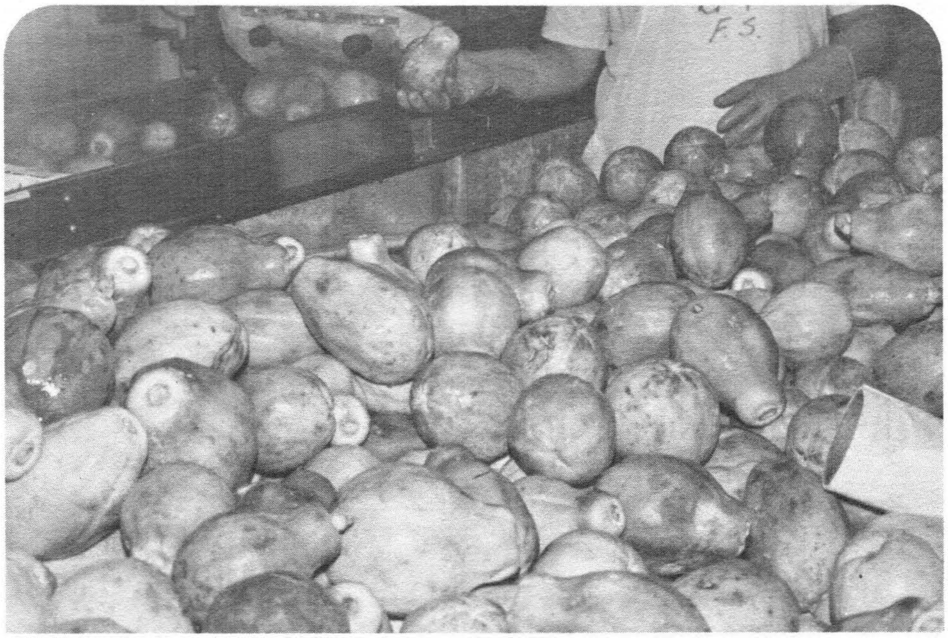
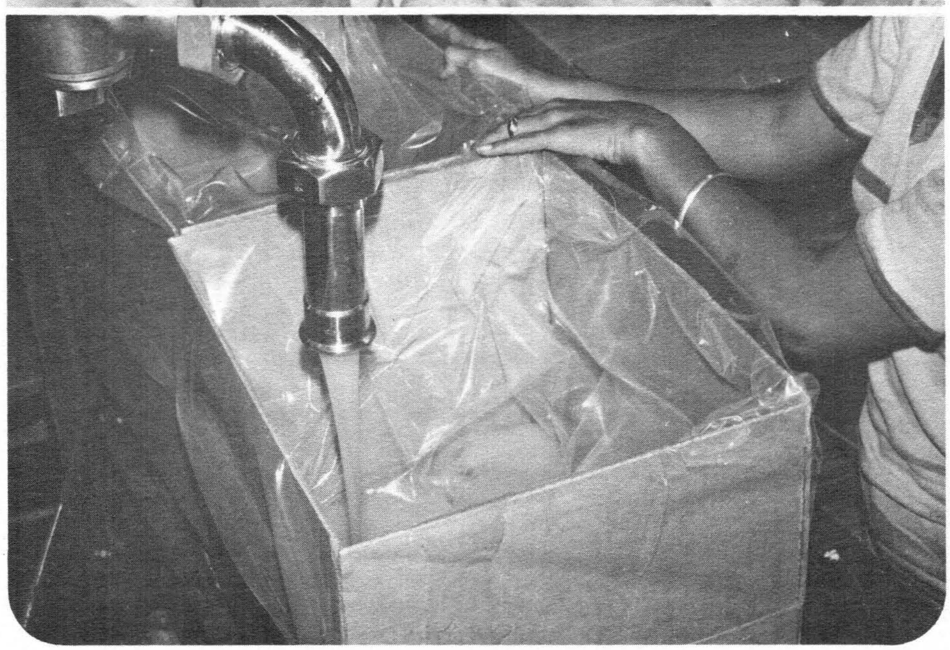
Operating Manual for Papaya Puree Processing

J.E. Brekke, H.T. Chan, Jr., K.L. Hibbard, T.O.M. Nakayama, R.C. Someda, A.E. Myers, and C.G. Cavaletto





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FOREWORD

This manual is an attempt to present our collective thoughts on the operation of a commercial-scale papaya puree line using a newly developed processing method. It represents part of a research and development project designed to make results of laboratory findings available to potential processors. It is intended to be a starting point for those contemplating processing and is not intended to be the last word in processing. The balance of the project concerns a market potential investigation and will be published separately.

ACKNOWLEDGMENTS

This project has been carried out through the efforts of many individuals and organizations, and it would be unwieldy to name all those who have helped in so many different ways.

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We acknowledge the considerable assistance from the Administration of the College of Tropical Agriculture and the Agricultural Research Service of the United States Department of Agriculture for the funds and personnel made available to the project, without which this project could not have been carried out. We wish to acknowledge also the help of our colleagues and those in the industry who have given unstintingly of their advice and knowledge to this project.

DISCLAIMER

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THE AUTHORS

JOHN E. BREKKE was Research Leader of the Hawaii Fruit Laboratory, United States Department of Agriculture, Agricultural Research Service, Honolulu, Hawaii, cooperating with the Hawaii Agricultural Experiment Station, College of Tropical Agriculture, University of Hawaii. He is currently with the United Nations Developmental Program in Iran.

HARVEY T. CHAN, JR., is Research Food Technologist, Hawaii Fruit Laboratory, United States Department of Agriculture, Agricultural Research Service, Honolulu, Hawaii.

KENNETH L. HIBBARD is Research Associate, Hawaii Agricultural Experiment Station, College of Tropical Agriculture, University of Hawaii.

T. O. M. NAKAYAMA is Food Technologist, Hawaii Agricultural Experiment Station, and Professor of Food Science, College of Tropical Agriculture, University of Hawaii.

RAYMOND C. SOMEDA is Food Processor, Hawaii Agricultural Experiment Station, College of Tropical Agriculture, University of Hawaii.

ARTHUR E. MYERS is Agricultural Engineer with the United States Department of Agriculture, Agricultural Research Service, Honolulu, Hawaii.

CATHERINE G. CAVALETTO is Assistant Food Technologist, Hawaii Agricultural Experiment Station, and Assistant Professor of Food Science, College of Tropical Agriculture, University of Hawaii.

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INTRODUCTION

Approximately half the papaya harvested in Hawaii cannot be marketed as fresh fruit due to the rigid quality marketing standards. Even though this fruit is sorted from the fresh packaging line as unsuitable for the fresh fruit market, it is nevertheless wholesome and nutritious and can be processed into other products, such as puree.

A method for processing papaya puree was developed by the Hawaii Fruit Laboratory, United States Department of Agriculture, and the Department of Food Science and Technology, University of Hawaii (Brekke et al., 1973). Subsequently, a small, commercial-scale papaya puree processing line was installed and operated in a commercial processing plant to test the technological feasibility of the process and the performance of the equipment.

The purpose of this report is to provide the basic information necessary for operating a papaya puree processing plant. This information was obtained from the small-scale processing line, which had built-in limitations in size and capitalization. An operator with more adequate resources may change the design to improve both efficiency and production capacity.

DESCRIPTION OF THE PROCESS

Special Unit Operations

This report describes several special unit operations that differentiate this papaya pureeing operation from those now in commercial use. The overall objective of incorporating these special steps is to produce a consistently high-quality papaya puree devoid of off-flavors and one that is stabilized sufficiently to retain its high quality during frozen storage (Figure 1).

Steaming

The first of the special steps is steaming the whole fruit through a steam tunnel to coagulate (or denature) the latex in the peel, in order to prevent the

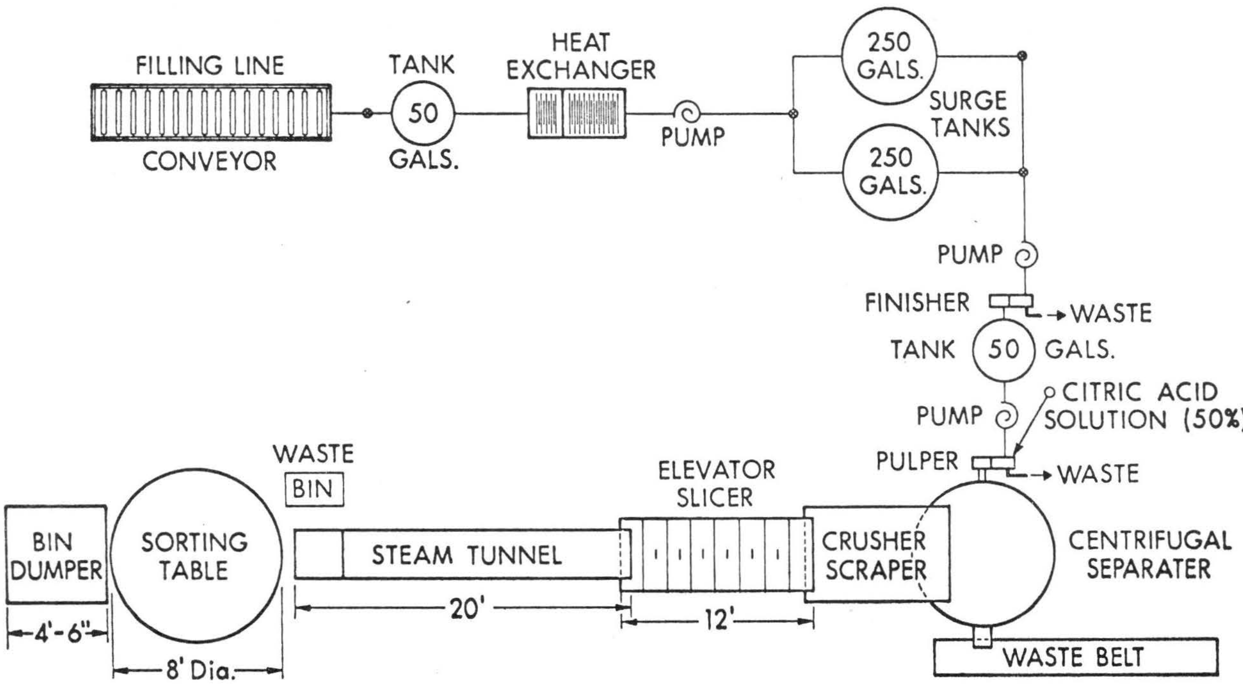

Figure 1. Flow chart of papaya puree processing line

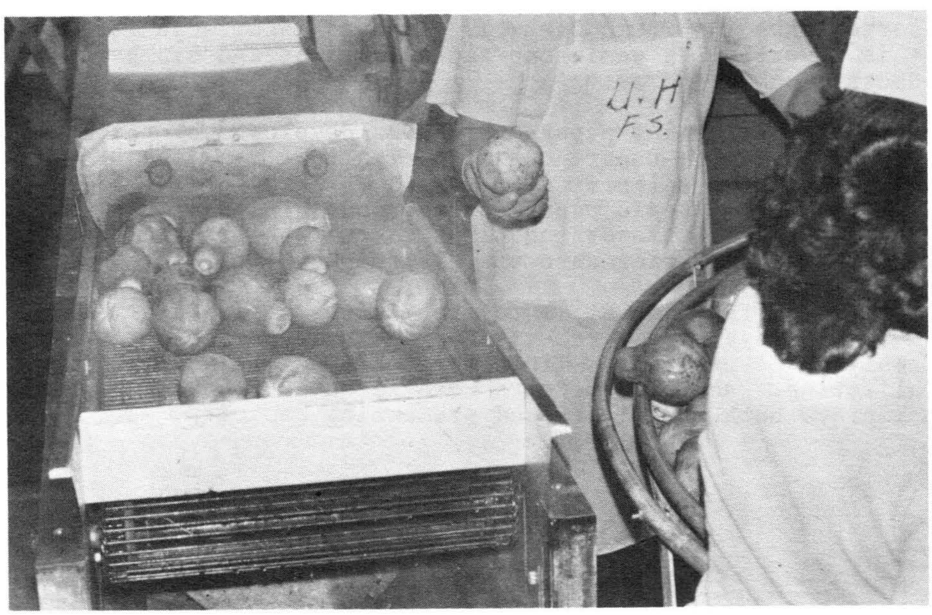

Figure 2. Papayas being fed into the steam tunnel

latex from exuding from the peel during the slicing operation. Steaming also cleans the surface of the fruit and reduces the microbial load (Figure 2).

Minimizing Seed Breakage

The second special step is the use of equipment designed to minimize the enzymatic action caused by seed breakage. The slicer and crusher-scraper are designed to minimize breakage of seeds and rupture of the sarcotesta, the sac surrounding the seed, since high concentrations of the enzyme myrosinase are found in the fluids in the sarcotesta, and the substrate for the enzyme is present in the seed. One of the products of the reaction between enzyme and substrate is benzylisothiocyanate, a very pungent and bitter compound (Tang, 1970). The combination of ruptured sarcotesta and broken seeds generates benzylisothiocyanate, causing off-flavors and off-aromas. To minimize this reaction, the slicer blades operate at relatively slow speed, and the crushing and scraping actions on the sliced papaya are adjusted to avoid seed breakage.

Acidification

The third special step is acidification. Within 5 seconds after the fruit tissue is disrupted, a 50 percent solution of citric acid is added to the puree. This acid is present naturally in papaya, and an increase in its concentration lowers the pH to about 3.5, which inhibits (1) enzymatic reactions that result in off-flavors, off-odors, and gelation, and (2) growth of certain microorganisms that cause spoilage (Chan et al., 1973).

Heat Inactivation

The final special step, which is essential in producing a stable puree, is the heat inactivation of enzymes (Stafford et al., 1966). The puree is pumped through a plate heat exchanger, heated for about 1 to 2 minutes at 198-204°F, then cooled to 85°F. This process is sufficient to inactivate the enzymes responsible for gelling and off-flavor development.

Required Equipment

Following is a detailed description of the equipment needed. All metal parts that come in contact with the puree are made of stainless steel and use a sanitary design.

Bin Dumper

The bin dumper is an open-frame structure constructed from angle and channel iron. A bulk bin full of papaya (wet weight 800-900 pounds) can be placed on the dumper, which then slowly tilts to empty the contents onto a table or belt for sorting.

Sorting Table

A rotating table, 8 feet in diameter, supported by eight rubber rollers and driven by a 1/3-HP motor with sprocket and chain, is used to sort the fruit.

Steam Tunnel

The steam tunnel is 20 feet long overall, inclined from the horizontal at an angle of about 3 degrees (Figure 3). The steam chamber is 17-1/2 feet long, with two 3/4-inch perforated steam pipes mounted above the belt, which runs through the chamber. The belt is 18 inches wide and constructed of tinned bars about 1/2 inch apart. The top part of the steam chamber, over the belt, is made of 24-gauge stainless steel, and the bottom of 24-gauge galvanized iron. A shut-off valve, strainer, pressure gauge, and pressure regulator are mounted on top of the steam tunnel. Steam vents are installed over the entrance and exit of the tunnel (Figure 4).

Elevator and Slicer

The elevator is 15 feet long, inclined upward at 50 degrees, with a 12-inch-wide cleated belt. The rubber cleats on the belt are 2 inches high and

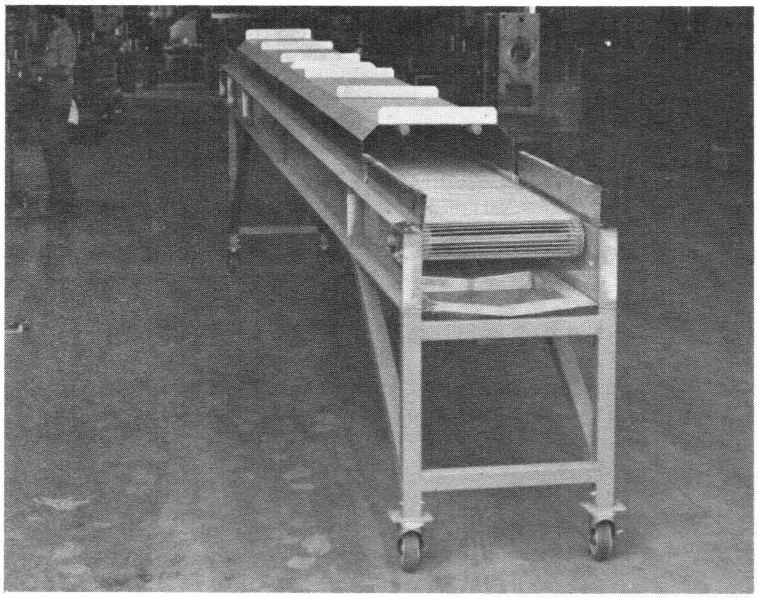

Figure 3. Steam tunnel

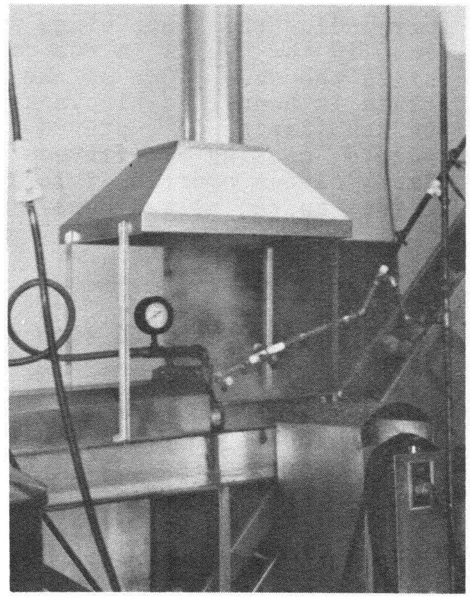

Figure 4. Steam vent

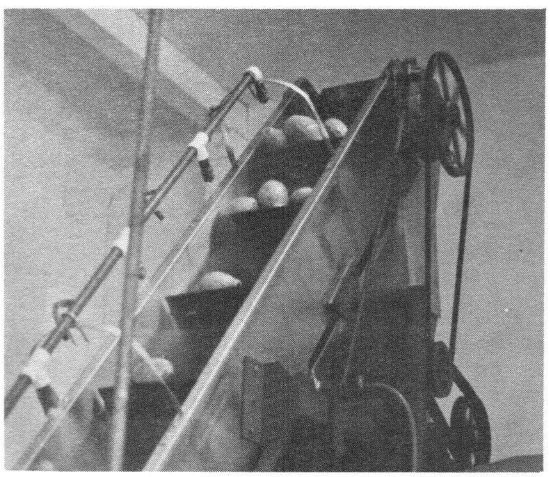

Figure 5. Spray-cooling of steamed papayas on elevator

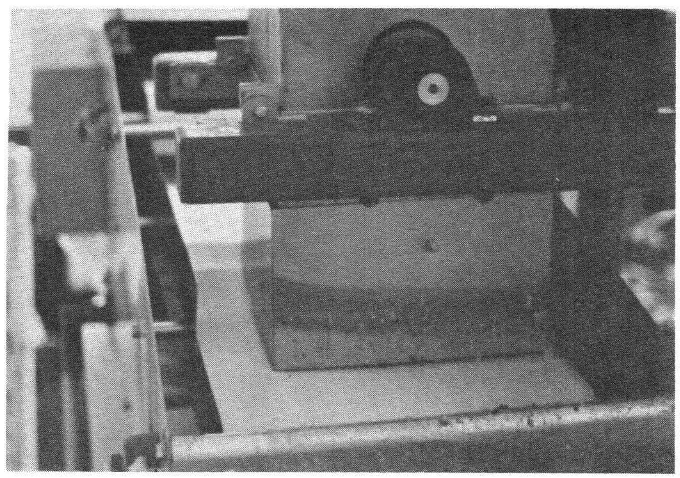

Figure 6. Slicer mounted on crusher-scraper

spaced about 10 inches apart. Water sprays are mounted above the belt to cool the papaya (Figure 5). The slicer, which is just under the end of the belt, consists of 12-inch circular blades mounted about 1 inch apart on the shaft and is operated at 350-400 rpm (Figure 6). A hood directs the slices down onto the belt of the crusher-scraper.

Crusher-Scraper

The crusher-scraper removes the edible pulp from the peel by a scraping action resulting from the rotation of a cylinder positioned 1 to 2 mm below a slow-moving (300 fpm) upper belt.

The slices of papaya from the slicer drop onto a lower belt (480 fpm) that moves the slices forward into the crushing and scraping elements of the machine. The plate on which the lower belt rides has 1/4-inch-thick x 12-inch-wide x 40-inch-long polyethylene strips, which facilitate start-up by preventing the belt from sticking to the plate during storage.

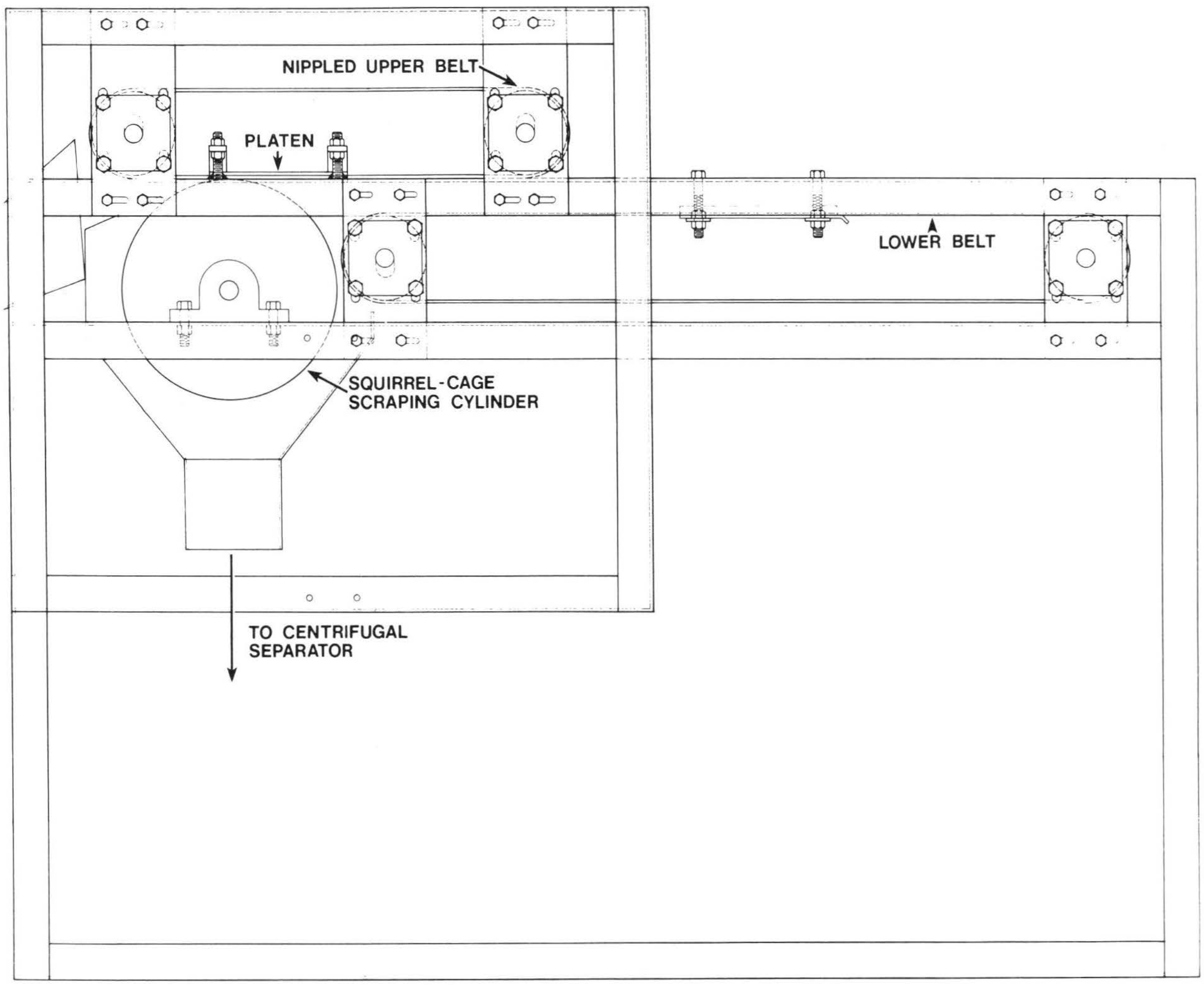

Figure 7. Diagram of crusher-scraper

The slower-moving upper belt, mounted above the forward end of the lower belt, has a nippled surface to facilitate the scraping action and is held in position by a spring-loaded platen. The slices move between the upper belt and a rotating, squirrel-cage scraping cylinder just below it. The surface of this cylinder is made of 1/8-inch stainless steel rods mounted 1/2 inch apart; peripheral speed of the cylinder is about 1200 fpm (Figure 7). Thus, the rapidly rotating cylinder, with a speed about four times that of the belt, scrapes the pulp and seeds away from the peel of the slices. The material that issues from the crusher-scraper is a mixture of papaya peels, seeds, and pulp.

Centrifugal Separator

The centrifugal separator is a continuously operating basket centrifuge in which the peels and seeds rise over the rim of the rotating basket and the puree issues through the holes in its walls. The walls slope upward and outward from the vertical at 21 degrees. Diameter at the top of the basket is 16 inches and at the bottom 14-1/2 inches. The basket is constructed of type 316 stainless steel sheetmetal perforated with 4-mm holes on 8-mm centers. It is secured to the rotor shaft by a large nut in a self-tightening orientation. Two strips of polyethylene (1/2 inch wide x 1/4 inch thick x 12 inches long) are secured vertically on the inner walls of the basket. These strips interrupt the spiral flow of the papaya macerate up the inner wall of the basket and force additional puree through the holes in the basket walls. The basket is rotated at 600 rpm.

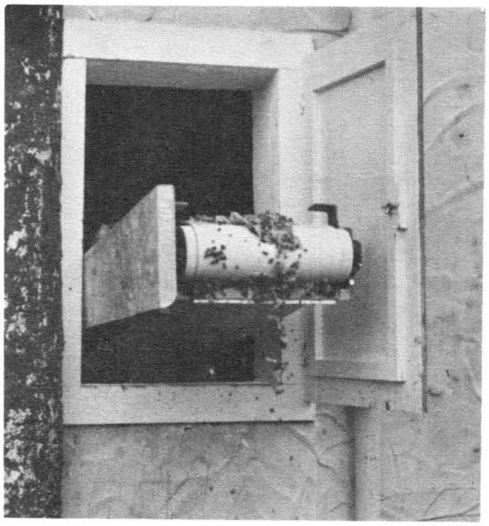

Figure 8. Waste discharge

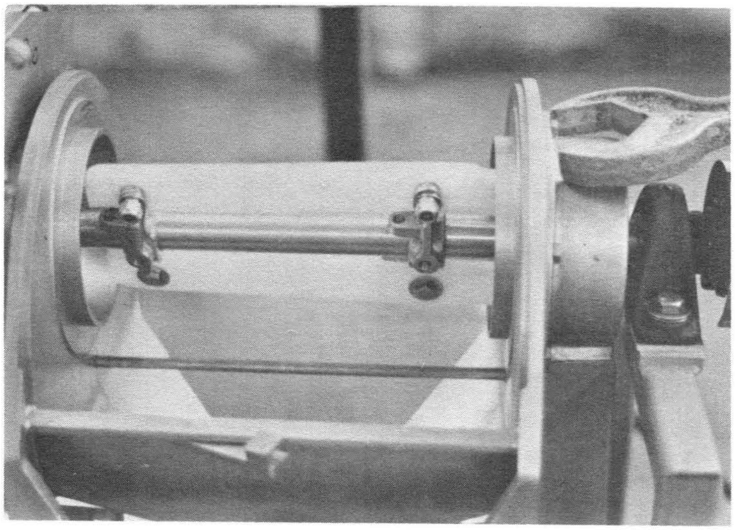

Figure 9. Finisher with polyethylene blades

Peels and seeds issue from one port of the separator and drop onto a trough belt conveyor to waste bins outside the processing room (Figure 8). The pulp, containing very few seeds, issues from another port and flows by gravity into the paddle pulper.

Pulper

The pulper used in this study was a Langsenkamp No. 17 laboratory pulper with specially constructed rubber paddles installed to minimize breakage of the seeds. A paddle pulper with a greater capacity should be used for a commercial operation; an FMC No. 50, a Langsenkamp Indiana Junior Pulper, or a Brown Co. 5-ton/hour pulper would each be a good choice for a moderate-size production line.

The pulper is fitted with an 0.033-inch screen. With the pulper set at number 4 speed, the rotary speed of the paddles is about 1600-1700 rpm. The puree issues through the screen of the pulper and drops into the hopper below the screen. The pulper must be adjusted so that unbroken seeds come out the waste port with a minimum of puree entrained with the seeds.

A solution of 50 percent citric acid in water is metered into the puree in the hopper to lower the pH to about 3.4 or 3.5. The acidified puree is then pumped into an elevated stainless steel holding tank mounted above the finisher to allow the puree to flow by gravity through the valve into the finisher.

Finisher

The Langsenkamp Model No. 17 laboratory paddle finisher has the same frame and drive as the pulper. Specially constructed 3/8-inch-thick polyethylene blades are fitted on the rotating paddle frame. The speed of the paddles is about 1500-1700 rpm. The finisher is fitted with an 0.020-inch screen or a 40-mesh stainless steel wire screen (Figure 9) to eliminate fiber and black specks from the product. The finer the screen, the better the quality of the product. A finisher with greater capacity is advisable for a commercial line.

The puree is pumped from the finisher to a large stainless steel holding tank (capacity about 2000 pounds) fitted with an electrically powered stirrer. Two holding tanks are used alternately in the processing line. The pH of the puree is monitored in these holding tanks and adjusted to 3.4 with the 50 percent solution of citric acid.

Pumps

The pumps used in the processing line are stainless steel and have a sanitary design. They are fitted with variable speed drives and pump heads, which have 1-1/2-inch sanitary pipe fittings and are easily disassembled for cleaning.

Tanks

The tanks in the processing line are constructed of type 316 stainless steel with 1-1/2-inch stainless steel sanitary fittings.

Heat Exchanger

The heat exchanger is an APV Model HXC6 paraflow plate heat exchanger (Figure 10). Flow plates and liquid bushings are fabricated from type 316 stainless steel. A variable speed drive sanitary pump is on the inlet side of the heat exchanger. The delivery rate of the pump at different settings is as follows:

Pump setting	Delivery rate (lb/hr)
2	1320
2.5	1620
3	2040

The product is heated on the hot side of the heat exchanger by circulating steam-injected hot water in a closed system. Temperature of the puree on the hot side is controlled by a Taylor instrument controller. The puree should be held at 198°F or higher for a period sufficient to inactivate enzymes (1 to 2 minutes). About half of the plates are on the cooling side, where the puree is cooled by indirect contact with water from the municipal supply. At pumping rates of 1500 to 2000 lb/hr, the product back pressure in the system is about 10 to 15 psig.

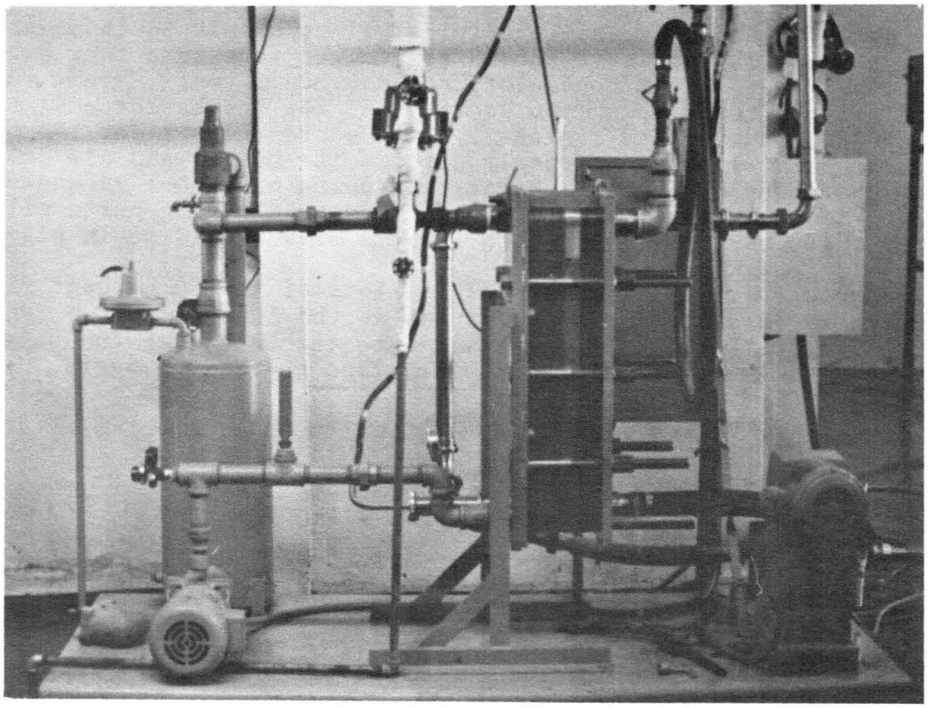

Figure 10. Plate heat exchanger

OPERATION

Fruit Handling

Treatments

The harvested fruit is treated with hot water to control storage decay (Akamine and Arisumi, 1953). Hot water treatment consists of immersing the fruit in water heated to 120°F for 20 minutes. The papaya is spray-cooled and then fumigated in a closed chamber. Fumigation consists of treatment with ethylene dibromide (EDB) sufficient to eliminate fruit flies but not injure the fruit. The fumigated fruit is then brought to the fresh fruit packing line. There the bins are emptied into a chlorinated water bath, after which they are conveyed to the packaging line. The fruit is graded, and fruit judged unsuitable for fresh marketing is sorted into bulk bins.

Delivery and Stacking

The off-grade fruit, obtained from the commercial fresh packaging line, is placed in bulk bins that hold 800-900 pounds of papaya. These bins are stacked four to five high.

Ripening

The fruit is allowed to ripen at ambient temperature in the bins. The fruit is ready for processing when it becomes at least 75 percent yellow in surface color; 4 to 5 days are usually required. The length of the ripening period will depend, of course, on the season and other cultural and climatic factors.

Preparation (Pre-Start-up Line Check)

Before starting the line, all electrical lines should be connected and operational. The following items should be checked to assure they are operational: sorting table, steam generator, steam exhaust vents, steam tunnel, elevator and slicer, centrifuge (the locking nut for the basket must be secured), waste belt, pulper, pumps, and finisher. The recorder chart for the heat exchanger should be in place and properly dated. The boiler and air compressor should be at operating pressures. Motors and pumps must have adequate lubrication; a food-grade lubricant is used on all pumps and moving parts with which the papaya or puree may come in contact. Waste bins should be in place.

The acid reservoir is filled with 20 gallons of the 50 percent citric acid solution, which is adequate for a 6-hour run at the line rate of 2 tons fruit per hour. This acid solution is dispensed into the hopper of the pulper, and the rate of acid flow must be checked before line operations begin.

Line Operation

Cooling Sprays and Steam Tunnel

Water sprays over the belt of the elevator are turned on first, then the steam (3 to 5 psi) in the steam tunnel. The remaining equipment is started up as the product flow proceeds. A bin of fruit is positioned on the bin dumper, and the conveyor that moves fruit through the steam tunnel is started. The wire bar conveyor in the steam tunnel should operate at a speed of about 12 fpm; this speed can be checked and adjusted with the variable speed drive.

The papaya is dumped from the bin onto a sorting table or a sorting belt. Dumping a bin every 10 or 11 minutes is a satisfactory rate for this line. Two people are assigned to the sorting operation to remove decayed and green fruit and to place the usable fruit on the conveyor of the steam tunnel. Fruit that is too green is returned to a ripening bin. The papaya must be exposed to steam for 1 minute or longer; the length of exposure is determined by the heat-ring test described in the following section.

Elevator and Slicer

The elevator, the slicer, and the crusher-scraper are started. When the fruit has traversed the steam tunnel and been conveyed about halfway up the elevator through the water sprays, two or three fruits are taken from the elevator and cut in half by the slicer. An easily distinguished heat ring (3 to 4 mm deep) should be visible just below the skin surface. If the heat ring is not seen, the steam supply to the tunnel must be increased or the conveyor speed decreased. The cleated belt on the elevator should be moving about 15 fpm.

Crusher-Scraper

The effectiveness of the crusher-scraper can be checked by inspecting pieces of peel in the waste coming from the centrifugal separator. Sarcotesta around the seeds in the waste should be intact, and there should be virtually no cracked or cut seeds in the waste. Very little pulp should adhere to the slices of peel. If the slices are not scraped clean, the line must be stopped and the platen lowered to decrease the clearance between the cylindrical scraper and the superimposed nippled belt.

Centrifugal Separator

The centrifugal separator should be operating at about 600 rpm. Seeds and peels, with a minimum of pulp, issue from the waste port of the machine (Figure 11). The puree issuing from the opposite port should be practically free of seeds; if many seeds appear, the line must be stopped and the interior of the separator inspected. If peels and seeds are packed at the top of the waste chute, they must be removed; if allowed to remain, they will fall into the gap between the rotating basket and the wall and get into the puree.

Puree and Acid Addition

The pulper is turned on and the speed set such that the velocity at the outer edge of the paddles is 2000 fpm. The pulper is fitted with an 0.033-inch

Figure 11. Papaya waste from centrifugal separator

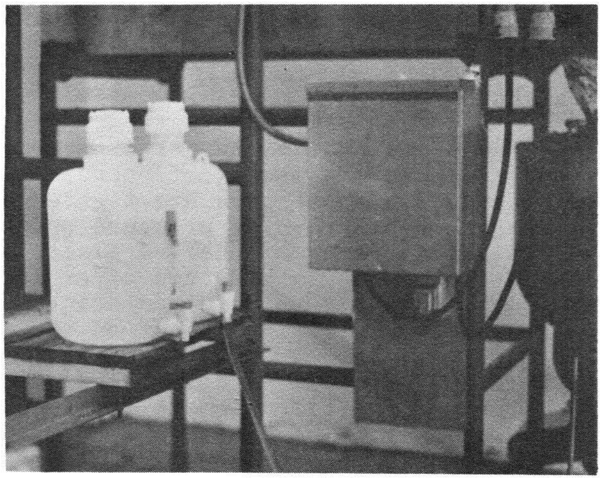

Figure 12. Polyethylene bottles containing 50 percent citric acid

screen, with sharply angled rubber blades fitted on the paddle frames. The angle should be set 25 degrees in the direction of flow of the product. The pulper is positioned under the puree port of the centrifugal separator. Rotary speed of the paddles should be adjusted (about 1500 rpm) so that seeds, if any, are ejected unbroken at the waste port. There should be some fiber and a minimum of pulp at the waste port.

The 50 percent citric acid solution is metered into the hopper of the pulper through a valve, which is adjusted to give a delivery rate sufficient to lower the puree pH from 3.5 to 3.6; precise adjustment to pH 3.4 is done later (Figure 12). The pH of the puree from the pulper should be checked every 15 minutes on samples taken from the 50-gallon surge tank just downstream from the pulper. (See Appendix for details of the pH procedure.)

The puree sample should also be tested and examined for black specks. (See Appendix.) If many black specks are present, the pulper should be adjusted to a slower speed or to a different clearance to reduce the milling action on seeds. If the flavor is not that of high-quality puree, the line must be stopped for corrective action.

Finisher

The pump that moves the puree from the pulper to the tank above the finisher is turned on. When that tank is half-filled, the flow to the finisher is begun, and the finisher and pump to the holding tank are turned on. The finisher is fitted with an 0.020-inch screen or a 40-mesh wire screen. If many black specks appear, the 0.020-inch screen should be replaced by the 40-mesh wire screen. The rotary speed of the paddles should be adjusted (about 1500 rpm) so that the material issuing from the waste port will be so high in solids that it will retain its shape. Black specks and fibrous material make up the bulk of this waste. There should be very few, if any, black specks in the puree. The puree is then pumped to a large holding tank.

Holding Tank and Acid Check Procedure

The holding tank capacity should be about 1 ton or more. A power stirrer is mounted in the tank. When the tank is about half-filled with puree, the heat exchanger is started with water to the proper temperature. (See the following section.) While the tank is being filled, samples should be taken at frequent intervals (15-20 minutes) to check the pH. The objective is to maintain the puree pH at 3.4. If the pH goes below 3.4, the rate of flow of the solution at the hopper of the pulper must be reduced. When the tank is filled, the pH is adjusted to 3.4, either by adding more acid if the pH is too high or by adding nonacidified puree if the pH is too low. Small increments (about 1 liter per 0.1 pH unit) of citric acid solution are added to the puree in the tank to avoid overshooting the desired pH. When the pH is adjusted to 3.4, the puree is pumped to the heat exchanger.

Heat Exchanger

The plate heat exchanger is assembled according to the detailed instructions found in the manual of operations (A.P.V. Co., n.d.). The nuts on the six threaded support rods are tightened alternately and in a zigzag opposing pattern to avoid warping pressure on the plates. The platage spacing between the inside surfaces of the end plates should be about 8-7/8 inches. The stainless steel piping is attached after the plates are secured in the operating position. The hot water circulating system is filled with water by a hose attached to the filling spigot on the side of the tank; the pump is turned on and more water added until it flows from the top petcock. A water hose is positioned to fill a pipe into the inlet side of the product pump; the pump is turned on for a continuous flow of water through the product side of the heat exchanger. The compressed air supply is set to the temperature controller at 20 psi, and the cooling water valve turned on for the cooling side of the heat exchanger. The steam valve is turned on and the temperature controller set to the desired product temperature for the hot side (198-204°F). The

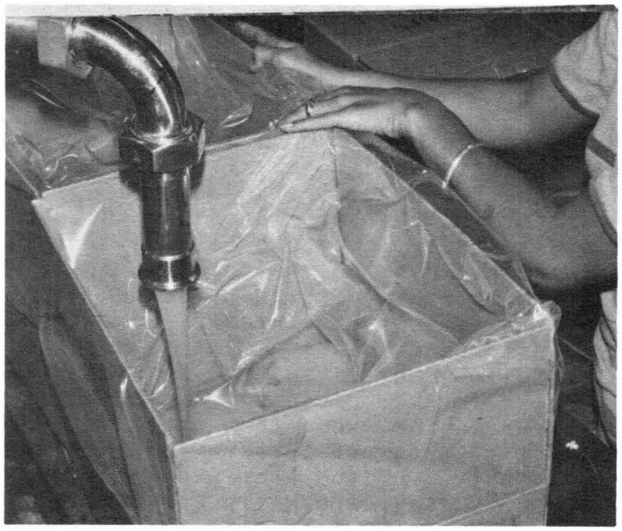

Figure 13. Filling puree into plastic-lined cartons

Figure 14. Placement of cartons on pallet for freezing

heat exchanger may be run for 15 or 20 minutes with water on the product side so that proper adjustments can be made.

The two-way valve on the inlet side of the product pump is then switched to admit puree to the pump. The puree temperature on the hot side of the heat exchanger must be checked; it should be about 200°F. The variable speed drive on the product pump should be set at about 2.5. The puree temperature at the outlet side of the cooling section should be as low as possible, depending on the temperature of the cooling water. With cooling water at about 70°F, the puree temperature should be at about 85°F. After discarding the first 4 to 5 gallons, the puree can be collected in a 50-gallon stainless steel tank fitted with a valve outlet for filling into suitable packages for freezing (Figure 13).

Packaging and Freezing

A fiberboard box with a polyethylene bag liner is a satisfactory package for freezing and storing the puree. The bag should be of 3-mil wall thickness, and the box rated for 250 pounds crushing weight. A box 6 x 12 x 15 inches will accommodate about 35 pounds of puree. After being filled, the polyethylene bag is closed and secured with a plastic-wire tie. The top flaps of the box are left open when it is placed on the pallet. Boxes are spaced 1 to 2 inches apart on the pallets (Figure 14), which are then moved into the freezer and placed in single layers on the floor or on shelves.

CLEANUP

Sanitation of the processing room and equipment is necessary to prevent contamination of the puree with microorganisms.

Immediately upon shutdown of the processing line, surfaces of the equipment should be hosed with abundant water. Food contact surfaces should be scrubbed with a detergent solution and sanitized with a chlorine solution. All piping must be disconnected and scrubbed thoroughly. The pulper and finisher are disassembled and the parts sanitized and placed on a rack to dry. All pump heads are disassembled, sanitized, and set aside to dry. The crusher-scraper is scrubbed with detergent and then rinsed while in operation. The slicer hood is laid open on its hinges so the inside can be cleaned. The basket is removed from the centrifugal separator for cleaning, and the inside of the separator body is scrubbed with detergent and rinsed. All valves are disassembled and sanitized. Propeller blades are removed from the stirrer shafts and cleaned.

Special procedures are used for sanitizing the heat exchanger. While the heat exchanger is still running, water is introduced right after the last of the puree. The steam is turned off, and the hot water in the heating system is replaced by cold water. When the temperature on the hot side drops to 100°F or less, the unit is stopped and the stainless steel piping and fittings are removed. The platage is loosened by loosening the nuts on the threaded frame rods, again in an alternate and zigzag pattern to avoid warping stress on the plates. When the nuts are within 1 inch of the ends of the threads, the plates are freed, one at a time, and washed with a detergent solution that is applied with a soft rag or washing mitten. This is followed by exhaustive rinsing with clean water from a hose. If the plates require further cleaning, a fine abrasive household cleaner and plastic scouring pad may be used; then they are rinsed with clean water. Special caution must be observed in removing the gas-filled sensing bulb from its fitting near the bottom of the heat exchanger. The bulb and the gas-filled tube connecting it to the temperature controller are fragile and must not be touched with a wrench or any hard object. The bulb and fittings are then washed carefully and reassembled at once. The plates are then repositioned together loosely, and the nuts gently tightened by hand.

The water is drained from the hot water circulation tank. The head of the product pump is disassembled and sanitized. All conveyor belts are rinsed with a stream of water from the hose and scrubbed with detergent, then rinsed again. The floor and soiled wall areas are hosed with water, scrubbed with detergent, and flushed again with water.

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APPENDIX

Labor Requirements

The personnel required to operate the papaya puree processing line are listed below. Total labor requirements for the complete operation of a processing plant have been omitted since this manual describes the operation of a papaya puree line within an existing fruit processing plant. Personnel omitted include administration, clerical staff, maintenance persons, and ground crews.

1 supervisor
1 forklift driver for bins
2 sorters at rotary table
1 attendant for pulper, finisher, pumps, waste belts
1 quality-control person
1 person for product filling line and heat exchanger operation
1 forklift driver to freezer
3 cleanup persons

Utilities and Other Requirements

The electrical power requirement for operating 6 hours per day, 22 days per month, is 3700 kilowatt hours per month. Applying rate G of 1975 (Hilo Electric Co.), this amounts to about $280 per month.

The water requirement is estimated at 1300-1500 gallons per day for operation and cleanup.

Steam consumption is estimated to be 260,000 BTU per hour.

A floor or shelving area of 650-700 square feet is required in the freezer to accommodate 1 day's 6-hour production. About 48 hours is needed for the puree (80-85°F) to freeze in the boxes sufficiently for stacking. About 6000 cubic feet of space is required to store 3600 stacked cases of frozen papaya puree. The freezer should operate at -10°F or below and have vigorous air circulation (1000-1200 cfm.). A refrigeration capacity of no less than 12 tons is required. The packages are placed on the pallets with at least 1 inch free space on each side of each package.

Quality Control

Procedures

Determination of pH. The pH of the puree is determined with a pH meter. The meter is turned on and allowed to stand for 10-15 minutes. The tip of the electrode assembly is kept immersed in water at all times. The meter is standardized at pH 4 by immersing the assembly in a standard pH 4 buffer solution and adjusting the reading to 4. After standardizing, the electrode is rinsed with distilled water. Then the electrode assembly is immersed in a small sample (about 100 ml) of the puree and the pH is read from the scale or digital readout.

Determination of total acid. Ten grams of puree are weighed into a 100-ml beaker. About 50 ml distilled water are added, and a magnetic stirring bar is put in the beaker. The beaker is placed on a magnetic stirrer. The electrode assembly of the pH meter is immersed in the puree, and care must be exercised so that the stirring bar does not touch the electrode. As the puree is stirred 0.1 N NaOH is slowly added from a burette. The pH is then brought to 8.1 and the volume of NaOH required is noted. The total acidity is calculated as citric acid; 1 ml of 0.1 N NaOH is equivalent to 0.0064 g of citric acid.

Sample calculation:

9.2 ml NaOH required to titrate
10 g of puree to pH 8.1
$9.2 \times 0.0064 \div 10 = 0.0059$
Total acidity is 0.59%.

Milk-clot test. Certain proteolytic enzymes (papain from papaya, and others) will cause milk to clot if certain amounts of enzyme and milk are mixed together.

Ten grams nonfat skim milk powder are dissolved in 90 g water; 15 ml of this is placed in a large test tube. Then, 5 ml of papaya puree is added and mixed with the milk, and this is allowed to stand for 30 minutes. The milk will form a clot if papain is present; however, no clotting will be seen if the puree has been properly made, as detailed in this manual.

Black speck count. A thin-layer chromatography plate is used to assist in examining puree for the presence of black specks. These specks are thought to be particles from the spicules of the seed coat of papaya seeds.

Ten milliliters of papaya puree are placed on the thin-layer plate, and a clear glass plate is positioned on top. This presses the puree into a layer about 0.25 mm thick. The plates are placed on a light box fitted with a green light filter. With the green light shining up through the thin layer of puree, black specks may be seen and counted.

The aesthetic quality of the puree will be lowered by the presence of black specks.

It should be noted that the amount of allowable harmless extraneous materials is specified in Hawaii State standards for grades of frozen papaya puree.[1]

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[1]State of Hawaii, Department of Agriculture, Division of Marketing and Consumer Services. 1968. Regulation No. 4: Processed foods. August 24, 1968.

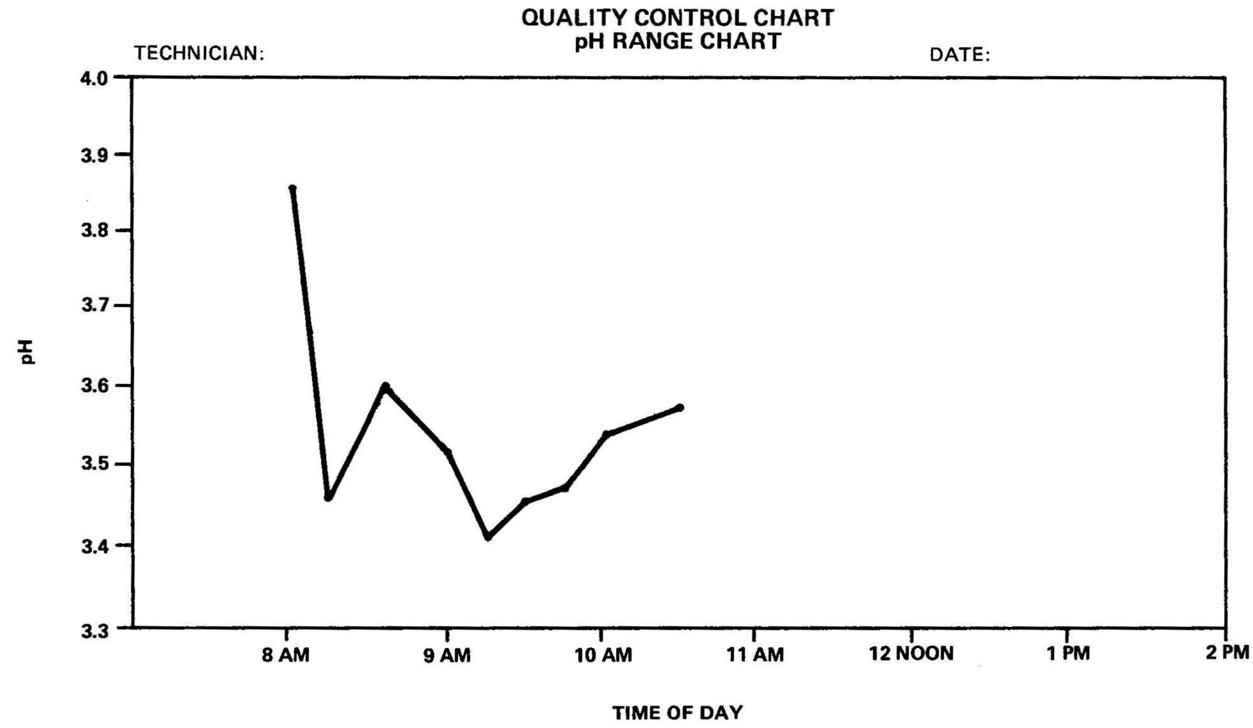

Figure 15. pH range chart

This method for the determination of black specks is different from the official method and is merely cited as a quick and convenient method for in-house monitoring.

Chart Samples

Figures 15 and 16 show two basic examples of quality control (Q.C.) charts. The purposes of Q.C. charts are (1) to maintain control over the process, and (2) to maintain adequate records.

By keeping a running Q.C. chart, the process will be properly monitored, so that necessary, prompt changes in operation may be made to maintain a high quality. The keeping of good Q.C. records cannot be overemphasized. Good records will help protect the processor legally and will also provide a convenient tool in the case of product recall or complaints.

QUALITY CONTROL CHART

DATE OF PROCESSING ________________ TIME ____________

SOURCE ______________________

DATE OF HARVEST ________________

MATURITY ____________________

NUMBER OF SKIPS ________________

NUMBER OF PALLETS OF PRODUCT ________________

REMARKS:

PRODUCT INFORMATION

pH ________ TOTAL ACIDITY ________ ml. BRIX ________ °

ENZYMES: CATALASE ________________

TEMPERATURE : BEFORE HEAT EXCHANGER ____________ °F

AFTER HEAT EXCHANGER ____________ °F

IN PACKAGE ______________________ °F

PRODUCT CODE:

REMARKS:

Figure 16. Quality control chart

Waste Characteristics and Puree Yield

Over half the weight of fruit that goes through the processing line ends up as waste (Figure 11). Repeated measurements on the effluents from our process gave the following results:

- 43% puree product
- 46% peels, seeds, and entrained puree from the centrifugal separator
- 7% seeds and entrained puree from the pulper
- 4% fiber and seed specks from the finisher

To evaluate this recovery, edible pulp from ripe papaya was scooped out with spoons and weighed separately from the peels and seeds; this resulted in the recovery of 61 percent edible pulp and 39 percent peels and seeds. Therefore, we obtained 43/61 of the edible pulp of papaya, or 70.5 percent of the theoretical yield.

Hawaii Agricultural Experiment Station, College of Tropical Agriculture, University of Hawaii
William R. Furtick, Dean of the College and Director of the Experiment Station
Noel P. Kefford, Acting Associate Director of the Experiment Station
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