IX. Packinghouse Procedures

Procedures involved in the movement of citrus fruit from the tree to the consumer's table may be visualized as a series of individual (unit) operations assembled in a certain order and each connected by some means of conveying the product from one unit to the next. Picking and methods of handling were discussed in the previous chapter. The present chapter begins with the unloading of containers and follows through the operations from there to loading of packed containers for transportation to market. No 2 packinghouses have the same mix or volume of fruit, house size or layout, with all degrees of efficiency of operation among them. The present-day packinghouse is a far different entity than those built 20 to 40 or 50 years ago. Some of the more radical changes have been the switch to ground-level construction, pallet box handling, single-grade packinglines, palletizing of packed containers, and increased mechanization throughout. Nowadays, individual fruit are touched only when they are picked, when removed as "eliminations during grading and when hand-packed into containers, the last dwindling every year. Packinghouse buildings are expensive and so is the machinery in them. "Errors in proper choice and matching of packingline components are extraordinarily costly in money, reduced capacity, and increased fruit losses and decay claims."

The general sequence of fruit movement from unloading to shipment is shown in Fig. 39 for a commercial packinghouse and in Fig. 40 for a gift-house, the latter differing mainly in being much shorter and simpler. The working area of a packinghouse is divided into 3 major sections, pre-packingline (unloading, degreening, temporary storage), packingline, and post-packingline (order assembly, palletizing, loading), arranged to give as nearly linear flow as practicable. Most of the space in the first section is devoted to degreening rooms, which double as temporary storage areas when not in operation, located near the dumping end of the packingline. That in the post-packingline section is taken up with floor area allocated to order assembly, palletizing and loading, the last usually being outside of the building proper. The packingline is, or should be, the primary factor in the size of the building, since its capacity determines how much fruit must be brought to the packinghouse and also how much can be shipped with a given packout. (Material in many of the following paragraphs has been excerpted in part or wholly from a manuscript copy of Grierson, Miller and Wardowski's forthcoming bulletin on "Packingline Machinery for Florida Citrus Packinghouses" to be published in late 1978. This bulletin is of particular importance since it is the first Florida publication to consider individual items of a packingline as units of an efficient system.)

A. Pre-Packingline Operations

Pallet boxes are unloaded from the carrier (semi-trailer truck, straddle carrier) which brought them from the grove with fork-lift trucks. Field boxes are transported one or 2 stacks per trip with hand or mechanical clamp trucks. They are taken to one of 3 destinations, to a degreening room, temporary storage (which may be a degreening room with the ethylene supply cut off), or directly to the dumper. Official samples for maturity tests are obtained at some point before the fruit are either degreened or dumped. Each lot of fruit entering the packinghouse is also inspected by house personnel, usually the foreman and head grader, to determine the probable packout and size range.

Conditions for degreening were covered in Chapter VI. It may be pointed out here that degreening capacity and generally lower % packout as a result of more eliminations for green color, are the 2 main factors limiting the output of packinghouses early in the crop season.

B. Basic Principles for Packinghouses

A packingline is essentially so many square feet or meters of conveying surface, regardless as to the function of the individual components The wider and shorter the line within reason, the lower is the initial cost. This is true because (1) the length of the line largely determines the size of the building; (2) there is more initial cost (75 to 80% in most cases) in the sides of the line (framing, bearings, chains, drives, etc.) than in the span; and (3) electrical and plumbing costs relate more closely to the length than the width of the line. Line capacity depends upon conveying surface area multiplied by linear forward speed. Thus, the wider the line, the slower is the linear speed needed for a given capacity. Extra capacity is obtained more easily with wide equipment, which can be speeded up without detriment to the fruit for those items where fruit treatment time is not a factor, or additional sections may be added to those items with critical fruit treatment time.

The conventional order of fruit treatments in a packinghouse goes back to the days when fresh fruit was paramount, several grades were packed, canneries were basically a salvage operation, and pesticide residues, etc., were simply not considered. Today, it is common to pack just one grade, although provision for an occasional second grade may be advantageous. A substantial proportion of the fruit (35 to 40% on the average) are graded or sized out and sent to the cannery; and unnecessary residues on or in those fruit are very much to be avoided.

Every fruit which is not going to be shipped as fresh fruit should be removed as soon as possible. Under- and over-sizes can be removed mechanically with a presizer immediately after dumping and trash elimination. Removal of fruit with excessive blemishes is usually not possible until after washing but provision should be made prior to wetting the fruit for removing rots and splits before they contaminate the rest of the equipment. Grading should follow immediately after washing and water elimination to remove excess surface moisture. There is no point in putting fungicides, waxes, and possibly color-add, on fruit which are going to be sent to the cannery. This costs the packinghouse money and gives the cannery problems. Grading immediately after washing reduces considerably the amount and energy costs to run the machinery necessary for the remainder of the line: Either about 50% more packable fruit can be handled if the line width is not reduced or the size and horsepower requirements of equipment beyond the washer can be reduced proportionately. The machinery cost per box is reduced in either case. The order in which other operations are done depends, in part, upon the types of fungicide and wax used and whether fruit are color-added, as will be explained in detail in later paragraphs.

It is not logical to have a complete line of sizing and packing equipment for a second grade of fruit in citrus-packing areas such as Florida where a second grade is of very minor importance. The fluctuation in volume between the first and second grades precludes advantageous use of equipment and labor. The second grade should be accumulated in pallet boxes, instead, and run on the same equipment once the first grade fruit is packed. This can be accomplished in the regular working day, if the equipment has the proper capacity.

C. Packingline Operations (Tables 20-22)

1 Dumping:

Pallet boxes weigh about 1000 lb (roughly 450 kg) when loaded, hence they are emptied mechanically with any of several different types of pallet-box dumpers. These range from simple homemade chain-hoist devices used in small gifthouses to elaborate equipment with cog-chain feed, de-stacking, dumping and stacking sections to handle a continuous flow of pallet boxes. The dumper proper consists of a lid with a trap door and clamps attached to a hydraulic turning mechanism. Fruit roll out of the box as it is tilted onto a conveyor belt. Dry dumping is strongly recommended, since dumping into water subjects the fruit to inevitable contamination with all sorts of pathogens (e.g., sour rot).

a. Surge control: A pallet box dumper typically empties 900 lb (408 kg) of fruit onto the line at 30-second intervals (=roughly 1200 boxes per hour). All of the equipment along the line needs a steady, continuous flow of fruit, hence these surges must be leveled out. Typical surge-control devices are (1) twin belts, one fast, one slow; (2) return-flow belts with a travelling shear; or (3) a short, wide slowly moving belt from which fruit stacked several deep are metered to the line.

b. Trash elimination: Fruit in containers of any type always have sand, leaves, twigs and other debris mixed with them. All dumpers in the past have had a series of parallel steel bars over which fruit roll as they are poured out of the container. This system has worked reasonably well to remove trash that would otherwise clog up machinery on the line until the last few years.

Citrus Maturity and Packinghouse Procedures

Packinghouse Procedures (cont.)

It is now virtually unknown for a packinghouse to have provision for trash elimination capable of coping with the products of today's ill-disciplined pickers, or perhaps even mechanical harvesting of some kind in the near future. A sloping belt trash eliminator will remove most loose trash and deliver it to a conveyor or container. A vacuum brusher can be used to remove loose sand, which is otherwise extremely injurious to packingline equipment. Pintle rubber-wood roller conveyors for removal of stems should always be self cleaning. Devices such as these are becoming increasingly necessary as the Florida Department of Environmental Regulations issues citations to packinghouses for unacceptable b.o.d. (biological oxygen demand) levels in effluents. (More will be said about effluents under washing.)

c. Presizing: Fruit too small or too large to be shipped according to Growers Administrative Committee regulations or current market demand are sorted out in a presizer and sent to a cannery. A typical presizer has several (up to 10 or 12) longitudinal belts with 3 rollers per belt, one roller each for undersize, shippable and oversize fruits, in parallel lanes, with takeaway belts under each size category. Some of the newer packinghouses have installed small belt-and-roll central sizers, which have 5 to 7 rollers per lane, so that individual commercial sizes can be separated as needed (e.g., for sectionizing fruit, special orders, etc.).

d. Pregrading: Rotten and split fruit must be removed at some stage between the dumper and washing because these not only contaminate wash water and equipment with spores but the acid released plays havoc with maintenance of proper pH for keeping residues within prescribed tolerances. The usual procedure is to have a short section of roller conveyor either before or after the presizer where these and projecting stems or fruit can be picked off the line. (Grading out of blemished fruit is usually done after washing rather than before, since sooty mold, dirt, etc., obscure many defects.)

Citrus Maturity and Packinghouse Procedures

Packinghouse Procedures (cont.)

2. Washing:

Citrus fruit are washed to remove dirt, sooty mold, scales, spray residues, etc., which attract from their appearance. The process results in removal of most or all of the natural wax, which must be replaced if washed fruit are to have normal keeping quality. The whole process of washing consists of 4 or 5 steps, wetting, sudsing, washing, application of fungicide (SOPP only, as explained later under fungicide application), and water elimination.

a. Wetting: Fruit are conveyed on rollers under a series of coarse water spray nozzles to wet them thoroughly and soften the dirt, etc., before they reach the washer. Dip or "soak" tanks, such as some gifthouses still use are not recommended because of contamination with fungus spores.

b. Sudsing: Foamed soap or detergent is dribbled over the wet fruit, usually between the first and second brushes, as an aid to more efficient cleaning of the fruit.

c. Washing: Revolving transverse palmetto, tampico (sisal) or synthetic (nylon or saran) fiber brushes do an effective job of cleaning with an exposure time of at least 20 seconds, 30 seconds being better if fruit have much sooty mold on them. Slower brush speeds are more efficient than faster ones. Fruit are given a thorough rinsing under at least 2 nozzles as they pass over the last of the brushes or a roller conveyor just beyond the brushes.

d. Water elimination: The final stage of washing is to remove excess water, the best and most economical way being to run the fruit over sponge rubber rollers which are sectioned ("do-nuts") or soft (ca. horse-hair grade) plastic brushes, rather than heat and blown air (e.g., the old polisher-drier). Water is squeezed out of the sponge rubber rollers with spring-loaded wringer rolls mounted on the underside, the latter in turn wiped dry by neoprene blades held rigid in metal supports. Water on the soft plastic brushes is removed with metal "flick bars" which barely touch the underside of the rotating brushes (Fig. 41). Brass, aluminum or wooden (gift houses) rollers are still used in some older packinghouses.

e. Effluent treatment: Disposal of trash accumulated from trash elimination and pre-grading operations plus wastewater from washing, etc., has become an increasingly serious problem in Florida packinghouses. Enforcement of regulations by the Florida Department of Environmental Regulation has resulted in a large number of Indian River and other packinghouses being currently (July 1978) under notice they can not reopen in the fall unless they amend their present methods of effluent water disposal. The following paragraphs and diagram are quoted from Packinghouse Newsletter No. 94 (June 30, 1978):

" . . . The perfect way to avoid such problems [being shut down] is not to have any effluent water. For this reason we have been working on a recycling system.

"Physical-chemical methods of wastewater treatment are well suited for treatment of citrus packinghouse effluents. Essentially, packinghouse wastewater is polluted with surface dirt and sooty mold washed off the fruit in addition to small amounts of detergents and in some cases, phenolic compounds, both natural and industrial, e.g., SOPP.

"The essential components of a physical-chemical wastewater treatment system are shown in [Fig. 42]. Trash, such as leaves, twigs and broken fruit, must be screened from the water before it is delivered into a flocculator-clarifier. A suitable coagulant is added to induce flocculation. Coagulated solids settle to the bottom of the clarifier and are removed at appropriate intervals. Fairly clear wastewater is passed through a multimedia (garnet, sand and anthracite) filter to remove suspended particles. At this point, filtered water can be reused to prewet and rinse incoming fruit. Complete purification can be achieved by passing filtered water through a bed of amberlite resin for removal of dissolved organic solids, and finally chlorination for disinfection. Such a system can also be useful in treating wastewater from other fresh fruit and vegetable packing industries.

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Packinghouse Procedures (cont.)

"An experimental recycling system . . . has recently been installed at Haines City Citrus Growers Association packinghouse . . . ." (p. 1,2)

3. Grading:

Traditionally, the location of the "grading table" has been the last major step before sizing, meaning fruit unfit for fresh shipment received color-add (oranges, 'Temple', tangelos), fungicide and wax and were stamped along with those to be packed. This situation persisted for a great many years until economic and regulatory pressures and the transition to single-grade packing have succeeded in putting the operation where it belongs, namely just as near the beginning of the line as feasible to do a proper job of grading.

Fruits are sorted into grades to provide uniform appearance with regard to color, discoloration (rust mite) and blemishes. Fruit unfit for human consumption, such decays, severe bruises, unhealed cuts, bird pecks, wormy fruits, etc., are removed as culls. Those fit for human consumption but not of fresh fruit quality are sorted as cannery fruit ("eliminations"). Grading is done under U.S. standards, which apply to fruit in interstate commerce and west of the Suwannee River, and Florida standards, which apply to fruit in intrastate commerce.

Grading of citrus fruit is done on 2 basic types of conveyors, wooden rollers in commercial packinghouses and canvas belts in small gifthouses (where only an occasional fruit must be eliminated, since pickers are supposed to leave blemished or otherwise unacceptable fruit on the trees). The usual arrangement of the roller grade table is for blemished fruit to be removed and "in-grade" ones left on the line. Culls and elminiations are tossed into separate flush-mounted chutes beside each grader, with a second grade of packable fruit placed on a belt running down the side or center of the table. Grading is done principally in Florida by women who sit or stand. Grading is tedious, tiring work whose efficiency depends upon a number of factors, including, among others, illumination, workers fatigue and crop quantity and quality.

Several important points to be considered in the design and operation of a grade table (Fig. 43) are given below:

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Packinghouse Procedures (cont.)

a. Good lighting is essential; cool white fluorescent lamps to provide about 180 foot candles (1938 lumens per m^2) at the fruit surface are recommended.

b Lifting, which can amount to over 3 tons a day for oranges and 10 tons for grapefruit, should be kept to the minimum by having chutes flush with the edge of the table and auxiliary no more than 2 inches (5 cm) above the rollers.

c. The number of grade positions which should be provided is determined by the number of individual fruit which in turn determines the number of decisions to be made and consequent actions. For example, approximately 5,300 grapefruit, 16,000 oranges or 24,000 tangerines, respectively, would have to be removed per hour, assuming a 60% packout and rate of 200 boxes (8,160, 7,720, and 8,620 kg respectively) per hour. (A large house might run 1,000 to 2,000 boxes of oranges an hour.) The usual tendency in a packinghouse is to set the number of graders for oranges, which then means tangerines get under-graded and grapefruit over-graded. There is a marked tendency for graders to throw a given number of fruit per minute (usually about 30), regardless of the quality of the fruit. Either the rate of fruit flow or the number of graders should logically be varied according to the proportion of fruit to be graded out.

d. The limitation with a high packout lot is how many fruit the graders can observe per minute; the limitation with a low packout lot is how many fruit the graders can pickup per minute. A study in apple houses showed each worker could cope with over 7,000 fruit per hour with good fruit and well-designed grade tables but only about 2,000 per hour with poorly designed tables and low packout fruit. (Workers in Florida citrus packinghouses are expected to grade twice as many fruit per hour per perso as in a typical apple house.)

e. The least experienced graders should be positioned upstream and the most experienced downstream on a given lot of fruit. Fruit flow should be broken into several lines with no more than 3 or 4 graders per stream, instead of the common situation of 7 or 8 graders per stream.

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Packinghouse Procedures (cont.)

f. Grading should be done inside an enclosed air-conditioned room and metal chutes padded on the undersides with foam rubber to deaden the noise, which otherwise may reach unlawful limits under OSHA regulations.

g. A severe limitation on the efficiency of the customary roller grader is that the rate of forward travel and speed of fruit rotation can not be varied independently. Rollers turn as the linked conveyor travels across the frame of the machine and fruit revolve opposite the direction of travel. Various types of "reverse-roll" (powered roller) grade tables developed for the apple industry are beginning to appear in Florida packinghouses. They definitely increase the work-capacity of the graders as well as improving their efficiency, if properly used. They must, however, be constantly adjusted for the type and volume of fruit being run.

Electronic sorting of lemons into color categories was begun in California in the 1950's, machines then costing around $10,000. There has been great interest in Florida since then in mechanical sorters for oranges and other varieties. The chief impediments, aside from their expense, have been to devise machines capable of sorting for color (notably nonuniform in Florida) and blemishes (including rust mite discoloration) and the sheer volume of fruit handled by individual packinghouses. (Individual electronic lemon sorters handle 600 to 1200 lemons per minute which sounds high but translates into 120 to 240 1-3/5 bu. box equivalents per hour.) Electronic sorting is not currently used in Florida although machines technically capable of sorting for both color and blemishes are now available.

4 Color add:

The natural color of some orange cultivars is not deep nor uniform enough for best consumer appeal. A law permitting color-add was passed in 1935, such fruit being required to have higher juice, total soluble solids and solids:acid ratio under legal maturity standards and be stamped "Color Added." Color add was permitted on tangelos with the same maturity requirements as for natural color fruit, under the Tangelo Act of 1955, now incorporated into Fla. Dept. of Citrus Rule 20-13.

Color adding of 'Temple' was made legal a few years later, such fruit being required to have a higher total soluble solids:acid ratio (9.0:1) than natural color (8.5:1). Color add is not permitted on grapefruit and tangerines, including hybrids designated as tangerines (e.g., 'Honey', formerly 'Murcott').

Color-adding is an optional treatment in the sense that it can only be used on oranges, 'Temple' and tangelos and then only on the crops which need it. The color-add tank is a wide piece of equipment in which fruit stack very deep and hence move forward very slowly. About 40% of the oranges (including 'Temple') and tangelos shipped fresh in 1976-77 were color-added, with the proportion in individual packinghouses handling 200,000 boxes (4/5 bu.) of oranges or 100,000 boxes of tangelos ranging from about 20 to nearly 100%. Traditionally, the color-add operation has been on the main line, with a by-pass around it for grapefruit, tangerines and hybrids. Grierson et al., in the packingline machinery bulletin, suggest a more logical arrangement is to have the color-add tank as a by-pass to the main line, just the reverse of past practice. Some packinghouses do run primarily oranges and tangelos and color-add a large share of them; many others, however, color-add a good proportion of their oranges and tangelos but also run sizable quantities of grapefruit and tangerines. Placement of the color-add tank on the by-pass may result in the latter having greater carrying capacity than the through-put at this point in the line for those houses color-adding a large percentage of their fruit but does reduce the possibility of damage to non-color-add fruit and eliminates a bottle-neck in their flow.

Color-add is a time-dependent operation. The dye (currently Citrus Red No. 2), depth of color, and conditions for application are specified in Fla. Dept. of Citrus Rule 20-32. Dye solution is applied as a drench or dip. The lightest color is for early oranges and 'K-Early' tangelos; medium color, for midseason oranges, 'Temple' and tangelos; and the deepest color, for late oranges. Application time and temperature for oranges is a maximum of 4 minutes at 120°F (49°C) and for 'Temple' and tangelos, 2.5 minutes at 115°F (46°C). Color-add must always be followed with a good rinse to prevent "bleeding" of the dye through the wax and ensure that the 2 ppm FDA tolerance is not exceeded. Rinsing is best done on washer-brushes or moving rollers rather than a mesh belt or slat conveyor on which fruit do not roll. Color-add tanks are usually leased by the packinghouse, with a standard charge for its use and for dye solutions.

A water eliminator is used after the post-color-add rinse to remove most of the moisture on the fruit. This operation can be combined with a bed of horsehair brushes to serve also as a fungicide applicator if a water-emulsion wax is to be used. Fruit must be completely dry before solvent wax can be applied, hence the more water which can be removed at this stage, the less that has to be gotten rid of in a drier.

5. Drying and polishing:

The usual drier-polisher in a packinghouse with 20 to 50 brushes, fans and heater is an anachronism from earlier days when fruit required polishing to give them a proper shine. Fruit do need to be thoroughly dry before solvent-type wax is applied but the operation is pointless in the case of water-emulsion wax. Brushes cause damage to fruit surfaces, particularly tangerines, tangelos and 'Temple'. They are useful in removal of grove grime in the washer; they are harmful elsewhere. The typical drier-polisher has a series of horsehair, saran or nylon brushes (of value roughly $50 per brush per year) inside a metal tunnel made in 2 sections. The first, or drier, has large fans and heaters mounted over the brushes; the second, or polisher, may or may not have fans only over the brushes. Many packinghouses have replaced the brushes with a roller conveyor, on which the fruit ride. (Old brushes mounted on spindles find excellent use as wipe-offs where the direction of fruit movement must be changed.)

The largest cause of fruit damage in many packinghouses is combining hot air drying with polishing. What is just as bad is the usual error of simply recirculating wet air, there being no provision whatever in most instances for expelling the warm moist air outside the building after it has passed over the fruit. Failure to get rid of this moist air not only slows down the drying process but also adds heat, humidity and noise in the vicinity of the drier-polisher. Proper design of a drier which will finish the job begun in the water eliminator and do it with minimum damage to the fruit is a simple matter, but it does require some understanding of the principles of humidity (see section in Chapter VI).

6. Waxing:

Most or all of the natural wax on fruit is removed in the course of washing and must be replaced to reduce loss of moisture and to impart a high gloss to the fruit surface. Many different materials, mixtures and formulations are used for waxing fruit (and vegetables). Three materials are true waxes (long-chain hydrocarbons), paraffin, which retards the loss of moisture, carnauba, which imparts gloss, and microcrystalline wax (a petroleum product), which does both but not as well. Most of the materials, however, are food-grade synthetic resins, such as coumarone indene (in Flavorseal) or epolene (a high density polyethylene resin). Four different types of wax and methods of application are in current use:

a. Slab wax: A mixture of paraffin and carnauba waxes is molded into a series of rectangular slabs fitted directly under and in contact with several brushes near the outlet end of the drier-polisher in small gift house lines. Wax rubs off on the fruits as they pass over the revolving brushes (gift houses).

b. Solvent-type "waxes": Coumarone indene or other resins dissolved in an organic solvent are sprayed in a fine mist onto fruit as they are conveyed through the applicator. Fruit are then dried on a slat conveyor about 30 feet long, with a "flip-over" in the middle (the machine has 2 conveyors with the outlet end of the first one a few inches above the inlet end of the second one so that the fruit turn over as they pass from one to the other.) Many packinghouses use solvent-type wax. Many companies manufacture a wide range of materials (Flavorseal is FMC's brand name) and lease equipment for application and wax drying.

c. Water-emulsion "waxes": Wax (e.g., microcrystalline) or a synthetic resin is emulsified in water and applied as a foam, dip, spray

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Packinghouse Procedures (cont.)

or brush wipe after the color add operation or directly after washing in the case of grapefruit or tangerines. The conventional method in Florida is spraying, preferably with usually 2 travelling nozzles ("wig-wag") over a bed of slowly rotating (not over 100 rpm) horsehair brushes. (It is recommended that a steam line be connected to the emulsion delivery line with valves so that the latter can be cut off and the lines cleaned out with steam. Brushes are cleaned with "flick bars" which are on a sliding rack below the brush bed so they can be pushed between the brushes when not in use.) Careful cleaning is essential when switching from plain to fungicide-containing wax or vice versa, as may be necessary depending upon regulations for fruit going to export vs. domestic markets.

Waxed fruit are dried on a "wax-setter," a slat conveyor 20 to 40 feet (6-12 m) long with a "flip-over" near the middle. Water-emulsion waxes, like the solvent type, are self-polishing. Sta-Fresh (FMC), Primafresh (Johnson), Britex (Brogdex), and other brands are obtainable in a range of formulations.

d. Fungicidal "waxes": The first successful funcigidal wax was Wax 101A, formulated at AREC Lake Alfred as a water-emulsion type containing Dowicide A-hexamine. FMC and other manufacturers now offer both solvent type and water-emulsion type waxes with fungicide added. A typical installation has a metering pump, which is turned on only when the fungicide is required, that injects benomyl (benlate) or thiabendazole (TBZ) into the wax just ahead of the applicator. Water-emulsion fungicidal waxes contain sodium-o-phenyl phenate, thiabendazole or benomyl in their formulations.

The tendency, recommended by AREC Lake Alfred, has been to apply a fungicide (as immediately following the washer) and wax separately, since fungicidal waxes require thorough cleaning of equipment before and after one is used.

Differences in legal tolerances among foreign countries for certain fungicides further complicate the situation for packinghouses which export fruit to Japan or Europe.

Fungicide application:

All domestic (including Canada and Mexico) shipments of fresh fruit are required by Fla. Dept. of Citrus Rule 20-33 to have a fungicide applied. Fungicides, which include sodium-o-phenyl phenate (SOPP), thiabendazole (TBZ), benomyl (benlate) and diphenyl (biphenyl) can be applied on unwashed fruit before degreening (TBZ and benlate), during washing (SOPP), following water elimination (TBZ, benlate), in solvent waxes (benlate), in water-emulsion waxes (SOPP, TBZ, benlate; the last is unstable so must be freshly prepared), or as pads in cartons (diphenyl).

a. Thiabendazole (TBZ) and benomyl (benlate): These are applied as nonrecovery sprays, TBZ at 1000 ppm (0.1%) or benlate at 600 ppm (0.06%). Benlate 50W may be sprayed preharvest 1 day to 3 weeks before harvest at the rate of 1 to 2 lbs. per acre (1.12-2.24 kg per ha.).

b. Sodium o-phenylphenate (SOPP): This can be used to replace the detergent during washing or applied as an aqueous recovery flood or foam immediately following washing. A water rinse is given fruit after 2 to 3 minutes treatment time. SOPP "fixes" (as the free phenol) in minor lesions; whereas TBZ rinses right off (and hence should not be used during washing). Usual formulations of SOPP are 2% aqueous solution (2% hexamine) or 1% in water-emulsion wax. Careful pH control (at 11.5-11.7) is necessary to prevent peel injury and excess residue.

c. Diphenyl (biphenyl): One or 2 treated pads (see Chap. VII for concentrations) are placed in a carton or bagmaster carton at the time of packing. Diphenyl is often used in conjunction with SOPP.

8. Stamping:

All grapefruit and oranges, except navels and 'Temple', of U.S. No 1 Golden or higher grade shipped in interstate commerce must be stamped wi the word "Florida," or if applicable, "Indian River." Private brands or grade designations may also be put on the fruit and must be if they are shipped in bulk. Size of letters and requirements for stamping are specified in Fla. Dept. of Citrus Rule 20-39. Stamping is done by passing

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Packinghouse Procedures (cont.)

fruit under inked rollers either after application of water-emulsion wax or prior to a solvent-type wax. There is growing interest in fruit labels attached with pressure-sensitive adhesive after waxing because of ever-increasing restrictions on food additives (which include inks). These are more expensive than ink stamping.

9. Sizing:

Citrus fruit are sorted into size categories for 2 main reasons, eye appeal to the consumer and ease of packing. Two main types of sizers are used in commercial citrus packinghouses and gifthouses, belt-and-roll and transverse, of which only the first is used in Florida.

a. Belt-and-roll: Two configurations of the belt-and-roll sizers have been developed. The original version which was used in all packinghouses up to about the middle 1950's consisted of 5 to 8 cylindrical or bottle-shaped rollers revolving at 100 to 200 rpm set in a line with a belt traveling 200 to 400 feet per minute (61-122 m per min.). The belt is inclined at an angle of about 30° so that fruit rest against the rollers. Relative speed of belt travel and roller revolution is critical; if it is too low, fruit will not revolve on their equatorial axis; if too high, fruit may be kicked away from the rollers. Exhaustive studies by machinery companies and government agencies have shown that a linear (belt) speed of about 225 feet per minute (68.6 m per min.) and roller speed of 102 rpm (= linear speed of 80 ft. per min. = 24.4 m. per min.) provides the best ratio (2.8:1). All belt-and-roll sizers measure the diameter of only one fruit at a time, belt speeds higher than this resulting in fruit dropping into the wrong bins.

The capacity of a 40-foot long sizer is about 1000 4/5 bushel boxes (20.4 m. tons) a day, a shorter one, as in the Fruit Crops packinghouse, handling about 600. Most longitudinal belt-and-roll sizers have separate adjusting screws for oranges, grapefruit and tangerines to permit running any of them through it.

The central belt-and-roll sizer, which is now standard in most packinghouses, has the same characteristics as the longitudinal belt-and-roll one, except that it combines several lines of sizers into a single machine This means that all of the fruit of a given size are collected on a single belt, rather than being scattered in one bin per line.

One other feature of the central sizer has but which the longitudinal one does not concerns how the fruit drop onto the collection belts. The latter run perpendicular to the flow of fruit through the sizer, the direction of movement being right or left. Fruit dropping from a right-hand sizer (belt sloped toward the right as viewed in the direction of fruit flow) onto a collection belt moving to the right do so smoothly but those dropping from a left-hand sizer onto the same collection belt must stop rolling and reverse direction, thus receive a "kick" which can result in damage. Central sizers can be built with all right hand or all left hand or pairs of right and left hand belts according to whether collection belts run to the right, left or both directions, the determining factor for the latter being where the packing stations are located.

b. Transverse: The transverse sizer has pairs of rollers which diverge, open up, as they move along the machine. It has immense capacity for its physical dimensions, since the width of the machine divided by the diameter of the fruit determines how many can be sized simultaneously. The transverse sizer does an excellent job of sizing either prolate or spherical fruit but a poor one on oblate ones because the latter do not have sufficient momentum to spin on their equatorial axis. Fruits touch the pairs of rollers at 4 points instead of only 2 for belt-and-roll sizers.

A few packinghouses in Florida installed transverse sizers but soon took them out because of the inability to size properly the diverse shapes of the various types of fruit to be handled on the same line.

Two other types, the perforated-belt (tomato) sizer and weight sizer have capacity much too low or are too cumbersome (e.g., the perforated-belt requires a separate belt for each size and has no adjustment) for use with citrus. The weight sizer has been utilized in sorting mangos and avocados, but most tropical fruit packinghouses either have a conventional belt-and-roll sizer or sort the fruit by hand.

D. Post-Packinghouse Operations

1. Packing:

Fruit leaving the sizer go to one of 4 places, carton fillers, bag machines, a place-packing station, or into a bulk container (pallet box field box, etc.) for local sale. Cartons (80%) and bags (14%) were the principal containers in 1976-77.

a. Carton filling: Machines for automatic filling of cartons were developed in California shortly after World War II and came into widespread use there for lemons and oranges in the 1950's. Two systems, volume fill, where fruit are poured into the carton and vibrated to settle the pack with leveling by hand when necessary, and count fill, which differs from the former only in that a definite number of fruit are poured into the carton, are used in California, Arizona, Texas and Florida. Cartons are filled upside down which means the bottom layer becomes the top when the container is righted. An automatic pack is surprisingly regular, if properly shaken during filling, the only visible indication that it has not been hand packed being the random orientation of fruit stems (ordinarily either all up or down in a hand pack). Containers for volume or count fill are slightly larger than those used for hand packs, as given in Fla. Dept. of Citrus Rule 20-39. Cartons are run through a glue sealer for closing.

b. Bag filling: Two types of bags, polyethylene and plastic mesh, in 2 sizes, 5 and 8 pound (2.27 and 3.63 kg), for oranges and grapefruit, respectively, are authorized in Fla. Dept. of Citrus Rule 20-39. Fruit are sold by weight but filling is by count (Occasional bags are weighed to ensure proper minimum weight). Small numbers of bags may be filled and tied closed by hand. Most commercial packinghouses have bag-filling machines. These are either semiautomatic, where the packer holds the bag up to a spout on the machine which pours in the proper number of fruit, or fully automatic, where bags in rolls or endless tubes are cut, opened, filled and closed by the machine. Closing of bags in the semiautomatic system is done by a separate staple or twist tie machine. The final step is to place the filled bags in bagmaster cartons, which hold 8 5-lb or 5 8-lb containers, for shipment. The latest development is a machine (Burford) that can automatically pack cartons or bags.

c. Place packing: Fruit are hand-packed, often with mechanica aids, in regular patterns in 4/5 bushel wirebound boxes (5.6% in 1976-77) or fiberboard cartons, as prescribed in Fla. Dept. of Citrus Rule 20-39. Two main systems are used for place packing, conventional bins (now rare in full sized commercial packinghouses) and rollboard tables. (Note that only the latter is shown in the flow sheet.)

Conventional packing bins are 3 to 4 feet wide, 12 to 15 inches deep and of variable length but usually filled from one or 2 sizer rolls as separated with movable dividers. The entire bin extends the full length of a longitudinal belt-and-roll sizer and is padded on the bottom and front and back sides. The last fruit into a bin are on top so that they are the first ones to be packed. Boxes or cartons are placed on movable stands and are set perpendicular to the bins, which means the packer must make a quarter turn each time fruit are conveyed to the container

The rollboard table was developed in California and the first one built in Florida about 1961 is still in use at the Fruit Crops packinghouse. Initially, conventional bins were converted to rollboard tables by laying a sheet of plywood over the bin with a 2 x 6 (5 x 15 cm) board laid flat along the front edge to give additional width and an adjustable (for height) retainer board along the front. The last has a small bumper along the inside near the top. Most packinghouse operators tore out the conventional bins and rebuilt them as rollboard tables, in which case the slope was made 6 to 8 feet (1.83-2.44 m) long to provide greater capacity

Original studies in California showed and Florida experience quickly verified the fact that rollboard tables were at least 20% more efficient than the old bins. Among the reasons for this are that fruit roll down the table and form a single layer, the fruit closest to the packers being the first ones onto the table, and most important, packers face the table with the container on its stand between them and the table.

Improvements to the original layout include a distribution table with wide lanes at the top of the rollboard to give additional storage capacity and utilizing carton filling or bag machines minus the container holders as an aid in filling after the packer has placed the bottom layer in regular order. Many packinghouses utilize the space under the table for the filled-container conveyor, packing stands being built with knee joints which can be tripped by the packer when she has completed filling a container.

Wirebound boxes are closed by hand with a special closing hammer or by machine. Flaps on lids and bottoms of cartons may be stapled prior to packing or those of the bottom half simply folded under for sealing after packing in a glue sealer.

d. Consumer packs: A few packinghouses have experimented with packaging citrus fruit on trays with stretch film overwraps but most supermarkets prefer to make up their own consumer packs for a number of reasons (e.g., less loss from decay).

e. Gift fruit: A wide assortment of boxes, cartons, baskets, etc., is hand packed for shipment of gift fruit. Neither containers nor packs are under regulation.

Samples of fruit are obtained from packing bins, rollboard tables, filled cartons or bags for inspection for grade. Any packer in a large gift fruit packinghouse (e.g., G. & S. Packing Co., Weirsdale) can reach 4 types of fruit, 6 types of containers, plus "extras," such as printed inserts, jars of jelly, etc.

2. Precooling:

Rapid cooling of fruit prior to shipment is definitely recommended during most of Florida's citrus season. The primary system, as described in Chapter VI under Refrigeration, involves precooling of packed containers.

Packinghouse Procedures (cont.)

3. Order assembly and palletizing:

A large area of floor space is required in a packinghouse for sorting different kinds of fruit (oranges, grapefruit, 'Temple', tangerines, etc.) grades (in some houses), sizes and containers into orders for shipment. The present tendency in all new packinghouses and many older ones is to use conveyors to reduce handling and palletize everything. Palletizing in conventional packinghouses packing several sizes simultaneously is by hand, since mechanical palletization would require a very expensive accumulation system.

4 Loading

Over 99% of the certified fresh fruit shipments in 1976-77 were by truck, of which 15.3% were for exports and the remainder either semi-trailer trucks or trailers on flat cars (piggyback). Only about 0.6% were shipped in refrigerated rail cars. Exports were shipped mainly from Tampa (49.5%) and Port Everglades (43.3%). Over three-quarters (78%) of the exports went to Japan (6.92 million boxes), with another million boxes (11.2%) going to France. About 89.5% (7.95 million boxes) of the exports were Indian River grapefruit. (The size of the Japanese export market may perhaps be better visualized by considering it accounted for 11.9% of the total fresh fruit shipments in 1976-77.)

Precise loading patterns have been worked out for containers shipped by rail, as described in the "Container and Loading Rules Tariff" under Interstate Commerce Commission regulations. Several loading patterns for truck shipments have been developed by U.S. Department of Agriculture research workers.

Loading and proper placement of containers so that they will not shift and will receive adequate air circulation during transit is a skilled operation. Actual loading is done by hand with containers lifted from a conveyor and stacked or by fork lift with containers properly spaced and secured on pallets or slip sheets. Loading of trucks, particularly those for hauls less than 24 hours' travel (roughly 800 to 1000 miles), is more flexible than for rail cars. There is a distinct trend towards use of "van containers" (20 or 40 ft = 6.1 or 12.2 m dismountable trailer bodies) in shipments to Europe, although most of those to Japan presently go "break bulk" (i.e., restacked at dockside prior to loading on shipboard). About 95% of the domestic shipments travel as "citrus only" loads, the mixed cargos of fruits and vegetables now being a thing of the past with the decline of "buying brokers" vis-a-vis supermarket buyers.

5. Transportation:

Details of procurement, routing, services required, and necessary papers for rail, piggyback or truck shipments are handled by the shipping clerk in the packinghouse sales department and the local freight agent or truck broker. A number of the larger packinghouses or sales organizations like Sealdsweet have their own traffic manager.

Trucks are procured from brokers as a rule, although arrangements may be made with individual owners (many drivers own their trucks). Citrus and other agricultural commodities are seldom shipped via common carrier, which like railroads are under Interstate Commerce Commission Regulations. Most shipments from Florida travel under refrigeration, precooling, except in cold weather when ventilation only or a combination of ventilation and heating may be needed.

Shipments by boat involve at least 2 different types of transport, that from individual packinghouses to the port (Ft. Pierce, Port Canaveral, Jacksonville, Port Everglades or Tampa) by truck (or rarely by rail) and that overseas. Steamships ordinarily carry 100,000 to 200,000 boxes or more per trip, which is usually far more than any individual packinghouse can provide. A second important consideration is that steampship companies wish to keep their vessels in port as short a time as possible, which means fruit must be on hand ready for loading when the ship arrives. Unfortunately, few of the ports have adequate cold storage facilities to permit accumulation of fruit. Details of export shipments are handled through shipping agents for the steamship companies. Stowage of containers on shipboard is by stevedores and the ship's crew. Ships vary in size , hold capacity, etc., but those used for transport of citrus have refrigeration facilities, in some cases far superior to those of other carriers.

Packinghouse Procedures (cont.)

Refrigerator cars, now mostly mechanical rather than ice bunker, are procured through the local freight agent for Seaboard Coast Line (interior and west coast) or Florida East Coast (Indian River area) railroads, as are piggyback trailers. Refrigerator cars will be brought to the packinghouse siding and hauled away after being loaded. Piggyback trailers will be picked up from a truck park, hauled to the packinghouse, loaded and then hauled to one of the loading ramps for placement on a flat car. Arrangements for piggyback service will be made through the freight agent. Routing of rail cars or piggyback trailers as to which railroads they will travel over en route and at destination and services as to refrigeration, ventilation, heating or combinations are spelled out on the bill of lading.

6. Market handling:

The great bulk of citrus fruit shipped fresh are sold FOB (buyer pays freight but shipper is responsible for safe delivery) or acceptance final (AF, buyer pays freight and is responsible for safe delivery). They go either to terminal warehouses of supermarket chains or to jobbers and then to retail stores. A small percentage, less than 2 to 3% now, is sold on auction, mainly to hotels or restaurants. There is a growing trend in supermarkets and grocery stores toward prepackaging in containers, either in bags or tray packs. This implies that decay must be held to the absolute minimum (Grierson maintains that it is the percentage of bags showing decay which is important rather than the decay level *per se*).

Miscellaneous Procedures

1. Freeze damage separation:

Some part of Florida has temperatures low enough at least once a year to cause freeze damage and necessitate a special sorting operation. Many different devices have been tried, among which were ultraviolet and x-ray scanners about 1937, visible-light scanners such as the Horti-Spect, and specific gravity separators. The first were much too expensive and too slow and visible-light scanners are useful only for research purposes. Specific gravity separators alone have proved practical, these sort freeze-damaged fruit from sound ones on the basis that the former are lighter for their volume.

The most effective system, described in Florida Coop. Extens. Serv. Cir. 372, consists of adjusting the specific gravity of water with oil so that damaged (dry) fruit will float and sound ones will sink. Unfortunately, sound large fruit may have a lower specific gravity than badly damaged small ones and certain varieties like tangerines or grapefruit are so variable that separation is difficult even when the fruit are sized. A water-oil freeze-damage separator necessitates washing the fruit after sorting. Separators using rapidly moving water to provide differences in buoyancy for sorting have been installed in some packinghouses but are generally less efficient than those using oil in the water. Freeze-damage separators are best run independently of the main packinghouse line since continuous sampling and adjustment of the machine are necessary.

A new complication is the Florida Department of Environmental Regulation has introduced effluent water standards so stringent that packinghouses using oil-emulsion separators may find it impossible to stay in compliance.

2. Packinghouse operations as sources of fruit damage:

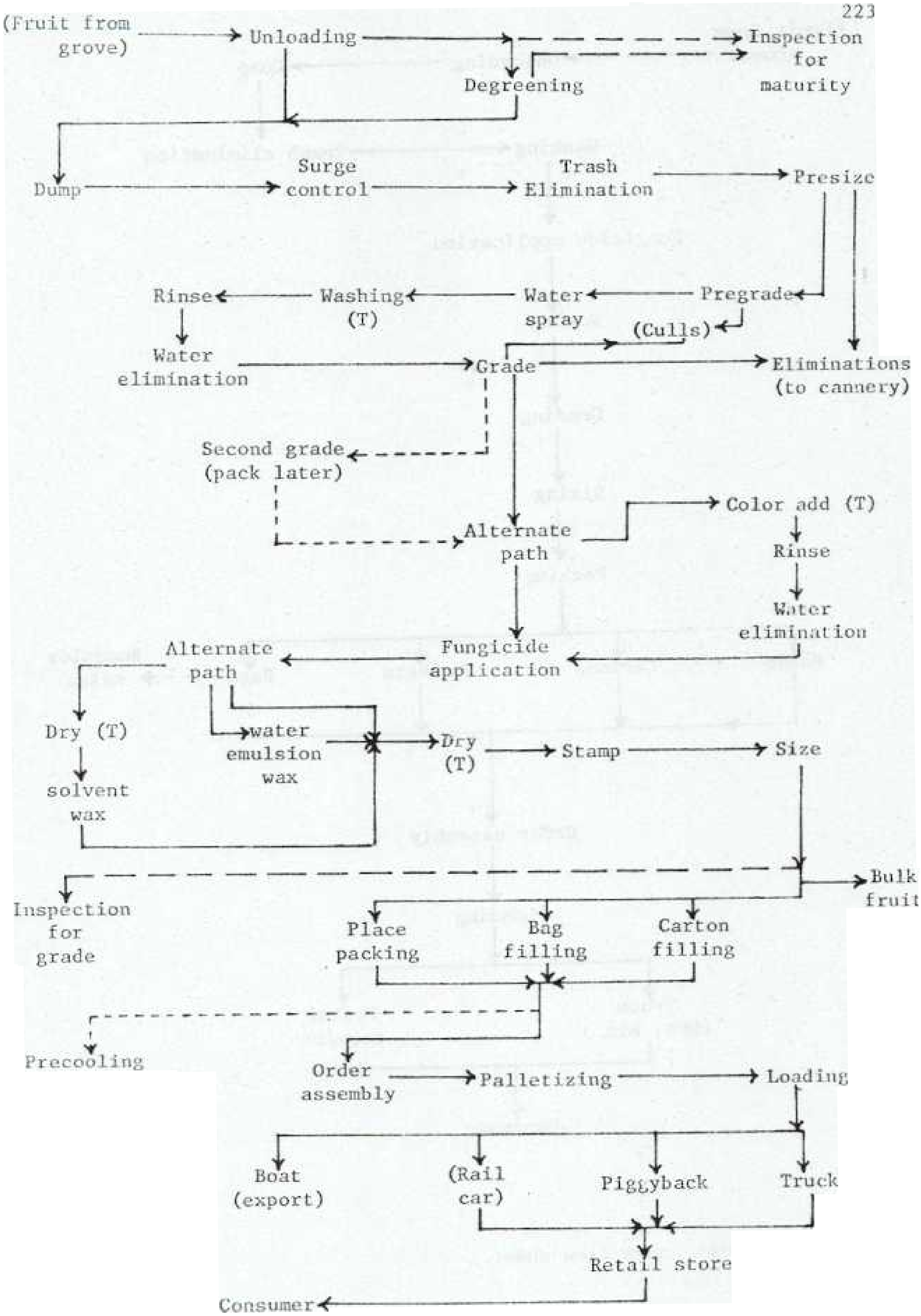
Several forms of fruit damage can be distinguished. (1) Rough surfaces on boxes, projecting nails or staples, squeezing by box slats, bouncing of fruit against wooden or metal surfaces during handling, and sharp projecting corners on machinery cause cuts and severe bruises that are readily noted and eliminated in grading. Citrus fruit are comparative resistant to bruising due to impact but very susceptible to decay from being scratched or scraped enough to cause small, often invisible breaks in the peel. (2). Inoculation with decay organisms is very common when a water dump or soak tank is in the packinghouse, even when a fungicide is put into the water. The reason for this is there are several minor diseases, such as anthracnose (Collectotrichum gloeosporioides), sour rot (Geotrichum candidum), black rot (Alternaria citri), and various fungicide-resistant strains of Penicillium, that are not controlled by legal fungicides. (3). A particularly subtle type of damage occurs as a consequence of excessive polishing. Fruit that have been through a hot polisher-drier can look beautiful when packed but crisp and brown few days later.

Mechanical damage along a packingline most commonly occurs at the transfer points between pieces of equipment or going around corners. Potential trouble spots include dumping, deliveries from roller and slat conveyors, points of impact where fruit drop onto a belt or are delivered at right angles onto a belt, and at turns, particularly those at a right angle.

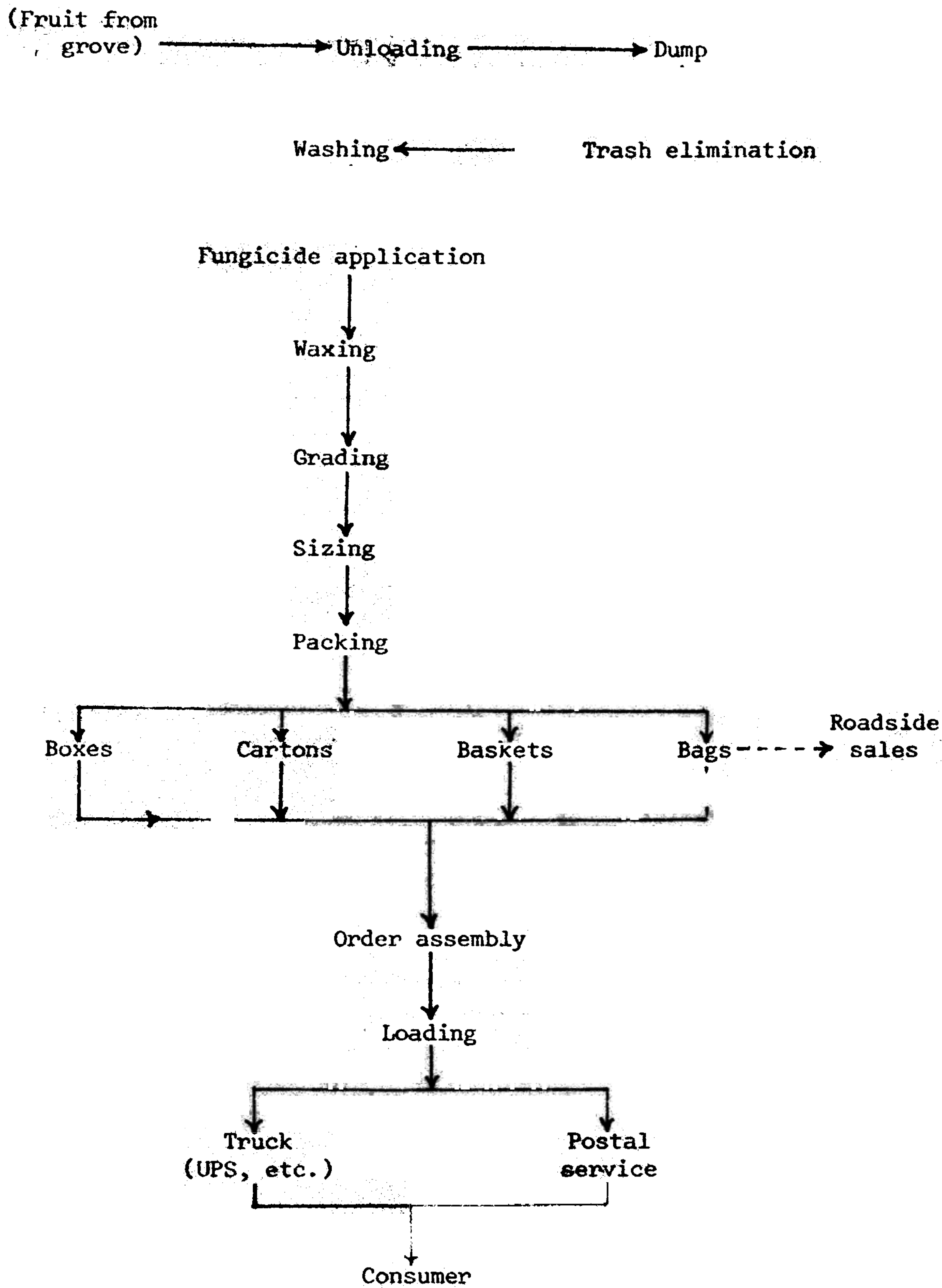
Methods for location of sources of damage include: (a) holding tests of samples taken at intervals throughout fruit movement from tree to loading platform, which is slow and actually indirect; (b) indicator solutions such as tetrazolium chloride (red) or indoxyl blue in very dilute concentrations produce spots overnight showing where there are breaks in the rind, such spots often being difficult to see; and (c) indicator papers prepared from filter paper or toweling impregnated with phenolphthalein (pH indicator) and Victoria Blue, which produce green-yellow spots with rind oil and blue spots with juice. Indicator papers are the easiest to use and give an immediate indication as to where the source or sources of damage occur. Full details are given in Florida Agr. Exp. Sta. Cir. S102.

3. Handling of Florida lemons:

Florida was at one time (about 1900) the leading lemon producer in the United States. Commercial interest in the crop revived during the 1950's when several growers planted sizable areas primarily for concentrate fruit. Lemons in southern Florida, as in the interior zone of California and Yuma area of Arizona, are harvested for fresh use during the summer months. Lemons are the most sensitive of all citrus fruits to injury until they have been cured and extraordinary precautions must be taken against stem-end rot. They must be handled as gently as possible, preferably in pallet boxes where damage is usually less, provided they are not piled too deep. Immediate pallet box drenching with a fungicide (TBZ, benomyl or 2-aminobutane, separately or in combination) is essential prior to curing. The latter takes one to 4 weeks at 60°F (15.5°C) and 85 to 90% relative humidity. The fruit are picked immature and green (and sized with rings) but turn yellow as they cure. Grocery stores can sell all they can obtain. (The curing procedure involves 2 different, important changes. They gradually degreen and the colloidal compounds which hold the moisture in a bound or "gel" form break down so that the fruit become very much juicier. Lemon thus is the only citrus fruit in which post-harvest changes result in an improvement in edible qualities.)



'ig. 39 Packinghouse flow sheet (T signifies a time-dependent operation)



ig. 40. Gift house low sheet.

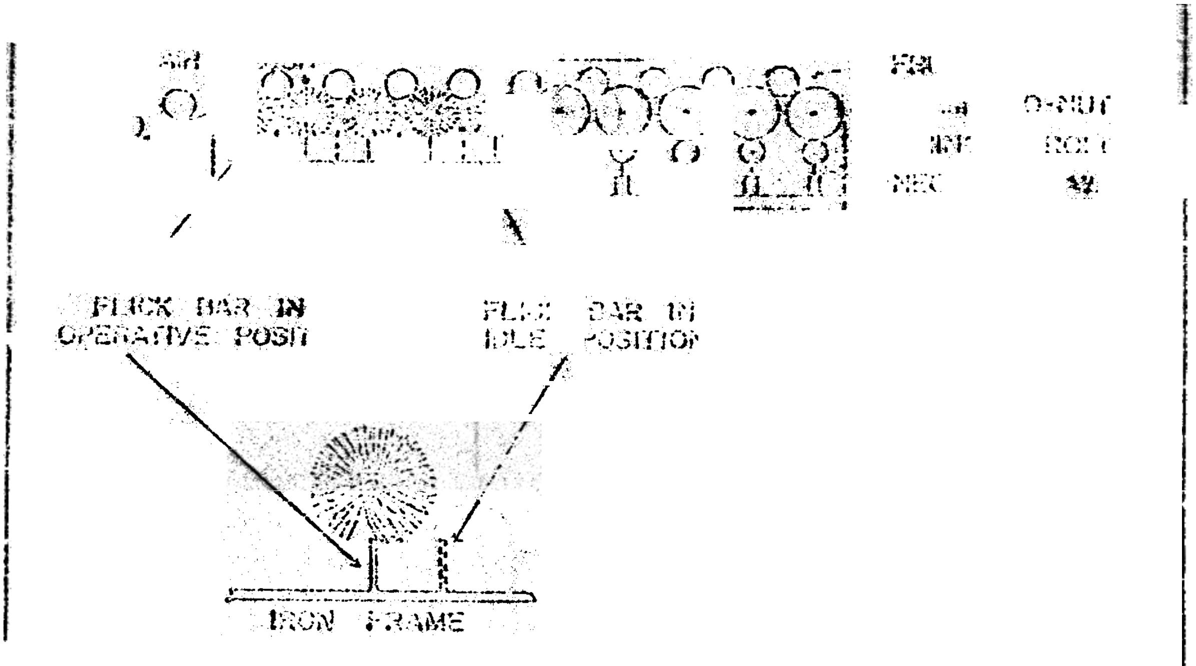


Figure 41. Combination water eliminator and fungicide-wax applicator, with detail of flick bar below. (Grierson, Miller and Wardowski, 1978.)

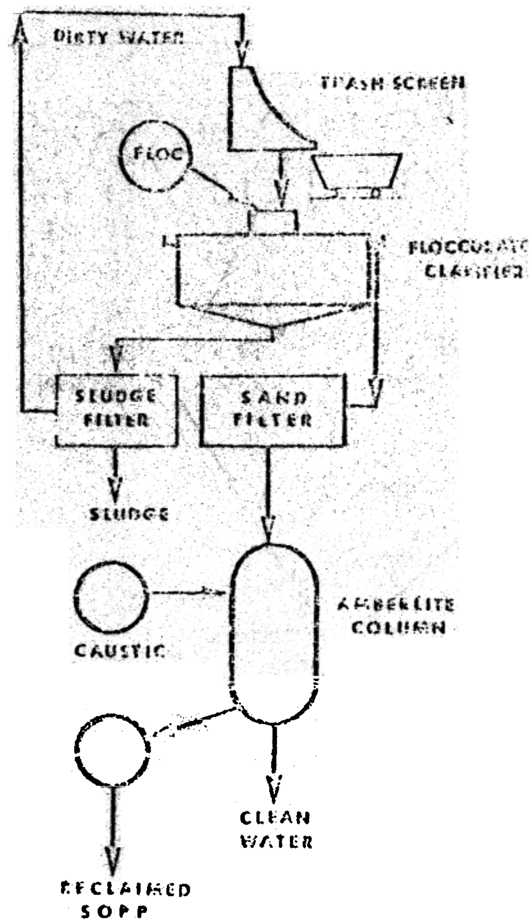


Figure 42. Water and chemical recovery system for citrus packinghouse effluents (Ismail, 1978).

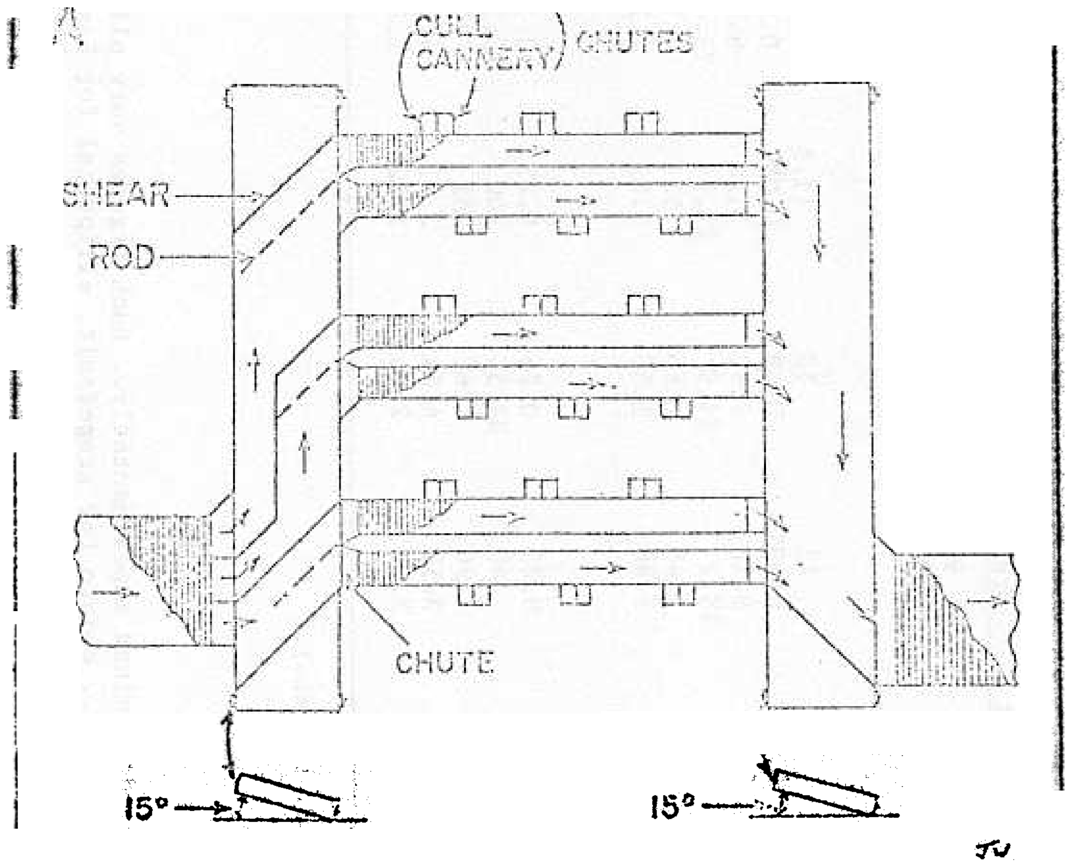


Figure 43. Multiple grade tables, a way to improve efficiency of grading. (Grierson, Miller and Wardowski, 1978.)

Table 20. Physical Characteristics of Fruit (From Grierson, Miller and Wardowski, 1978).

Abbreviation	Characteristic	Grape-fruit		Tanger-ines	Lemons	Persian	Key Limes
lb/box	Pounds per Florida field box[y]	85[x]	90[x]	95[x]	95[w]	95[w]	100[w]
No./box	Average number of fruit per box	70	200	300	250	400	1200
US Measures							
ft^2/box	Area (ft^2) per field box	9	11	12	11.5	14	20
boxes/ft^2	Field boxes per square foot (ft^2)	0.111	0.091	0.083	0.087	0.071	0.050
lb/ft^2	Pounds (lb) per square foot (ft^2)	9.44	8.18	7.92	8.26	6.79	5.0
No./ft^2	Average number of fruit per ft^2	7.78	18.2	24.9	21.8	28.4	20.0
ft/box	Linear feet per field box	30	48	60	52	75	178
lb/ft	Pounds (lb) per linear foot	2.83	1.88	1.58	1.83	1.27	0.58
Metric Measures							
m^2/10 kg	Area (m^2) per 10 kilograms of fruit	0.22	0.25	0.26	0.25	0.30	0.41
kg/m^2	Kilograms per square meter (m2)	45.5	40	38.5	40	33.3	24.4
No./m^2	Average number of fruit per m^2	83	196	267	231	308	644
m/10 kg	Linear meters per 10 kilograms	2.37	3.58	4.24	3.67	5.30	12.00
kg/m	Kilograms per linear meter	4.22	2.79	2.36	2.72	1.89	0.83

[y]Florida field box = 4,800 cu. ins. (approx. 2.23 U.S. bushels).

[x]Legal measure.

[w]Estimated.

NOTE: Area per box and linear feet per box have been determined experimentally. Such figures vary slightly from theoretical values when fruit are not spherical, e.g., oblate for grapefruit, elliptical for lemons, etc.

Table 21 Formulas involved in conveyor capacity (From Grierson, Miller and Wardowski 1978).

Value Needed	Belt Conveyor	Slat or Roller Conveyor[z]
U.S. Measures[y]		
Capacity of a given conveyor (boxes[x]/hr)	$c = \frac{w \times s \times 60}{a}$	$c = \frac{60 \times rpm \times N \times w}{\ell}$
Necessary linear speed (ft/min) for a given capacity	$s = \frac{c \times a}{w \times 60}$	$s = \frac{c \times \ell \times r \times 2 \times \pi}{w \times N \times 60}$
Necessary drive shaft rpm for a given linear speed (ft/min)	$rpm = \frac{s}{\pi \times d}$ or $\frac{7 \times s}{22 \times d}$	$rpm = \frac{s}{2 \times \pi \times r}$
Necessary rpm for a given capacity (boxes/hr)	$rpm = \frac{c \times a}{w \times \pi \times d \times 60}$	$rpm = \frac{c \times \ell}{60 \times N \times w}$
Metric Measures[w]		
Capacity of a given conveyor (tonnes/hr)	$C = \frac{W \times S \times 6}{10 \times A}$	$C = \frac{RPM \times N \times W \times 6}{L \times 10}$
Necessary linear speed (m/min) for a given capacity	$S = \frac{10 \times A \times C}{6 \times W}$	$S = \frac{C \times L \times R \times 10 \times 2 \times \pi}{W \times N \times 6}$
Necessary drive shaft RPM for a given linear speed (m/min)	$RPM = \frac{S}{\pi \times D}$ or $\frac{7 \times S}{22 \times D}$	$RPM = \frac{S}{2 \times \pi \times R}$
Necessary RPM for a given capacity (tonnes/hr)	$RPM = \frac{A \times C \times 10}{6 \times W \times \quad \times D}$	$RPM = \frac{C \times L \times 10}{6 \times W \times N}$

[z] N - number of fruit rows/revolution; r - pitch radius, ft.; R - pitch radius, m.

[y] U.S. Measures: c = capacity (boxes/hr); w = width of conveyor (ft); s = linear speed (ft/min); a = area (sq.ft) of a box spread 1 fruit deep; d = diameter of drum (ft.); rpm = revolutions/min; ℓ = length of 1 box as a single row of fruit (ft.)

[x] A Florida box = 90 lbs oranges, 85 lbs grapefruit, or 95 lbs tangerines.

[w] Metric measures: Tonne = 1,000 kg = 2,205 lbs. C = Capacity (tonnes/hr); W= width of conveyor in meters(m); S = linear speed (m/min); A = area (m^2) of 10 kilograms (kg) fruit; RPM = revolutions per minute; W = width of conveyor (m); L = length of 10 kg fruit in a single row; D = diameter of drum (m).

Table 22. Standard equipment dimensions (From Grierson, Miller and Wardowski, 1978).[a]

	Standard Sizes
Belt Conveyors	
Width (in.)	14, 18, 24, 36, 48, 60
Drum size (in.)	6, 8, 10, 12, 14, 18
Roller and Slat Conveyors	
Width (in.)	12, 18, 24, 30, 36, 48, 60, 72, 84
Chain	RC2060 with D5 attachment (roller RC2060 with A3 attachment (slat)
Rollers	2" Aluminum tubing 2" Sch. 40 Steel Pipe 2" Sch. 40 PVC Pipe
Washers and Water Eliminators	
Brush length	(As required)
Brush diameter (in.)	Less than 6
Moisture eliminators (in.	4 to 6.25 (various sizes

[a]1 inch = 2.54 cm.

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