, Brazil. (in spanish) Anais de Escola de Agronomia e Veterinaria 7(1): 116-120.

GUAVA BIBLIOGRAPHY

Ahlawat, V.P., R. Yamdagni and P.C. Jindal. 1980. Studies on the effect of postharvest treatments on storage behaviour of guava (Psidium guajava L.) cv. Sardar (L 49). J. Res. 10(2): 242-247.

Anonymous. 1977. Hawaii's tropical fruits processing industry. State Dept. of Agric., Div. of Marketing & Consumer Serv. 27 pp.

1970-1976 data are used for papaya, passion fruit and guava production estimates, value estimates, volumn for processing, markets for guava nectar, papaya products and passion fruit juice.

Anonymous. 1977. A Japan market study of selected Hawaii agricultural products. State Dept. of Planning and Econ. Development., Honolulu, Hawaii.

The following are included in the report: fruit drink consumption in Japan, import statistics, transportation for guava products, distribution, price analysis, competitors, future market projections, and recommendations.

Anonymous. 1981. Statistics of Hawaiian Agriculture 1980. Hawaii Dept. of Agric., Marketing & Consumer Serv. Div.

Production data for pineapple, bananas, papayas and guava and other fruits and vegetables grown in Hawaii.

Anonymous. 1981. Hawaii's Guava industry. State of Hawaii, Economic Development Div., Dept. of Planning and Econ. Development.

Provide State and world production of guava; marketing requirements in Hawaii, Japan and Mainland. Guava industry characteristics discussed.

Bates, R.P. 1964. Factors affecting foam production and stabilization of tropical fruit products. Food Tech.. 18(1): 93-96.

Guava included as one of the torpical fruits.

Bhullar, J.S. and H.L. Farmahan. 1980. Studies on the ripening and storage behaviour of Safeda guava (Psidium guajava L.). Indian Food Packer 34(4): 5-7.

El Tinay, A.H., A.R. Saeed and M.F. Bedri. 1979. Fractionation and characterization of guava pectic substances. J. Food TEch. 14(4): 343-347.

Gerakas, A. and C. Lee. 1974. Profit potentials in Hawaii's guava. Honolulu, Hawaii, State Dept. Planning and Econ. Develop.

The report finds that large-scale growing and exporting of guava would be economically feasible if the growing, processing and marketing were vertically integrated.

Gupta, O.P., B.P. Singh and A.K. Gupta. 1979. Studies on the shelf life of different guava cultivars. Haryana Agric. Univ. J. Res. 9(3): 247-250.

Keeler, J. and I. Getubig. 1973. Cost and returns of guava production in Hawaii. Univ. of Hawaii, Coop. Ext. Ser. Misc. Publ. No. 111.

Presents two alternative cost studies for guava production - one conservative and one under conditions of intensive fertilization and cultivation. The conservative budget reflects actual commercial production (1973). The intensive budget reflects experimental conditions already proven to be feasible.

Muroki, N. and P. Saint-Hilaire. 1977. Pectin of good commercial grade from guava fruit. Nairobi, Kenya: Nairobi University.

As part of an analysis of potential guava by-products, techniques for extracting pectin are examined.

Nogueira, J.N. and J. Soybibe Sobrinho. 1978. Retention of ascorbic acid and beta-carotene in freeze-dried red guava pulp (Psidium guajava L.) during storage. (in spanish). Archivos Latinoamericanos de Nutricion 28(4): 363-377.

Pradad, A. and J.P. Shukla. 1979. Studies on the ripening and storage behaviour of guava fruits (Psidium guajava L.). Indian J. Agric. Res. 13(1): 39-42.

Salomon, E. and Z. Martin. 1977. Comparison of guava products made from puree preserved by freezeing or by addition of sodium metabisulfite. Boletim de Instituto de Tecnologia de Alimentos. Sao Paolo, Brazil: Instituto de Tecnologia de Alimentos.

Comparative studies on the quality of guava nectar and concentrated sweetened guava puree prepared from frozen guava puree stored for six months at 20°C or from guava puree preserved with $Na_2S_2O_5$, and stored for six months at ambient temp. No significant differences were found.

Scott, F., Jr. 1958. Commercial uses and consumer preferences for Hawaiian Guava products. Univ. Hawaii, Hawaii Agric. Exp. Stn. Agric. Econ. Bull. 13.

Examines the market for several types of processed guava and identifies the major market potentials for each. Makes suggestions on the basis of survey results, for modification of the nectar in order to make it more appealing to mainland tastes.

Scott, F., Jr. 1958. An economic analysis of the market for frozen guava nectar base. Univ. of Hawaii, Hawaii Agric. Exp. Stn.

Reports the results of test marketing guava juice concentrate in the San Francisco bay area and in Illinois. These results are compared with data obtined from the Kailua market and potentials for mainland market development are explored.

Scott, F., Jr. and R. Shoraka. 1974. Economic analysis of the market for guava nectar. Univ. of Hawaii, Hawaii Agric. Exp. Stn. Res. Rept. No. 230.

By examining the Hawaii market for guava nectar, comparing findings from previous analyses of guava markets and markets for passion fruit, and expanding data obtained from a test market in Sacramento, California, the report provides an indication of the Mainland market potential for guava nectar.

Scott, F. Jr. and R. Shoraka. 1973. The U.S. market potential for guava nectar. Univ. of Hawaii, Coop. Ext. Serv. Misc. Pub. No. 111.

Reports the results of test marketing of frozen or heat processed guava nectar - with and without the aid of television commercials. Most popular was frozen guava nectar. Television increased returns to producers by almost 600%.

Singh, B.P., H.K. Singh and K.S. Chauhan. 1981. Effect of post-harvest calcium treatments on the storage life of guava fruits (Psidium guajava, India). Indian J. Agric. Sci. 51(1): 44-47.

Sutiwataniti, M. 1976. Characteristics of consumer demand for guava nectar in metropolitan Honolulu. Univ. Hawaii, Dept. Agric. Economics.

Reports the results of a telephone consumer survey of 600 households in Honolulu. In addition to assessing buying patterns, the survey obatined information on flavor preferences, occasions of most frequent use, and ethnic and financial status of respondents.

Vandendriessche, H. 1976. Tropical fruit processing industry, case studies of the industry in developing countries. Paris: Development Centre, OEDC.

Contains the worldwide harvest production and processing of guava fruit, by country, for various years, 1966-1972.

Wenkam, N.S. and C.D. Miller. 1965. Composition of Hawaii fruits. Hawaii Agric. Expt. Sta. Bull. 135. 87 pp.

MANGO BIBLIOGRAPHY

Akamine, E.K. 1963. Haden mango storage. Hawaii Farm Sci. 12(4): 6-7.

Refrigeration at 55°F is recommended as fruits at the mature green or ripe stages of maturity can be held for a week at this temperature without quality loss.

Ammu, K., K.G. Krishnappa, V. Subramanian, T.R. Sharma and H. Nath. 1976. Freeze drying of mango pulp. Food. TEch. Aust. 28(9): 339-341.

Ashraf, M., N. Khan, M. Ahmad and M. Elahi. 1981. Studies on the pectin-esterase activity and some chemical constituents of some Pakistani mango varieties during storage ripening. J. Agric. &. Food Chem. 29(3): 526-528.

Bates, R.P. 1964. Factors affecting foam production and stabilization of tropical fruit products. Food Tech. 18(1): 93-96.

Mango included.

Bose, A.N. and J.M. Dutt. 1952. Dehydration of mango pulp. India Food Packer 6(4): 12, 33.

Dried mango pulp mixed with an equal vol. of water on a Buflovak double drum dryer was used. The flake product, containing 3.5% moisture, was very hygroscopic but was reported to have good color, flavor, and rehydration characteristics.

Brekke, J.E., C.G. Cavaletto, A.E. Stafford and H.T. Chan, Jr. 1975. Mango: Processed products. USDA ARS W-23. 26 pp.

Characteristics and composition of mango is discussed. Processing methods and products are also mentioned.

Bruno, A. and P.H. Goldberg. 1963. The morphology and chemical composition of some Nigerian mangoes (Mangifera indica L.). Trop. Agr. 40: 143-152.

Coleman, R.L., C.J. Wagner and R.E. Berry. 1980. Solar drying mango slices and mechanically deseeded muscardine grapes. Proc. Ann. Meet. Florida St. Hort. Soc. 93: 334-335.

Cooke, R.D., G.R. Breag, C.E.M. Feber, P.R. Best and J. Jones. 1976. Studies of mango processing. I. The foam-mat drying of mango (Alphonso cultivar) puree. J. Food Tech. 11(5): 463=473.

Czyhrinciw, N. 1969. Tropical fruit technology. Adv. in Food Res. 17: 153-214.

Indicated that an abrasive peeling of frozen mangoes is possible.

Dabhade, R.S. and D.M. Khedkar. 1980. Studies on drying and dehydration of raw mangoes for preparation of mango powder. Part II. Mango drops and their assessment for physicochemical composition. Indian Food Packer 34(3): 18-31.

De George, L.M., de R. Iguina, A.L. Collazo, J.R. Benero and W. Pennock. 1969. Provitamin A and vitamin C contents of several varieties of mango grown in Puerto Rico. Puerto Rico Univ. J. Agric. 53(2): 100-103.

Reported 0.4 to 7.9 mg/100g of B-carotene in mangoes produced in Puerto Rico.

El Ansari, M.A., K.K. Reddy, K.N.S. Sastry and Y. Nayudamma. 1971. Polyphenols of Mangifera indica. Phytochemistry 10: 2239-2241.

Isolated B-glucogallin and gallotannin from mature green mango fruit; the toxic gallotannin was present to a small or negligible extent in well-ripened fruit.

Esquerra, E.B., D.B. Mendoza and E.B. Pantastico. 1978. Regulation of fruit ripening. II. Use of Perlite-$KMnO_4$ insert as an ethylene absorbent (On mangoes, and bananas, storage life) Philippine J. Sci. 107(1/2): 23-31.

Heikal, H.A., N.Y. El-Sanafiri and M.A. Shooman. 1973. Some factors affecting the quality of dried mango sheets. Agric. Res. Rev. 50(4): 185-194.

Jain, N.L., G. Lal and G.V. Krishnamurthy. 1957. Further studies in the preparation and uses of mango cereal flakes. Indus. J. Hort. 14(3): 172-177.

A mango cereal flake product is described as being tasty and nutritious, has attracted much attention in India. It is the drum-dried mixture of mango pulp, cooked flour paste, and sugar, and contains 1.2 to 2.0% moisture.

Jungawala, R.B. and H.R. Cama. 1963. Carotenoids in mango. Indust. J. Chem. 1: 36-40.

Reported 12.5 mg/100 g of carotenoids in mango pulp.

Khedkar, D.M. and R.K. Susantha. 1980. Histological evidence for the reconstitutional property of dried dehydrated raw mango slices. J. Food Sci. & Tech., India 17(6): 276-277.

Krishna Murthy, S. 1981. Chemcial studies on internal breakdown in Alphonso mango (Mangifera indica Linn.). J. Hort. Sci. 56(3): 247-250.

Mukerjee, P.K. and R.B. Srivastava. 1979. Increasing the storage life of mango (Mangifera indica L.) by lowering the critical temperature. Progressive Hort. 10(4): 63-69.

Narasimhachar, B.L., R.D. Achyuta, G. Azeemoddin and S.D. Thirumala Rao. 1979. Drying and storage of mango stones and kernels. J. Oil Tech. Assoc. India 11(4): 94-95.

Orr, K.J. and C.D. Miller. 1955. Description and quality of some mango varieties grown in Hawaii and their suitability for freezing. Hawaii Agric. Exp. Stn. Tech. Bull. 26. 24 pp.

Describes characteristics and composition of several cultivars of mango grown in Hawaii.

Priestley, R.J. and H.J.P. Redelinghuys. 1980. Mango aachar. I. Nature and composition. South African Food Rev. 7(2): 79-82.

Roy, B.N., S.K. Saha, S. Pramanick and S. Biswas. 1980. Effects of wax emulsion and maleic hydrazide on the storage behaviour of mangoes. Progressive Hort. 11(4): 35-38.

Sharma, S.P., J.L. Bhanumurthi and M.R. Srinivasan. 1974. Studies on the production and storage behaviour of spray dried mango. J. Food Sci. Tech. 11(4): 171-174.

Temghare, P.B. and S.G. Borude. 1976. Marketing of mango in Ratnagiri district of Maharastra State. J. Maharashtra Agric. Univ. 1: 206-210.

Wagner, C.J., Jr., R.L. Coleman, W.L. Bryan and R.E. Berry. 1978. Preliminary studies on SO_2 absorption in mangos, nectarines and peaches prepared for drying. Proc. Florida St. Hort. Soc. 91: 117-119.

Wenkam, N.S. and C.D. Miller. 1965. Composition of Hawaii fruits. Hawaii Agric. Exp. Stn. Bull. 134. 87 pps.

Zauberman, G. and Y. Fuchs. 1979. Mango storage. Prelim. Rept. Agric. Res. Organ. 11 pp.

PAPAYA BIBLIOGRAPHY

Angara, F.S., J. Wang and U. Agena. 1969. Development and performance of equipment for removal of papaya flesh. Amer. Soc. Agr. Eng. Trans. 12(6): 745-747.

Anonymous. 1977. A Japan-market study of selected Hawaiian agricultural products. Dept. Planning and Econ. Develop., State of Hawaii. 72 pp.

Deals with fresh papaya, papaya and guava puree and juices as well as anthuriums. Papaya puree has failed to grow in Japan market due to tropical flavor, also a 1¢ commodity tax. No sharp growth is expected unless Japan's import quota is lifted on guava juice.

Anonymous. 1977. Hawaii's tropical fruits processing industry. State Dept. of Agric. Div. Marketing and Consumer Serv.

Provides an overview of the guava, papaya and passion fruit processing industries in Hawaii, including projections of fruit supply, nectar value estimates, production figures and marketing information.

Anonymous. 1980. A plan for mareting Hawaii grown papayas in Japan. Papaya Admin. Comm. for Calendar year 1980. 10 pp.

Japan is an active market for fresh fruit attested by the large volumes of imported bananas, citrus fruits and more recently kiwi fruit, cherries and avocados. The initial and continued acceptance of papayas offers substantial growth opportunities provided a planned and well organized advertising and promotion program is adopted.

Anonymous. 1981. Statistics of Hawaiian agriculture 1980. Hawaii Dept. of Agric., Marketing and Consumer Serv. Div.

Production data for pineapple, bananas, papayas, and guava and other fruits and vegetables (Agric. commodities).

Arriola, M.C., J.F. Calzada, J.F. Menchu, C. Rolz and R. Garcia. 1980. Papaya (production, storage, composition). Tropical and subtropical fruit: composition, properties, and uses. Nagy, S. and P.E. Shaw, AVI Pub. Co., Westport, Conn.: 316-340.

Aung, T. and B. Ross. 1965. J. Food Sci. 30: 144.

Determined the average pectin esterase activity in ripe papaya flesh to be 0.013 mequiv/min/g. Also heat inactivation of pectin esterase in acidified puree (pH 4.2) in the range 169°-186°F which gave a z value of 11°F and a D_{180} of 10 min.

Bahadur, K. and B.D. Atreya. 1960. Enzymologia 21: 325.

Proposed that certain inhibitors are formed in papaya juice as ripening advances, and that the inhibitor deactivates the existing papain in the lates.

Blumberg, S., I. Schechter and A. Berger. 1970. Eur. J. Biochem. 15: 97.

Separated active papain from the nonactive molecules by affinity chromatograph.

Brocklehurst, K., J. Carlsson, M.P.J. Kierstan and E.M. Crook. 1973. Preparation of fully active papain from dried papaya lates. Biochem. J. 133: 573.

Proposed that a mechanism of the activation of "propapain" through intramolecular thiol-disulfied interchange.

Broughton, W.J. and A.W. Hashim. 1977. Maturation of Malaysian fruits. I. Storage conditions and ripening of papaya (Carica papaya L. cv. Sunrise solo). Mardi Res. Bull. 5(1): 59-72.

Burke, D.E., S.D. Lewis and J.A. Shafer. 1974. Arch. Biochem. Biophys. 164: 30.

Separated active papain from the nonactive molecules by affinity chromatograph.

Carpenter, J.R., L.R. Ching and S. Fujiuyama. 1980. Evaluation of the nutritional value of cull papaya fruit for monogastric animals. Proc. Ann. Meet. Amer. Soc. Ani. Sci. West. Sec. 31: 98-102.

Laboratory rats were used as the test animal.

Chan, H.T. Jr. 1979. The chemistry and biochemistry of papaya. Trop. Foods. 1: 33-53.

Gives mineral analysis of papaya flesh.

Chan, H.T. Jr., and C.G. Cavaletto. 1978. Dehydration and storage stability of papaya leather. J. Food Sco. 43: 1723-1725.

Chan, H.T. Jr., T.S.K. Chang, A.E. Stafford and J.E. Brekke. 1971. J. Agric. Food Chem. 19: 263.

Extracted and purified papaya acids by ion exchange and quantified by glc to have malic, citric, and alpha ketoglutaric acids (0.464 mequiv/100 g wet weight of papaya, respectively).

Chan, H.T. Jr., R.A. Flath, R.R. Forrey and C. G. Cavaletto. 1973. J. Agric. Food Chem. 21: 566.

Reported volatile flavor compounds of papaya.

Chan, H.T. Jr., R.A. Heu, C.S. Tang, E.N. Okazaki and S.M. Ishizaki. 1978. J. Food Sci. 43: 255.

Evaluated the possible utilization of papaya seeds. Also gave percent composition of papaya seeds. Also provided the fatty acid composition of papaya seed oil.

Chan, H.T. Jr. and S.C.M. Kwok. 1975. Food Sci. 40: 770.

Reported that the discrepancy in the amound of sucrose in papaya as reported by various authors was due to an invertase enzyme in papayas. By inactivating the enzymes with microwave heat. Ripe papayas had 43.3% sucrose, 29.8% glucose and 21.9% fructose.

Chan, H.T. Jr. and S.C.M. Kwok. 1976. J. Food Sci. 41: 320.

High amounts of papaya invertase are present in papaya puree which causes browning during processing and storage. This is a potential problem in products containing dehydrated papaya purees.

Chang, L.W.S., L.L. Morita and H.Y. Yamamoto. 1965. J. Food Sci. 30: 128.

Determined the optimum conditions for papaya pectin esterase activity (PE) to be pH 7.5 and 9.2 m NaCl. PE was inhibited by sucrose thereby delaying the gelation of puree.

Chen, N.K.S. 1963. Chemical changes during the postharvest ripening of papaya fruit. M.S. Thesis, University of Hawaii, Honlulu, HI.

Reported that 60% of the sugars were sucrose using a hot alcohol extraction method.

Dollar, A.M., M. Hanaoka, J.H. Moy, A.D. Cinnamon, E. Hamill, De. Helber, S.T. Hsia and D. Wenkam. 1969. In "Radioisotope and radiation applications" NV = 347-17, TID-4500, 86 pp. Div. of isotopes development, U.S. Atomic Energy Comm.

Reported that sucrose was not present at any time during postharvest ripening.

Dooley, J. 1976. Research and development at Puna Papaya. Proc. 12th Ann. Hawaii Papaya Indus. Assoc. Conf., Univ. Hawaii Coop. Ext. Serv. Misc. Pub. 140: 36-38.

Development of a yield prediction model. Use of mechanized harvesting, pest control, postharvest research, Puna papaya marketing aspects.

Dreuth, J., J.N. Jansonius, R. Koekoek, L.A.A. Sluyterman and B.G. Wolthers. 1970. Phil. Trans. Roy. Soc. London B. 257: 231.

Presents a comprehensive review of the structure and the reaction mechanism of papain.

Dreuth, J., J.N. Jansonius, R. Koekoek and B.G. Wolthers. 1971. Adv(s) in Protein Chem. 25: 79.

Presents a comprehensive review of the structure and the reaction mechanism of papain.

Elliot, R. 1950. Prospects for marketing Hawaiian papaya products in the United States. Agric. Econ. Bull. 1, Hawaii Agric. Exp. Stn., Univ. Hawaii.

Esquerra, E.B., D.B. Mendoza and E.B. Pantastico. 1978. Regulation of fruit ripening. II. Use of perlite-$KMnO_4$ insert as an ethylene absorbent (on mangoes, and bananas, storage life). Philippine J. Sci. 107(1/2): 23-31.

Ettlinger, M.G. and J.E. Hodgkins. 1956. J. Org. Chem. 21: 204.

Since papaya seeds are sometimes used as a substitute for pepper, these authors found that the spicy, pungent flavor was due to the presence of benzyl isothiocyanate.

Flath, R.A. and R.R. Forrey. 1977. J. Agric. Food Chem. 25: 103.

Reported volatile flavor compounds of papaya. They concentrated the volatiles of fresh papaya fruit by several different methods. Linalool was the major component with smaller amounts of benzyl isothiocyanate. Minor quantities of butyric, hexanoic, and octanoic acids and their corresponding methyl esters were also present. Phenylacetonitrile and linalool oxide also present. The relative proportions of the major components, linalool, linalool oxide, phenylacetonitrile, and benzyl isothiocyanate were shown to be dependent upon the method of volatiles concentration.

Garrod, P.V. and W. Miklius. 1976. Effect of TV promotion on development of the papaya market on the mainland, A pilot experiment. Hawaii Agric. Exp. Stn. Univ. Hawaii, Dept. Papaer 43. 5 pp.

TV promotion in this experiment didn't result in a significant increase in papayas sales. This may be due to insufficient exposure due to budget constraints. Only one specific 30 sec. spot commercial was used. Exposure of commercial was during the day and fringe time. Also TV ad effects are delayed rather than immediate.

Giri, J., V. Bhuvaneswari and R. Tamilarasu. 1980. Evaluation of the nutritive content of five varieties of papaya in different stages of ripening. Indian J. Nut. & Diet. 17(9): 319-325

Hundtoft, E.B. 1976. Papaya handling from field to market. Proc. 12th Ann. Hawaii Papaya Indus. Assoc. Conf., Univ. Hawaii Coop. Ext. Serv. Misc. Pub. 140: 7-13.

Papaya industry and surface shipment tech. Research on a rapid decay control process, Research on waxing for shrinkage control.

Jones, W.S. and H. Kubota. 1940. Plant Physiol. 15: 711.

Reported that sucrose as 18% of the total sugars of papaya.

Ortiz, N.A., S.L. Madrigal, H.R. Fernandez and R.D. Cooke. 1980. The storage and drying characteristics of papaya (Carica papaya L.) latex. J. Sci. Food & Agr. 31(5): 510-514.

Oioem W.T. 1930. Hawaii Agric. Exp. Stn. Bull. 61, Honolulu, Hawaii.

Reported that sucrose was 0-13.2% of the total sugars in papaya.

Pratt, D.S. and J.I. Del Rosario. 1913. Philippine J. Sci. 8A: 59.

Reported that sucrose comprised of 1.2-1.3% of the total sugars in papaya.

Pulley, G.N. and H.W. von Loesecke. 1941. Fruit Product J. 21: 37.

Reported that the edible portion of the papaya fruit has a pH range of 4.5 to 6.0.

Rossinskii, V.I. 1978. Pawpaw cultivation at Gagra and the production of the proteolytic enzyme papain in the USSR. Byulleten' Glavnogo Botanicheskogo Sada 107: 8-12.

Sanner, T. and A. Phil. 1963. J. Biol. Chem. 238: 165.

Found that in active papain, the active site is cysteine-25 which has a free sulfhydryl group.

Sawato, M. 1969. Changes in isozyme pattern and kinetics of heat inactivation of peroxidase enzyme of papaya following gamma irradiation. M.S. Thesis, University of Hawaii, Honolulu, Hawaii.

Determine the heat inactivation of isozymic pattern of papaya peroxidase following gamma irradiation at 0, 75, and 300 krad.

Scott, F.S. Jr. 1976. Marketing research on papaya products. Proc. 12th Ann. Hawaii Papaya Indust. Assoc. Conf., Univ. Hawaii Coop. Ext. Serv. Misc. Pub. 140: 4-6.

Progress report on the U.S. Mainland market potential for papaya nectar and restaurant use of papaya in metropolitan Honolulu.

Shehata, S., F.S. Scott, Jr. and R.A. Souza. 1978. Fresh papaya utilization by restaurants in metropolitan Honolulu. Univ. Hawaii Agric. Exp. Stn. Dept. Ppaer 40. 12 pp.

Skeltone, G.S. 1969. Phytochemistry 8: 57.

Reported that papain concentration in papaya latex reaches its maximum just before ripening of the fruit.

Sluyterman, L.A.A. and J. Wijdenes. 1970. Biochim. Biophys. Acta 200: 593.

Separated active papain from the nonactive molecules by affinity chromatograph

Katague, D.B. and E.R. Kirch. 1965. J. Pharm. Sci. 54: 891.

Reported volatile flavor compounds of papaya. Reported the presence of the homologous series of normal primary alcohols from C_1 to C_6 and its primary isoalcohols from C_3 to C_5 along with the corresponding acetate esters.

Khedkar, D.K., V.K. Patil and R.S. Dabhade. 1980. Studies on preparation of tuti fruiti from raw papaya (Carica papaya Linn.) fruit. J. Food Sci. Tech., India. 17(4): 197-198.

Kimmel, J.R. and E.L. Smith. 1954. J. Biol. Chem. 207: 515.

Reported a method of purifying papain from papaya latex.

King, G.S., H. Sakanishi and E. Song. 1951. Food Eng. 23: 147.

Reported that sucrose comprised of 1.2-1.3% of the total sugars in papaya.

Klein, I.B, and J. F. Kirsch. 1969. J. Biol. Chem. 244: 5928.

Showed that in the activatible papain, the thiol group is in a dithiolinkage with another cysteone.

Kunimitsu, D.K. and K.T. Yasunobu. 1967. Biochim. Biophys. Acta 139: 405.

Reported the crude papain contains at least two types of proteolytic enzymes, papain, and chymopapain. Also reported when a solution of papaya latex is brought to 0.45 saturated ammonium sulfate, papain precipitates and chymopapain remains in the supernatant.

Menery, R.C. and R.H. Jones. 1972. Aust. J. Biol. Sci. 25: 531.

Reported the presence of nitrate reductase in papayas. The enzyme plays an important role in controlling high nitrates levels in Australian-grown papayas. High nitrate levels were reported to be causing severe detinning in canned fruit products. Highest nitrate reductase activity was found in the exocarp.

Moore, D.J. 1980. A simple method of collecting and drying papaya (pawpaw) latex to produce crude papain. Rural Tech. Guide, Trop. Prod. Inst. No. 8., 19pp.

Nip, W.K. 1979. Development and storage stability of drum-dried guava- and papaya-taro flakes. J. Food Sci. 44(1): 222-225.

Ogata, J.N., Y. Kawano, A. Bevenue and L.J. Casarett. 1972. The ketoheptose content of some tropical fruits. J. Agr. Food Chem. 20 (1): 113-115.

Determined that D-manno-heptulose and D-altro-heptulose in mango in a study of 10 tropical fruits in Hawaii. Also reported trace quantities of sedoheptulose in papaya.

Souza, R.A. 1977. Papaya production and marketing highlights. Univ. Hawaii, Coop. Ext. Serv., Misc. Publ. 151 5-12.

Souza, R.A. 1978. A financial analysis of the Hawaii papaya industry 1973-1977. Papaya Admis. Comm., 929 Queent St. Honolulu, Hawaii. 21 pp.

Spielmann, H. 1971. Demand characteristics for fresh and potentially gamma-irradiated papaya on selected U.S. Mainland markets--an attitudinal approach. Univ. Hawaii Agric. Exp. Stn. Res. Bull. 149.

The demand analysis for papaya clearly points up that this product behaves typically in the manner of a new product which is also an impulse item. The factors which most strongly affect its disappearance rate are 1. its availability in the store, 2. its appearance, 3. degree of in-store promotion and of store-identified newspaper ads, 4. attractiveness of the display and 5. quality control carried from farm to retail outlets. The degree of price elasticity indicates that the consumer does not particularly concern himself with the price of the product as long as he can get the quality and the appearance of the product that he desires. Offerings have in all instances been readily absorbed by the market under investigation. Need good quality control of papaya.

Spielmann, H. and R.A. Souza. 1973. Papaya marketing on Oahu: retail markup analysis and consumer behavior study. Univ. Hawaii, Coll. Trop. Agric. Exp. Stn. Dept. Paper 8. 41 pp.

Demonstrated some of the factors and their impact on consumption of papaya. Shown some of the buying habits and taste or preference patterns by individual consumers.

Stahl, A.L. 1935. Univ. Florida Agric. Exp. Stn. Bull. 283, Gainesville, Florida.

Reported that sucrose was from 0-4.4% of the total sugars of papaya.

Tang, C.S. 1970. Paper No. 92, 160th Ann. ACS Meeting, Chicago, Illinois (Abstract).

Reported volatile flavor compounds of papaya.

Tang, C.S. 1973. Phytochemsitry 12: 769.

Benzyl isothiocyanate in papaya seeds are formed from benzylglucosinolate by the action of thioglucosidase. The enzyme is found in the sarcotestae but not in the endosperms, while the reverse is true for the substrate glucosinolate, which constitutes more than 6% of the endosperm.

Tang, C.S. 1974. J. Food Sci. 39: 94.

Determined that the various grades of papain contain benzyl glucosinolate, a naturally occurring thioglucoside in papaya latex.

Tang, C.S. and W.J. Tang. 1976. Biochim. Biophys. Acta 452: 510.

Reported that isothiocyanates formed by the hydrolysis of benzyl isothiocyanates have been shown to inhibit papain activity.

Thompson, A.R. 1914. Hawaii Agric. Exp. Stn. Ann. Rept. Honolulu, Hawaii.

Reported sucrose was 0-13.2% of the total sugars of papaya.

Wenkam, N.S. and C.D. Miller. 1965. Composition of Hawaii fruits. Hawaii Agr. Exp. Stn. Bull. 135. 87 pp.

Presents characteristics and composition of fruit cultivars grown in Hawaii.

Yamamoto, H.Y. 1964. Nature 201: 1049.

Isolated and identified the carotenoids in both yellow and red fleshed papaya. Yellow-fleshed type lacked lycopene. 3.7 mg/100 and 4.2 mg/100 g total carotenoids were obtained from the yellow and red-fleshed fruits, respectively. Pigments present included beta-carotene, ζ-carotene, cryptoxanthine monoepoxide, cryptoxanthin, lycopene.

PINEAPPLE BIBLIOGRAPHY

Anonymous. 1981. Statistics of Hawaiian Agriculture 1980. Hawaii Dept. Agric., Marketing & Consumer Services Div.

Includes production data for pineapple among other fruits grown in Hawaii.

Balakrishnan, S., M. Aravindakshan, K.C. Marykutty and V. Mathew. 1980. Effect of nitrogen nutrition on quality and storage behaviour of pineapple. Agric. REs. J. of Kerala 18(1): 33-39.

Bates, R.P. 1964. Factors affecting foam production and stabilization of tropical fruit products. Food Tech. 18(1): 93-96.

Pineapple is included in this study.

Cheema, L.S. and C.M.C. Ribeiro. 1978. Solar dryers of cashew, banana and pineapple. In "Sun, Mandkind's future source of energy. Vol., III."

Nayar, N.K., V. Mathew and M. Aravindakshan. 1981. Studies on varietal variations in pineapple (*Ananas comosus* L. Merr.) for various morphological and nutritive characters. South Indian Hort. 29(2): 81-86.

Wenkam, N.S. and C.D. Miller. 1965. Composition of Hawaii fruits. Hawaii Agric. Expt. Sta. Bull. 135. 87 pp.

APPENDIX A

SCHEDULE "G"

General Service

Availability:

Applicable for general lighting and power service supplied through a single meter.

Rate:

CUSTOMER CHARGE:

Single phase service	- per month	$6.00
Three phase service	- per month	$8.00

ENERGY CHARGE: (To be added to Customer Charge)

The charge for the first 200 kwh per month per kw of billing demand shall be:

First	1000 kwh per month - per kwh	12.6¢	126	
Next	1500 kwh per month - per kwh	9.6¢	144	
Next	2500 kwh per month - per kwh	7.7¢	192.50	= 462.50
All over	5000 kwh per month - per kwh	7.2¢		

The charge for the next 200 kwhr per kw of billing demand shall be:

- per kwh 6.1¢

The charge for all kwh over 400 kwh per month per kw of billing demand shall be:

- kwh 4.9¢

Minimum Charge:

Non-demand Service:

Single phase	$ 6.00
Three phase	15.00

Demand Service:

$2.00 per month per kw of billing demand but not less than $50.00.

A customer will be a demand customer and a maximum demand meter will be installed when the customer's load and use characteristics indicate that the maximum demand may exceed 25 kw or when the customer's monthly use exceeds 5000 kwhr per month.

Primary Supply Voltage Service:

Where, at the option of the Company, service is delivered and metered at a nominal supply line voltage of 2400 volts or more, the above monthly energy charges will be decreased 4%.

Determination of Demand:

The maximum demand for each month shall be the maximum average load in kw during any fifteen-minute period as indicated by a demand meter. The billing demand for each month shall be the maximum demand for such month but not less than 50% of the greatest maximum demand for the preceding eleven months nor less than 25 kw.

Superseding Revised Sheet No. 52-A
Effective April 1, 1976

Revised Sheet No. 52-A
Effective September 11, 1978

SCHEDULE "G" (continued)

Fuel Clause:

The above rates are based on a composite cost to the Company of one hundred ninety-eight cents (198.0¢) per million British thermal units (Btu) for fuel delivered in its service tanks and the fuel equivalent for power purchased under agreements with Puna, Pepeekeo (Hilo Coast Processing, Inc.), and Honokaa Sugar Companies. When this cost is more or less than 198.0¢ per million Btu, there shall be a corresponding increase or decrease in the above rates. Such increase or decrease shall be in the amount per kwhr of adjusted for the additional revenue tax requirement, for each full fifteen hundredth cent (0.15¢) increase or decrease, in fuel cost, above or below 198.0¢ per million Btu. The revenue tax requirement shall be calculated using current rates of the revenue related taxes of franchise, public service and public utility commission fee. The adjustment shall be effective on the date of change and when a cost change occurs during a customer's billing period, the fuel adjustment will be prorated for the number of days each cost was in effect.

Rules:

Service supplied under this rate shall be subject to the Rules of the Company.

P.U.C. Order
Nos. 5261 & 5266

SCHEDULE "H"

Commercial Cooking, Heating, Air Conditioning and Refrigeration Service

Availability:

Applicable only to commercial cooking, heating, air conditioning and refrigeration service. This schedule applies only where the voltage supplied by the Company is less than 600 volts.

Rate:

The charge shall be the sum of the following capacity and energy charges.

CAPACITY CHARGE:

$2.50 per month per kw of required capacity, but in no case less than $2.50 per month.

ENERGY CHARGE:

First	100 kwhr per month - per kwhr	13.4¢
Next	200 kwhr per month - per kwhr	10.1¢
Next	500 kwhr per month - per kwhr	7.4¢
All over	800 kwhr per month - per kwhr	5.5¢

Minimum Charge:

The capacity charge but not less than $5.00 per month for single phase service or $15.00 per month for three phase service.

Term of Contract:

Not less than one year.

Determination of Required Capacity:

The required capacity for billing purposes shall be:

A. The sum of:

1) The total connected motor load,
2) 50% of the connected heating load exclusive of cooking and water heating, and
3) the water heating connected load in excess of one-sixth kilowatt per gallon of storage capacity; or

B. When the load is 25 kw or more, the capacity may be determined by measured demand. The maximum demand for each month shall be the maximum average load during any fifteen-minute period as indicated by a demand meter. The capacity for each month shall be the maximum demand for such month, the highest demand in the preceding eleven months, or 25 kw, whichever is highest.

SCHEDULE "H" (continued)

The required capacity will be determined to the nearest one-tenth kw.

Fuel Clause:

The above rates are based on a composite cost to the Company of one hundred ninety-eight cents (198.0¢) per million British thermal units (Btu) for fuel delivered in its service tanks and the fuel equivalent for power purchased under agreements with Puna, Pepeekeo (Hilo Coast Processing, Inc.), and Honokaa Sugar Companies. When this cost is more or less than 198.0¢ per million Btu, there shall be a corresponding increase or decrease in the above rates. Such increase or decrease shall be in the amount per kwhr of adjusted for the additional revenue tax requirement, for each full fifteen hundredth cent (0.15¢) increase or decrease, in fuel cost, above or below 198.0¢ per million Btu. The revenue tax requirement shall be calculated using current rates of the revenue related taxes of franchise, public service and public utility commission fee. The adjustment shall be effective on the date of change and when a cost change occurs during a customer's billing period, the fuel adjustment will be prorated for the number of days each cost was in effect.

Rules:

Service supplied under this rate shall be subject to the Rules of the Company.

P.U.C. Order
Nos. 5261 & 5266

SCHEDULE "P"

Large General Service

Availability:

Applicable to lighting and power service supplied and metered at a single voltage and delivery point.

Rate:

The charge shall be the sum of the following demand and energy charges.

DEMAND CHARGE:

First	200 kw or less of billing demand	$1100.00 per month
Next	300 kw of billing demand	4.50 per month per kw
All over	500 kw of billing demand	4.00 per month per kw

ENERGY CHARGE:

First	200 kwhr per month per kw of billing demand-per kwhr	5.4¢
Next	200 kwhr per month per kw of billing demand-per kwhr	4.7¢
All over	400 kwhr per month per kw of billing demand-per kwhr	4.0¢

Minimum Charge:

The minimum monthly charge shall be the demand charge.

Determination of Demand:

The maximum demand for each month shall be the maximum average load in kw during any fifteen-minute period as indicated by a demand meter. The billing demand for each month shall be the maximum demand for such month or the mean of current monthly maximum demand and the greatest maximum demand for the preceding eleven months whichever is the higher but not less than the minimum billing demand of 200 kw.

Power Factor:

The above charges are based upon an average monthly power factor of 85%. For each 1%, the average power factor is above or below 85%, the monthly bill as computed under the above rates shall be decreased or increased, respectively, by 0.15%. The power factor will be computed to the nearest whole percent.

In no case, however, shall the power factor be taken as more than 100% for the purpose of computing the adjustment.

The average monthly power factor will be determined from the readings of a Kwhr meter and a Kvarhr meter. The Kvarhr meter shall be ratcheted to prevent reversal in the event the power factor is leading at any time.

Special Terms and Conditions:

Supply Voltage Delivery:

If the customer takes delivery at the supply voltage

SCHEDULE "P" (continued)

designated by the Company, the demand and energy charges will be decreased as follows:

Transmission voltage supplied	7%
Distribution voltage supplied	5%

Metering will normally be at the delivery voltage. When customer's transformers are adjacent to the delivery point, the customer may elect to be metered at a single point on the secondary side of his transformers where such point is approved by the Company. When the energy is metered on the secondary side of the customer's transformers, the above decreases will be 6 and 4%, respectively.

Fuel Clause:

The above rates are based on a composite cost to the Company of one hundred ninety-eight cents (198.0¢) per million British thermal units (Btu) for fuel delivered in its service tanks and the fuel equivalent for power purchased under agreements with Puna, Pepeekeo (Hilo Coast Processing, Inc.), and Honokaa Sugar Companies. When this cost is more or less than 198.0¢ per million Btu, there shall be a corresponding increase or decrease in the above rates. Such increase or decrease shall be in the amount per kwhr of   adjusted for the additional revenue tax requirement, for each full fifteen hundredth cent (0.15¢) increase or decrease, in fuel cost, above or below 198.0¢ per million Btu. The revenue tax requirement shall be calculated using current rates of the revenue related taxes of franchise, public service and public utility commission fee. The adjustment shall be effective on the date of change and when a cost change occurs during a customer's billing period, the fuel adjustment will be prorated for the number of days each cost was in effect.

Excessive Instantaneous Demands:

The maximum demand may be limited by contract. In order to guard against excessive instantaneous loads on its system, the Company reserves the right to install load limiting circuit breaker equipment on the customer's service to automatically limit the maximum demand to the contract capacity.

Term of Contract:

Contracts for service under this rate shall be for not less than one year and thereafter until cancelled by six months written notice given by either party.

Rules:

Service supplied under this rate shall be subject to the standard Rules of the Company.

APPENDIX B

TABLE B-1

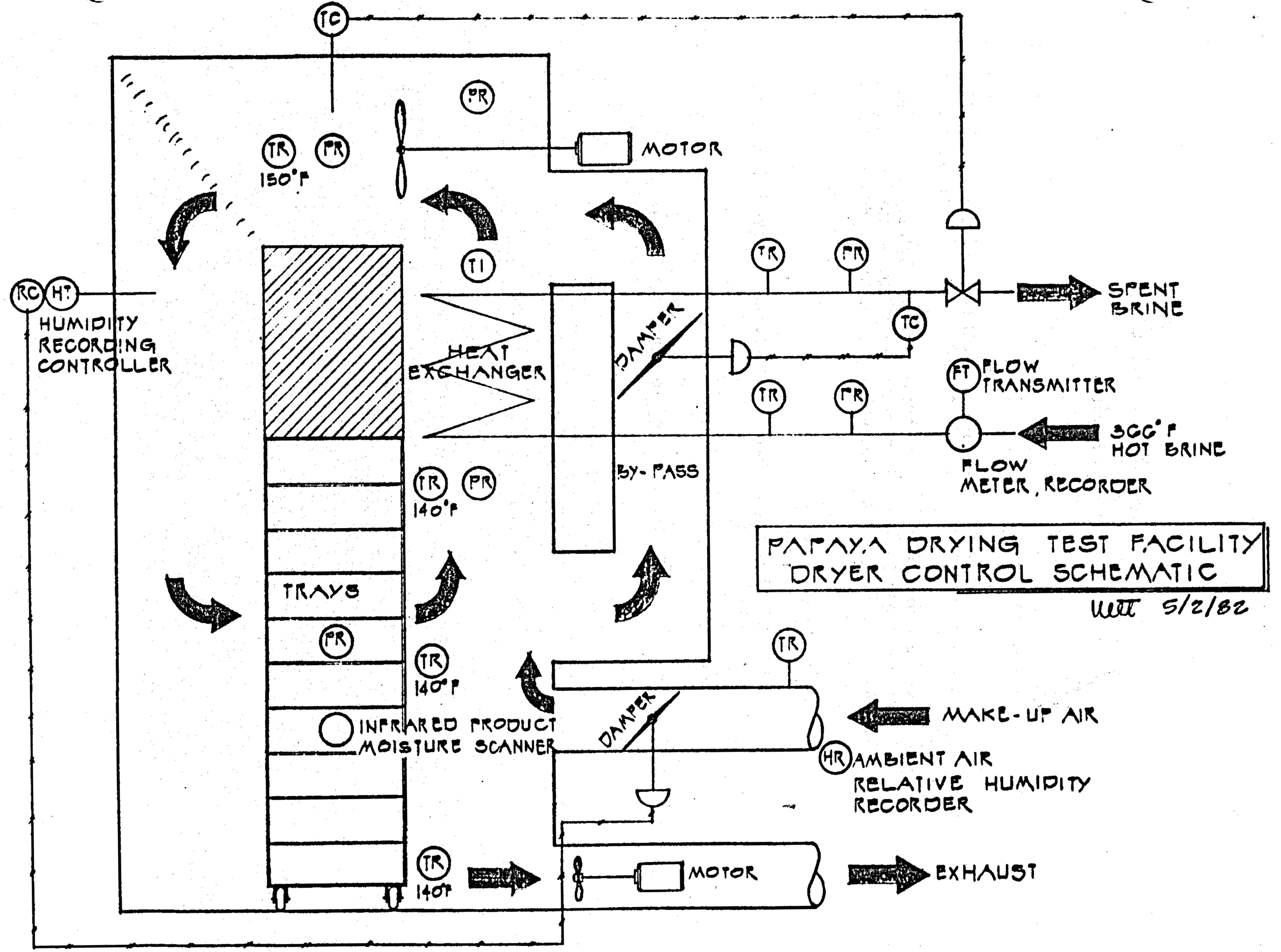
PAPAYA DIMENSIONS AND QUANTITY

OF WASTE BY PRODUCTS

PAPAYA NO.	WEIGHT (lb/oz)	DIAMETER (INCHES)	LENGTH (INCHES)	SKIN (lb/oz)	SEEDS (lb/oz)	END: (lb/o:
1	2 lb. 9 oz.	3-3/4"	5-1/4"			
2	1 lb. 4 oz.	3-1/2"	5"			
3	1 lb. 8 oz.	3-3/4"	5-1/4"			
4	1 lb. 8 oz.	4"	4-3/4"			
5	1 lb. 2 oz.	3-3/4"	5"			
6	1 lb. 15 oz.	4"	6"			
7	1 lb. 8 oz.	3-1/2"	5-1/2"			
8	1 lb. 6 oz.	3-3/4"	5"			
9	1 lb. 4 oz.	3-1/2"	4-1/2"			
10	1 lb. 6 oz.	3-3/4"	5-1/4"			
11	1 lb. 5 oz.	3-1/2"	5"			
12	1 lb. 8 oz.	3-1/2"	5"			
13	1 lb. 4 oz.	3-3/4"	4-1/2"			
14	1 lb. 5 oz.	3-3/4"	4-3/4"			
TOTALS	19 lb. 12 oz.			2 lb. 6 oz.	3 lb. 3 oz.	9 oz.
WASTE					6 lb. 2 oz.	
NET TOTAL	13 lb. 10 oz.					
NET WEIGHT %	69%					

APPENDIX C

FIGURE C-1



PAPAYA DRYING TEST FACILITY
DRYER CONTROL SCHEMATIC

5/2/82

PAPAYA DRYING TEST FACILITY

CONTROLS OUTLINE

1. Circulating Air Temperature Control

   a. Primary temperature controller on main air stream regulates brine flow through the heat exhanger to maintain circulating air temperature.

   b. Secondary temperature controller on brine stream regulates bypass air around heat exchanger to maintain minimum brine temperature during low evaporation periods. Minimizes brine precipitation due to low brine temperatures.

2. Circulating Air Relative Humidity

   a. Relative humidity controller on main air stream regulates ambient air make up and exhaust.

3. Air Velocity Across Papayas

   a. Circulating air fan motor speed varied to control circulating air flow rate

PAPAYA DRYING TEST FACILITY

TEST PROGRAM WITH

BRINE HEAT EXHANGER DRYER

1. Assumptions

   a. Ideal papaya drying temperature, 140-150°F
   b. Initial papaya moisture, 90% wet weight
   c. Final product moisture, 15% bone dry
   d. Effect of ambient air conditions are relatively minor.

2. Variable Parameters

   a. Air drying temperature
   b. Circulating air relative humidity
   c. Air velocity across papaya.

3. Monitored Parameters

   a. Temperatures:

      (1) Air before trays
      (2) Air after trays
      (3) Ambient air
      (4) Brine before heat exchanger
      (5) Brine after heat exchanger

   b. Pressures

      (1) Air after recirculating air fan
      (2) Air within trays
      (3) Air after trays/Before heat exchanger
      (4) Air before recirculating air fan
      (5) Brine before heat exchanger
      (6) Brine after heat exchanger

   c. Ambient Air Relative Humidity

   d. Brine Flow

   e. Drying Time

   f. Exhaust Air Fan Amperage

   g. Circulating Air Fan Amperage

APPENDIX D

SURFACE RATES

Young Bros.:

$20.00 per 40 cubic ft. or 2,000 lbs. to Honolulu from Hilo

$25.49 per 40 cubic ft. or 2,000 lbs. to Maui/Kauai from Hilo

No increase foreseen.

Matson:

$2.25 per cu. ft. minimum $65.00 to all West Coast
ports--Oakland, Los Angeles, Portland, Seattle

No increase foreseen. 30 days notice will be given if there is an increase.

AIR FREIGHT

United Airlines:

$1.16 per lb. or cu. rate (whichever is greater)

Hilo to Los Angeles

$.94 per lb. 100 lb. rate.

DHL:

Destination:

Honolulu*	100 lbs. $27.32 or cubic weight (whichever is greater)	
	0-36 lbs.	$ 9.18
	37-708 lbs.	.253 per lbs.
	704-1,000 lbs.	$179.00 flat rate
Maui*	0-40 lbs.	$ 9.18
	41-751 lbs.	.213 per lb.
	752-1,000 lbs.	$160.00 flat rate
Kauai*	0-29 lbs.	$ 9.18
	30-727 lbs.	.293 per lb.
	728-1,000 lbs.	$213.00 flat rate

*To all rates add 8% fuel adjustment until June 15. After June 15 all rates will include fuel adjustment. New rates will be issued June 15, 1982.

APPENDIX E

THE ECONOMIC VIABILITY OF PAPAYA FARMS IN THE PUNA DISTRICT

Michael N. Muench
Research Assistant
Department of Agricultural and Resource Economics
University of Hawaii

Introduction

This study of the Economic viability of Papaya production in the Puna District on the island of Hawaii was conducted as part of HITAHR Project 452-S: "Economic Feasibility Studies for Fruit and Nut Crops."

The objectives of the study are: (1) to assess the economic viability of papaya production under present conditions; (2) to evaluate the effects on the industry of changes in scale and resulting variations in input costs; and (3) to develop a more comprehensive grower-management information system. This paper is concerned primarily with objectives (1) and (2). The third objective has, to a limited extent, been achieved. A computer program has been developed which can provide growers with basic management information and financial analysis for their farms. This can be done on an individual basis given the ability of the farmer to supply limited input data.

Procedures

The Puna District, although restricted in geographical area, has great variations in soil types. Individual farms may be located in areas of many lava flows, each flow having different yield characteristics. Another difficulty which arises in assessing the viability of papaya farms is the great variation in meteorological conditions within the region and the resultant rainfall and wind differentials. These soil and weather desparities have led individual farmers to develop unique cultivation methods and in many cases to breed, on their own farms, types of trees to meet their specific needs. A further difficulty in assessing the industry arises from the fact that the papaya industry has become highly skewed in nature; with a few farms accounting for the major portion of production. For example, the five largest growers account for about 68 percent of the acreage, and the 13 largest growers 75 percent of the acreage.

In combination these factors make it difficult to derive industry averages which have economic relevance. In view of this, the present study has attempted to draw some generalizations about papaya production technologies which are presently being practiced and to present an assessment of these technologies as a means of gaining a better understanding of the present viability of the industry.

Conclusions were drawn from fifteen responses to a questionnaire, detailed interviews and visits to five farms of varying sizes, and actual work experience on two farms. Basic techniques employed in papaya production can be roughly grouped according to farm size. Differentiation was made between the methods employed on farms of 5 acres, 10 acres, 50 acres and over. A task oriented analysis of farm activities was then carried out for each of these farm types. For example, generalizations were made about the usage rates, frequency of application and labor inputs for weed control. Input costs were obtained from local distributors and some adjustment in prices was made to account for economies resulting from bulk purchases by larger growers. All input costs for weed control were then broken down on a monthly basis. This procedure was carried out for each farm task. Total yield estimates were obtained from the questionnaires and interviews and production trends were obtained from a Masters Thesis by Ronald Nakamura. The sum of task costs was then matched against production revenues. From this information, and the assumption that all monies were borrowed from the bank, a cash flow statement was developed.

Generalized Farm Technologies

Five Acre Farm:

The small grower is primarily a part-time farmer. The time devoted to farming activities is primarily on week-ends and after work. Because of limited time and capital availability, the small grower has adopted a less intensive method of cultivation. His labor contributions and input costs are, for the most part, lower than those of full-time farmers and, as a result, production levels of a typical 5 acre farm are substantially reduced in comparison to more intensive operations. The part-time grower generally hires no labor and all necessary operations are carried out by the farmer alone or with the help of family members.

Ten Acre Farm:

The ten acre farm is a full-time family operation. The grower employes more intensive methods of cultivation than the part-time farmer but continues to rely on large amounts of family labor. High family labor contributions enable the farmer to avoid additional capital costs which would result from the purchase of a tractor or other heavy machinery. The ten acre full-time farmer because of increased yield and acreage, is required to make larger expenditures for transport vehicles, gas and maintenance and additional support than the 5 acre farmer.

Fifty Acre Farm:

The farm of fifty acres and larger is run as a corporate operation. Even if it is family owned, all labor inputs whether family supplied or not are paid a wage. Because of its size the corporate operation can efficiently substitute machinery for labor and, except for increased labor inputs at the early stages of planting, it does so. It employs a tractor which aides in carrying out fertilization, weed control, misting and, in some cases, harvesting. In comparison with the ten acre farm, increased machinery use simply substitutes for labor and no increase in yield results.

It should be noted that the distinctions drawn between these farm sizes is by no means universal. They are generalizations about the technologies employed in the Puna area. Each actual farm is unique and the individual farmer may observe some aspects of his operation in more than one of the synthesized descriptions. Many of the trends and problems of the industry, however, can be revealed through an analysis of these three standard farms and further analysis of the reasoning behind the management decisions of the different types of farmers could indicate future trends in the industry.

An analysis of each of these farm types, because of the constraints of this presentation, is not feasible. Therefore to conserve time and space, further discussion will be restricted to an analysis of the ten acre farm. This operation was chosen because it is felt that a majority of the farms in the Puna region possess some characteristics which are similar. Some basic assumptions which will be made about this farm are: (1) Production of 60,000 pounds per acre in three year's life; (2) An average payout price of $.20 per pound; (3) A wage of $3.20 per hour. The analysis which is presented for the ten acre farm could be done for both the five and fifty acre farms and as stated in the introduction, can be tailored to any individual operation, given basic input costs.

Economic Analysis of the Ten Acre Farm

Not all farms employing ten acre technology are the same. Some farms have been in operation for years, and when they start-up new plantings they do so with assets which have long since been paid for. New farms must on the other hand, immediately deal with the purchase of these same assets at going market rates. As a result the attitudes of different farmers will vary. Finally whether a new or old family farm operation, it is economically unsound not to value the labor input on the farm. What may seem like a large profit might completely disappear if operator and family labor received the current market wage. In view of these variations we will analyze the Ten Acre technology assuming three different operations: 1. On-going (no wage); 2. New Farm (no wage); 3. New Farm (with wages and management costs). For each, our discussion will cover two aspects of the operation: its Net Cash Flows; and its Expenditures, both on a per acre basis over an estimated three year life of the planting.

By 'Net Cash Flow' we mean that if we assume that all revenues and expenses going in and out of a farm in any particular period are balanced against each other we will have some net inflow or outflow of cash. That is, in any period one may either pay-out more in expenses than he receives in revenues or vice versa. A Net Cash Flow analysis can tell a farmer a number of things about his operation. It can identify the point or time of maximum cash outflow; that moment where the farmer has the greatest amount of funds tied up in his operation. During the establishment period an estimate of average cash outflow can be derived; which provides the grower with some idea of how much cash he will be required to allocate to his acreage on a monthly basis. A break-even or pay-back point will become evident; that point where the acreage begins to pay-off or provide revenues in excess of overall expenditures. A point of maximum cash inflow can be calculated; and it identifies the point where the operation theoretically should close down, or at least severely restrict its inputs. In addition we can obtain some average revenue estimates for the productive years of operation which can help the farmer budget family expenditures or additional farm expansion.

An Analysis of Expenditures can help to explain to the farmer just where costs are and why, in relation to his neighbors, he may see some costs as more important than they do.

On-Going Ten Acre Farm

Column 1 of Table 1 shows the flows at establishment and by quarter during the growing period for an On-Going operation. As can be seen the On-Going Farm incurs about $755 in costs during establishment. Average inflows of cash in years two and three are approximately $550/acre/month and $220/acre/month respectively. The pay-back or break-even point in the operation occurs in the 18th month, while maximum cash inflow of $7760/acre occurs in the 33rd month.

Total expenditures for the three-year life of the farm are $4,595. A breakdown of the expenditure can be seen in Table 2. This analysis reveals that the most important expense to an On-Going Farm is fertilizer which accounts for 49 percent for all expenses. This major cost is followed by asset purchases with 16 percent, which in this case is primarily land clearance and preparation costs. Pest control and support costs are both 13 percent of the total.

New Farm (no wages)

It is difficult to value at market rates assets which have been purchased and used over a number of years. Economic analysis becomes difficult and, if proper account is not taken of replacement costs, may be misleading. It is therefore useful to look at the same oepration but assume that all assets are purchased new at establishment. We then may answer the question: What is the effect on our cash flows of purchasing all assets at the onset of operations instead of assuming we already own our machinery?

Assuming asset purchases at establishment, expenditures jump from $755 to $2,435 per acre (Table 1). The average yearly outflow of funds over the three years remains the same however. But because of establishment purchases, maximum cash commitment per acre is $4,028 in the thirteenth month, an increase of 92 percent over On-Going Farm operations. Pay-back occurs in the 21st month, a delay of three months over the On-Going Farm pay-back. The maximum cash inflow of $5,400 occurs in the 33rd month, a reduction of $2,220/acre, which is a drop in flows of 30 percent.

Looking at Table 2, the second section, 'New Farm', can be seen that the addition of asset expenditures changes the relative importance of each cash cost. Fertilizer now accounts for 36 percent of the total costs as opposed to the 49 percent for the On-Going Farm operation. Asset costs now account for 39 percent of total expenditures and Support and Pest Control are 10 and 9 percent respectively.

New Farm (with Management and Wage Costs)

In neither of the first two operations which have been reviewed has the labor input been charged as an expense. This was not done because in many cases farmers are operating strictly on a cash basis and are more concerned with the cash flows of the operation exclusive of any implied wage. However, in an economic sense, some value must be placed on an individual's labor and management inputs. Because if he doesn't work on the farm it must be assumed that he would be working elsewhere. In other words, some flow of cash would be contributing to the family's income whether it is farm generated or from an outside activity. This is often called the individual's 'opportunity cost'. That is, the wage which would be sacrificed by not working for someone else and instead working on the farm.

It is economically important to analyze the same ten acre operation, only this time we will charge for labor at $3.20/hour and charge 10 percent of total costs/year as a management expense. Using this procedure the resulting Net Cash Flow can be seen in the third column of Table 1. Though establishment costs have risen only slightly, from $2,435 to $2,521, the average monthly outflow during the first year of operation has risen 56 percent from $85/acre/month to $133/acre/month. In addition net receipts in year two have dropped 20 percent from $548/acre/month to $437/acre/month and in year three by 10 percent from $243/acre/month to $218/acre/month.

The maximum cash commitment has risen to $4,810/acre in the 13th month which is an increase of 129 percent over the On-Going Farm commitment of $2,100 and an increase of 19 percent over the New Farm commitment of $4,028. In addition we find that the pay-back point has been pushed back another two months to the 23rd month. Finally maximum cash inflow per acre has dropped to $2,350 down 70 percent from the On-Going Farm flow of $7,760 and down 56 percent from the New Farm flow of $5,400.

Analyzing expenditures of the 'New Farm' (with management and wages), (see the third section of Table 2), it can be seen that the fertilizer and asset costs, though not decreasing in magnitude, have dropped in relative importance as wages and management charges have been added to the analysis. Fertilizer, assets and wages are now roughly of equal importance accounting for one-quarter the total expenditure each (Figure 5).

A comparison of the three farm operations' Net Cash Flows is presented below:

'Ten Acre' Technology

(one acre)

	On-Going	New Farm	New Farm (with wages)
Establishment	$775	$2,435	$2,521
Average Outflow Year 1	85	85	133
Maximum Cash Outflow	2,100 - 13 mo.	4,028 - 13 mo.	4,810 - 13 mo.
Average Monthly Inflow Year 2	550	550	437
Average Monthly Inflow Year 3	218	218	128
Pay-Back or Breakeven Month	18	21	23
Maximum Cash Inflow	7,760 - 33 mo.	5,400 - 33 mo.	2,350 - 32 mo.

An analysis of the investment flow, shown on the top of Table 3, reveals that the internal rate of return on investment for a ten acre farm is 67 percent. Table 3 also shows the Present Value and Benefit Cost Ratio for one acre of papaya at different interest rates. All measures of financial performance indicate that papaya production, given the assumptions outlined, is a reasonably profitable enterprise. Such measures do not, however, take risk into account. In view of the recent troubles the industry has faced the inclusion of a valuation of risk in such measures may produce a more moderate performance indicator.

Conclusions

This report has differentiated some technologies employed on papaya farms in the Puna area. Three general techniques were distinguished and can roughly be categorized on an acreage basis. These were: the five acre part-time operation employing low levels of labor and capital inputs; the ten acre farm employing higher capital inputs and much more intensive labor input; and the fifty acres or larger farm employing more capital intensive technologies.

The ten acre technology, as with both the five and fifty acre farms can be distinguished by type of operation depending on the age of assets and whether labor is paid or not. For each of these operations, cash flow and expenditure analyses were conducted.

In addition, we conducted income and financial analyses of a new farm which pays wages. These studies revealed that much of the revenues of the farm, 80 percent, are taken up in payments to farm factors and that potential "profits" fall far below the level of cash inflow. It was noted, however, that given a .20/lb. pay-out price on 60,000 pounds of fruit/acre the present papaya farm would be achieving reasonable returns on investment.

TABLE 1

10 ACRE FARM

Net Cash Flow

	On Going Farm	New Farm	New Farm With Wages & Management
Start-Up	-755	-2435	-2521
Quarter 1	-144	-144	-298
2	-271	-271	-355
3	-256	-256	-343
4	-342	-342	-601
5	405	405	268
6	2144	2144	1892
7	1998	1998	1712
8	2034	2034	1381
9	1496	1496	1196
10	1010	1010	748
11	250	250	57
12	-133	-133	-457

TABLE 2

Analysis of Costs for 10 Acre Farm

Farm type/Expenses:		Wages	Weed Control	Pest Control	Fertilizer	Gas & Machinery	Support Costs	Asset Costs	Total Costs
On Going Farm	$	0	166	589	2231	272	600	737	4594
	%	0	4	13	49	6	13	16	100
New Farm	$	0	166	589	2231	272	600	2417	6274
	%	0	3	9	36	4	10	39	100
New Farm	$	2337	166	589	2231	272	1293	2417	9304
	%	25	2	6	24	3	14	26	100

TABLE 3

Analysis of Return on Investment

	Total Outflows	Total Returns*	Net
Year 1	4119.14	0.0	-4119.14
Year 2	2846.01	8099.98	5253.97
Year 3	2338.50	5082.40	2743.90

*Includes estimated salvage value of asset balances

Price equals: 0.20

Internal Rate of Return on Investment: 0.67354

Discount Rate	Present Value	Benefit Cost Ratio
0.075	5556.40	1.7901
0.100	5433.51	1.7804
0.150	5192.63	1.7612
0.200	4957.11	1.7421

APPENDIX F

HAWAII PAPAYAS

Hawaii Agricultural Reporting Service
Hawaii Department of Agriculture
U.S. Department of Agriculture
Papaya Administrative Committee
Box 22159 Honolulu, Hi. 96822
(808) 548-7159

Release: May 10, 1982

HIGHLIGHTS: FRESH PRODUCTION INCREASING AS SUMMER NEARS
KAUAI TREE LOSSES CONTINUE
FARM PRICE UP IN APRIL

May fresh papaya production is forecast at 4.50 million pounds, up 20 percent from April. The Hawaii Agricultural Reporting Service expects most of the increase to occur on Hawaii island with Kauai and Maui/Oahu registering slight increases. Compared to a year ago, fresh production this month will be down 66 percent on Kauai, down 33 percent on Maui/Oahu but up 2 percent on Hawaii.

For the upcoming summer months, fresh production is forecast to increase 13 percent in June and to peak at 5.15 million pounds in July. An 11 percent decrease is anticipated for August. Total fresh production from Maui/Oahu and Kauai for this May-August period is forecast at 1.51 million pounds, 55 percent less than the total amount realized during the same period last year.

Fresh production in April is estimated at 3.76 million pounds, down 15 percent from March. Out-of-State shipments, mainly to the U. S. mainland and Japan, totaled 3.04 million pounds or 81 percent of the April total. Due to the Phytophthora infestation, Kauai's share of Statewide fresh production was reduced to 6 percent in April. In 1981, Kauai accounted for 13 percent of all fresh papaya production in the State.

The latest Hawaii Agricultural Reporting Service acreage survey of papaya farmers estimates total area in crop, as of April 1, 1982, at 3,035 acres. This is down 2 percent from a year ago as increases on Hawaii and Maui/Oahu were not enough to offset a 34 percent reduction in acreage on Kauai. Farmers on Kauai continued to lose papaya trees to Phytophthora in April despite the advent of better weather conditions. It is estimated that Kauai has lost a minimum of 31 percent of its total acreage since the rains began last November. Future tree losses are anticipated as farmers eventually rogue infected plants. Disease and weather problems have also hindered planting activity on Kauai. Farmers there planted 10 acres in March and were planning to add 65 more acres through July. For the State, acreage for harvest in May is expected to increase 2 percent.

The average farm price received for all types of fresh sales rebounded in April to 25.0 cents per pound, 4 percent higher than March and 5 percent above last April's price.

LLOYD P. GARRETT
Statistician in Charge

RONALD Y. NAKAMURA
Research Statistician

PAPAYAS: Acreage in crop, nonbearing and bearing, and acreage planted, by islands, April 1982

Island	Total acreage in crop Apr. 1, 1981	Total acreage in crop Apr. 1, 1982	Nonbearing acreage in Apr. 1982	Harvested in 1st year of harvest	Harvested in 2nd year of harvest	Acreage planted in Mar. 1982	Acreage expected to be planted Apr. 1982	Acreage expected to be planted May-July 1982
	Acres							
Hawaii	2,630	2,680	730	1,255	695	70	85	160
Kauai	340	225	85	90	50	10	10	55
Maui/Oahu 1/	120	130	40	45	45	1	2	11
State 2/	3,090	3,035	855	1,390	790	81	97	226

1/ Combined to avoid disclosure of individual operations. 2/ State totals may not add due to rounding.

PAPAYAS: Harvest acreage and fresh utilization with comparisons, May 1982

Island	Acreage harvested May 1981	Acreage harvested April 1982	Acreage for harvest May 1982	Fresh utilization May 1981	Fresh utilization April 1982	Expected fresh utilization May 1982
	Acres			1,000 pounds		
Hawaii	1,720	1,950	2,010	4,094	3,430	4,160
Kauai	250	140	125	741	245	250
Maui/Oahu 1/	75	90	90	135	85	90
State	2,045	2,180	2,225	4,970	3,760	4,500

1/ Combined to avoid disclosure of individual operations.

PAPAYAS: Fresh utilization by islands, May-August 1981 preliminary and 1982 forecasts

Island	May 1981	May 1982	June 1981	June 1982	July 1981	July 1982	August 1981	August 1982
	1,000 pounds							
Hawaii	4,094	4,160	5,189	4,700	4,426	4,750	3,510	4,230
Maui/Kauai/Oahu	876	340	766	400	900	400	810	370
State	4,970	4,500	5,955	5,100	5,326	5,150	4,320	4,600

PAPAYAS: Fresh utilization, by place of sale, April 1982

Island	Local sales 1/	Shipments Intrastate	Shipments Out-of-State	Total fresh	January-April 1981	January-April 1982
	1,000 pounds					
Hawaii	61	539	2,830	3,430	16,138	13,140
Kauai	25	7	213	245	2,074	1,525
Maui/Oahu 2/	84	1	0	85	469	445
State	170	547	3,043	3,760	18,681	15,110

1/ On island of production. 2/ Combined to avoid disclosure of individual operations.

PAPAYAS: Monthly average fresh papaya farm price per pound, by place of sale, State of Hawaii, 1981-82

Year and place of sale	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
	Cents												
1981 Local	20.9	25.8	28.4	26.8	25.9	25.0	20.6	25.4	26.4	19.2	16.6	21.4	23.5
Mainland	16.1	26.4	24.7	23.4	23.8	25.8	21.6	25.4	19.7	11.4	12.4	13.1	20.5
Foreign	18.2	18.5	21.5	20.9	21.2	19.7	18.7	16.6	17.9	10.1	14.2	14.8	18.1
All	17.6	25.1	25.1	23.8	23.8	24.7	21.0	24.1	20.7	13.2	13.6	15.5	20.8
1982 Local													
Mainland													
Foreign													
All 1/	30.0	28.5	24.0	25.0									

1/ Preliminary.

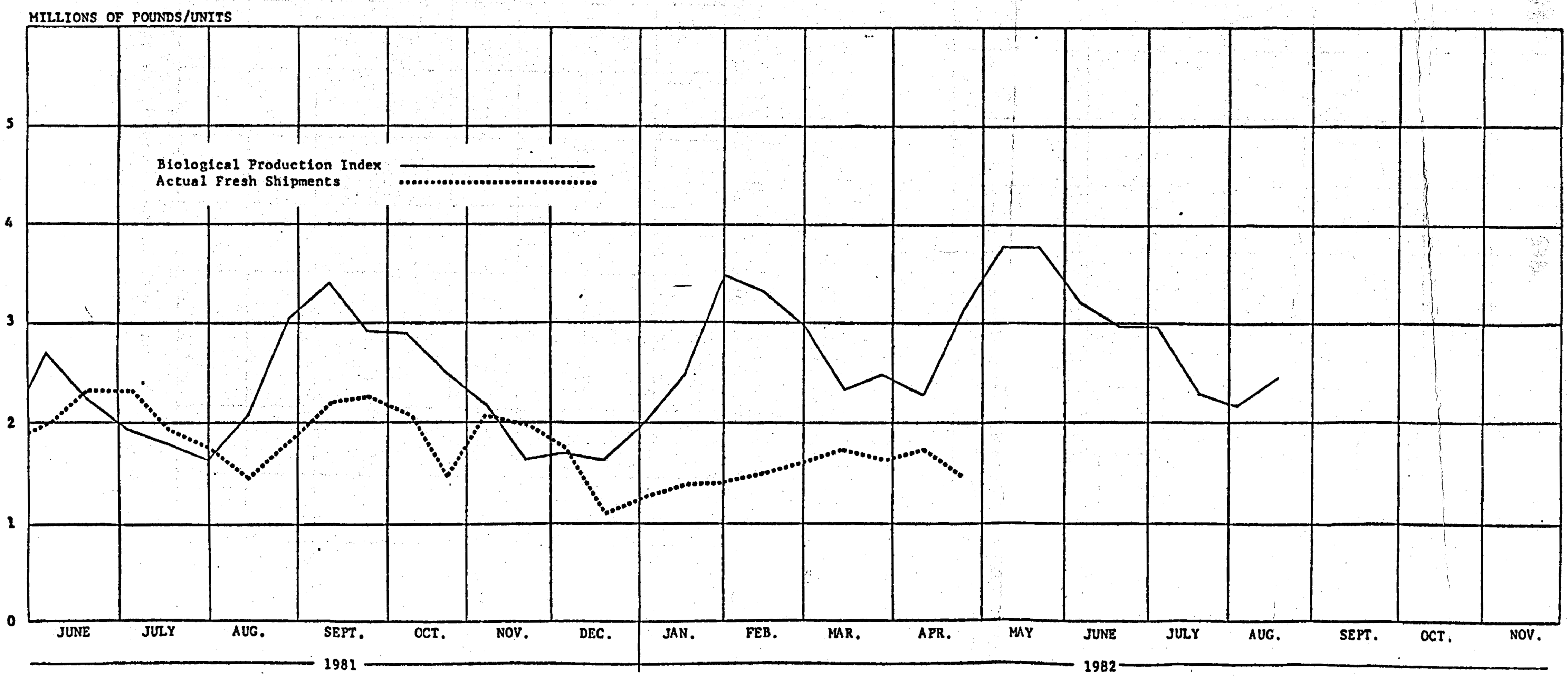
BIWEEKLY HAWAII (BIG) ISLAND BIOLOGICAL AND ACTUAL PAPAYA PRODUCTION

VOLUME (THOUSANDS OF UNITS/POUNDS)	LATEST BIWEEKLY PERIOD: APRIL 11-24, 1982	YEAR-TO-DATE 3/
BIOLOGICAL PRODUCTION UNITS 1/	6,240	45,874
ACTUAL FRESH PRODUCTION (POUNDS) 2/	1,480	12,213
ACTUAL AS PERCENT OF BIOLOGICAL PRODUCTION	23.7	26.6

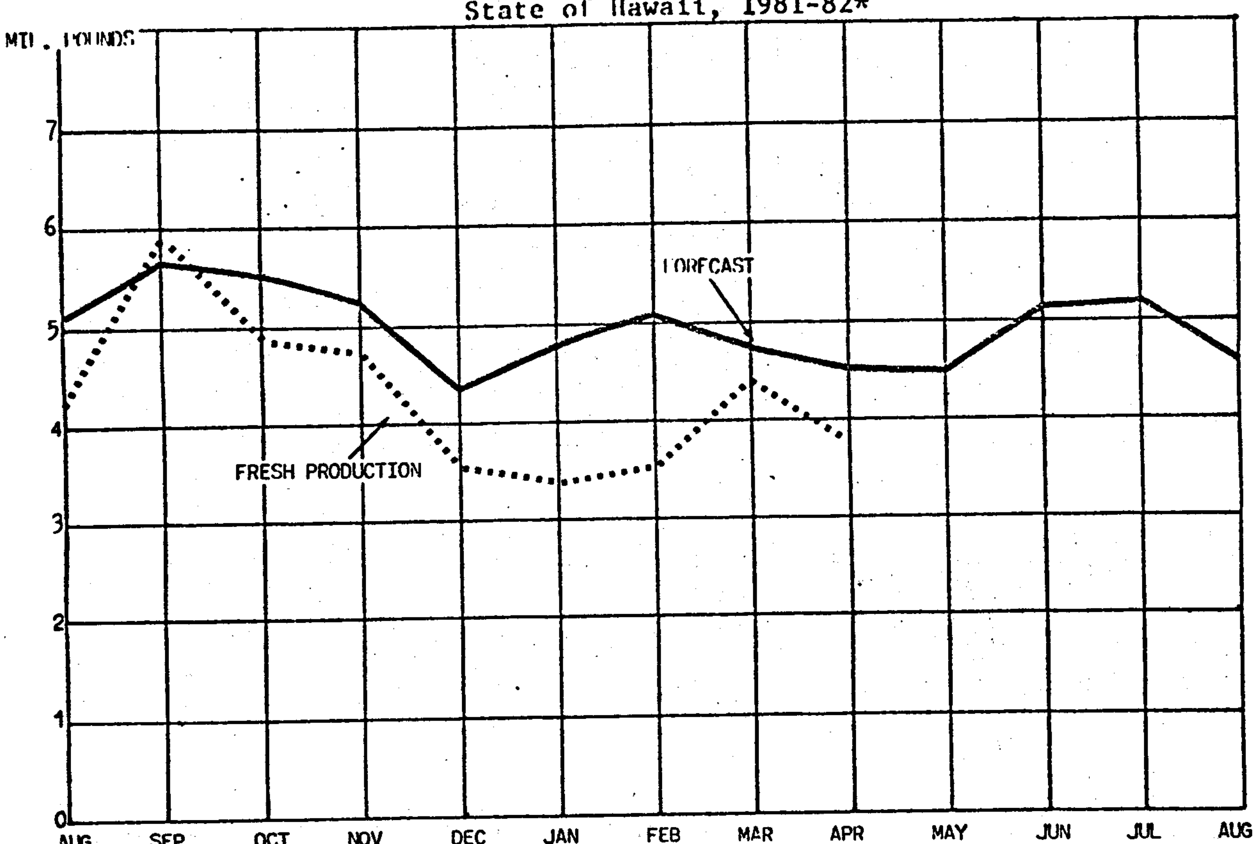
1/ Represents the biological or potential number of fruit to be produced during specific two-week (2) intervals. It does not take into account survival rate of fruit set, weight of fruit or grade out. Biological production obtained by multiplying the Biological Production Index figures by a factor of two (2).

2/ Fruit for processing not included.

3/ YEAR-TO-DATE commencing January 3, 1982.



Papayas: Latest forecast vs. production, State of Hawaii, 1981-82*



* Forecasts and production figures represent fresh utilization only. Production totals for 1981 and 1982 are preliminary.

Papayas: Acreage planted, State of Hawaii, 1980-82