PACKINGLINE DESIGN AND MACHINERY CONSIDERATIONS

W. M. Miller

University of Florida

M. A. Ismail

Florida Department of Citrus

Citrus Research and Education Center

700 Experiment Station Road

Lake Alfred, FL 33850

Table of Contents

Introduction

A well-designed packingline should allow the packer to maintain or enhance the quality of incoming product while providing the flexibility for marketing needs. The packingline can be visualized as a various unit operation which should be matched together (Figure 1). Some of the operations may be time dependent such as washing wh e others may be dependent such as grading. Other operations may be equipment limited, one example typically cited s separation of freeze-damaged

An overa listing of the packingline unit operations would include

I. Dumping
II. Trash Elimination
III. Presizing
IV. Washing
V. Dewatering
VI. Pregrading
VII. Fungicide Application
VIII. Waxing
IX. Drying
X. Marking (label, stamp)
XI. Final Grading
XII. Final Sizing
XIII. Packing (+ bagging)
XIV. Palletization

The type of fruit injury that may occur at the packinghouse includes mechanical, chemical, and thermal damage. Also, the damage is not imited to the packingline as mechanical or chemica damage may occur at the grove level and post-packing damage such as deformed fruit from overfilled cartons is common. The main thrust of this discussion wi center on the packinghouse and procedures to minimize mechanica damage that may occur. Schematics for many of the suggested design features to prevent damage can be found in Packingline Machinery for Florida Citrus Packinghouses (6).

Types of Mechanical Damage

Any damage that disrupts the cuticle or "protective skin" of a citrus fruit may lead to subsequent decay. This damage may be quite minor, such as abrasive sand or brush injuries, or quite severe such as a deep cut or puncture from a stem. Internal damage may also occur

through rupturing juice vesicles by dropping fruit from excessive heights or by deformation from excessive static loads

Injury Points in the Packingline

Dumping

Dry dumping s firmly recommended. If the machinery is well-designed with unimpeded fruit flow, the fruit will suffer no appreciable damage. Dumping into water inevitably subjects the fruit to an inoculum of fungus diseases, some of which may be resistant to fungicides.

Today most dumping s from pallet boxes that empty approximately 850 to 900 pounds of fruit at once. It is important, particularly with dry dumping, to level this mass of fruit as soon as possible so as to avoid squeezing and scraping of the fruit and to fac tate trash removal. Some form of "anti-surge" device, such as a vari-speed belt or controlled speed elevator (when taking fruit out of a wet dump), is advisable. This wil help to regulate the subsequent flow of fruit through the packinghouse ine

Trash Elimination

Few packinghouses have adequate provisions for the trash that is commonly included in deliveries of fruit from hand picking. The same problem may exist in the future with mechanically harvested fruit. A metal rod spaced section or a sloping belt trash eliminator will remove most loose trash and deliver it to a conveyor or container. Roller conveyors should always be self-cleaning. Several pregraders with clippers are required to remove adhering stems, and provision needs to be made for removing any rots and splits. Rots should be minima if the grove has been chopped or disked immediately prior to picking. The packingline should be checked daily to make sure there are no

contaminated fruit remaining on the line and that no equipment has malfunctioned which could lead to fruit injury.

Brushing

Abrasive damage occurs to fruit due to excessive brush speeds and excessive brushing time, especially with washer brushes having very stiff bristles. When stiff bristles are needed for thorough cleaning, the brushing time should be minimal. To control brushing time, a continuous wipeout or one activated by ack of fruit flow should be installed. Brushing time can be significantly altered by dump rate presizing, and pregrading in some cases. Since these factors vary, some wipeout mechanism is critical to prohibit excessive brushing action Another helpfu practice is to condition new brushes at the beginning of the season when the fruit peel is tender and especially when sensitive fruit such as tangerines are packed. A plywood sheet lightly touching the rotating brushes for 1 to 2 hours is effective to condition new brushes. Also, the installation of new brushes may be delayed until a midseason break when the fruit pee is more mature.

Damage from brushes can be minimized by prewetting the fruit so dry fruit is never on dry brushes. With this in mind, t is not advisable to use polisher dryers (soft brushes in dryers Any brush speeds over 120 rpm for washers and 100 rpm for fungicide and wax applicators should be carefully reviewed for benefit vs. damage to the peel. Fruit with brush damage (tiny scratches in the cuticle and possibly the outer layer of cells) is more subject to damage from contact with caustic chemicals or excess heat and will dehydrate during marketing. Fruit with damage from brushes will normally show an injury several hours or days after the damage occurs.

Deliveries from Roller and Slat Conveyors

Al deliveries from roller conveyors should be equipped with ejector slats on the drive shafts. The deliveries from slat conveyors should be equipped with spinner rolls. Chutes (transfer plates) from roller and slat conveyors should be aligned as an extension of a radius from the head shaft. The slight drop from the roller to the chute will not damage the fruit, but a chute with too little slope on which flat or irregular shaped fruit can back up can be very damaging.

Points of Impact

A common point of impact is when fruit drop onto a belt. Drops of several inches can be allowed onto a belt if there is no support under the belt at the point of impact. Where the belt is carried on rollers, the rollers are removed at the point of impact; where the belt is carried on a pan, the pan should be cut away under the impact area. However, support is required under shears to avoid pinching fruit. Rollers, rather than pans, for supporting the belts are recommended, as dragging the belts over a metal pan can increase the necessary horsepower by as much as 30%.

Another typical point of impact is where fruit is delivered at right angles to the belt travel, as from a dumper. A second point of impact is then on the side of the machinery, not on the belt itself. Most forms of padding wear away rapidly or build up with wax, which catches debris and becomes abrasive. An excellent form of bumper is made from plastic hose attached with tee-bolts such as are used for attaching slats in a slat conveyor. The bumper hose should be continued along the conveyor until the point at which the fruit are no longer rolling. The bumper can then be discontinued and the fruit will

continue on the belt without scraping against the sides, materially reducing the wear and tear on both the fruit and the equipment

With regard to internal damage, one study quantified the damage by assessing the amount of free-flowing juice from breakage of juice sacs (Figure 2). Yamashita and Kitano 7) reported the following for Mandarin fruit:

> Breakage of juice sacs occurred primarily in the processes of dumping, mixing and packing the fruit, and sealing and stacking the cartons. Two main factors causing breakage of juice sacs were dropping impact and compression. The maximum allowable dropping height of medium-sized Satsuma mandarins to prevent juice sac breakage was about 30 cm (12 in). Suggestions to improve the packinghouse processes are: 1 Should not drop fruit more than 30 cm (12 in) and should not drop more than seven times even at 20 cm (8 in) height. Soft buffering mats would be helpful to reduce the dropping impact. 2) Static load should not exceed 0.5 kg (1.1 lb) per fruit and should not pile fruit more than 35 cm (14 in). 3) The standard fiberboard cartons packed with 15 kg (33 lb) of the mandarins per box should not be stacked more than five high. It is desirable to improve cartons to decrease overhead pressure to the fruit and humidity in the cartons.

For specification of shipping containers, Peleg (4) presented the information of Table 1. Note that these values are for design of containers and should, therefore, be considered the maximum allowable limits as opposed to acceptable drop heights

Table 1. Typical Drop Heights for Design of Shipping Containers (4)

Gross weight range kg (lb)	Type of handling	Container drop height cm (in)
0-10 (0-22)	One man throwing	110 (42.5)
10-25 (22-55)	One man carrying	80 (30.0)
25-70 (55-155)	Two men carrying	70 (27.5)
70-250 (155-550)	Manual light handling equipment	60 (25.0)
250-500 (550-1100)	Motorized light handling equipment	45 (17.5)
500-2000 (1100-4400)	Medium duty handling equipment	30 (12.5)
2000 + (4400 +)	Heavy duty handling equipment	20 (7.5)

Points of Friction

More damage is done to fruit at turns of various kinds than anywhere else in a normal packinghouse. Most turns are at right angles and many involve delivery from one type of conveyor onto another. In general, over-the-end delivery from one conveyor to the other is preferable to the use of a shear. When two belts intercept at right angles, the belt pulling the fruit out of the corner should be on the top.

Most places, where the fruit s to turn at right angles, a shear is commonly used. It is at such turns that most fruit damage occurs due to cutting back the inside corner of the turn, thereby restricting the fruit flow and forcing it against a sharp edge at the inside corner. It is preferable to keep the angle of a shear no more than 30°. However, there are many cases where this is not possible, particularly when shearing from a narrow belt onto a wider conveyor. In such cases, rods should be used paralle to the shear and riding on the delivery belt. In most instances, a 0.64 cm 1/4") stee rod is adequate. Where several successive rods are used, they should increase in diameter, 1/4", 3/8", and 1/2". When fruit has to change directions rapidly, as in by-pass belts into and out of a color-add tank, the fruit

flow can be aided and damage minimized by sloping belts 5° in the direction of the fruit exit

The surface of the shear contacting the fruit should be slick and of a material that does not tend to accumulate fruit wax. Inclining the face of the shear away from the fruit or t ting the lower edge towards the fruit is advisable. This will tend to "lift" the fruit and guide it more easily to the side exit. This is particularly important with soft citrus fruits which tend to be flat and do not roll easily. Metal shears should not be painted and wooded shears are best covered with laminated plastic. Teflon strips have proven to be useful on shears at the point of fruit contact. At the early part of the fruit ine where there may be twigs and leaves carrying over, shears should be made "self-cleaning" by cutting back the downstream corner so that twigs caught under the shear will come free instead of catching. Other methods of turning fruit, i.e., transferring t from one belt to another, are by use of a right-angle belt specifically designed to operate through a right-angle turn or the use of a short, vertically mounted belt in place of a vertical shear and running in the direction of and at an angle to the fruit flow on the main belt. Such vertically mounted belts have their own drive motor

Another point of friction is between fruit and the side guides of a belt. In drying tunnels or on drying elevators, particularly where multiple-layer drying s practiced, it is important to keep the fruit from rubbing against the sides of the tunnel or elevator. This s most effectively achieved by installing "wedges" at the start of the tunnel or elevator

Grading in the Packinghouse

Grading is very important in establishing the quality of citrus eventually packed. To optimize grading efforts, the following points should be considered:

1. Consider the ergonomic aspects for grading--proper lighting, temperature controlled workspace, reduced noise levels than 85 dBA), and efficient grading stations. The IES recommends 100 to 200 footcandles of lighting for difficult to highly difficult inspection. Cul chutes should be at the height of the grading table and a second grade center belt should not require more than a 2 to 3 inch ifting motion. Controlled rotation of the fruit wi assist the grading task. A rotation rate of 1.6 rev/foot of inear travel is suggested for round objects. Forward rotation is desirable to avoid motion sickness.
2. Consider the management aspects in grading. Grading table areas should be designed so graders can be added or removed dependent upon fruit variety, packingline throughput, etc. In general, the number of graders should be determined by the number of individua fruit that are inspected. Graders should be aligned so an inexperienced grader is not checking fruit that has passed an experienced grader. When graders are asked to check for only one or two defects, their efficiency wil be improved. Extensive pregrading should be considered arrangement reduces costs for packing materials (fungicides waxes, etc. and can improve the throughput of the packingline.

Mechanical Damage Evaluation

In a forthcoming paper of this shortcourse, detailed methodologies in assessing mechanical damage will be presented. The section that follows provides an overview of potential options in techniques for mechanica damage evaluation. Three procedures have been reported to determine the degree of mechanical injury in fresh fruit handling. These procedures are considered specific to mechanical injury and would complement standard decay level with time storage tests. The first is respiration rate as reported by Eaks (2) and Brown (1) and used with Florida citrus by Parker et al. (3).

A second procedure s based on weight loss. This index was reported by Peleg (4) who noted a good correlation between weight loss per unit surface area and mechanical damage.

A third procedure specific to abrasive injury is the use of 2,3,5-triphenyl tetrazolium chloride (TTC) dye (2). This solution contacts living cells through surface injuries where enzymatic reactions convert the TTC to an insoluble red form creating a red halo appearance.

A new damage evaluation approach is to measure dynamic forces via an "instrumented" artificial fruit. USDA agricultural engineers 5) have developed this instrumentation to investigate bruise damage to produce in transit from grower to consumer using a portable, small-sized stand-alone data acquisition system. The use of this equipment may be highly valuable in future packingline designs.

Conclusions

Overall, maintaining citrus quality from the grove, through the packinghouse, and to the consumer is essential. Proper design and maintenance of machinery and processes in the packingline are key elements in this quality program. Many design considerations and damage evaluation techniques have been cited in this paper. It is hoped that they will be useful in providing a high quality image of fresh Florida citrus

References

1. Brown, J. M. 1985. Carbon dioxide evolution as a measure of damage to fresh apples handled in corrugated shipping containers. Thesis. Michigan State University. East Lansing, MI.

2. Eaks, I. L. 1961. Techniques to evaluate injury to citrus fruit from handling practices. Proc. Amer. Soc. Hort. Sci. 78:190-196.

3. Parker, M. L., W. F. Wardowski, and D. H. Dewey. 1984. A damage test for oranges in a commercial packinghouse line. Proc. Fla. State Hort. Soc. 97:136-137.

4. Peleg, K. 1985. Produce Handling Packaging and Distribution. AVI Publishing. Westport, CT.

5. Tennes, B. R., H. R. Zopp, and G. K. Brown. 1986. Detection and monitoring device for perishable ASAE Paper No. 86-3029. St. Joseph, MI.

6. Wardowski, W. F., W. M. Miller, and W. Grierson. 1987. Packingline machinery for Florida citrus packinghouses. IFAS Bulletin No. 239. Gainesville, FL

7 Yamashita, S. and Y. Kitano. 1981. Factors causing deterioration in the quality of Satsuma mandarins during sorting and packing processes, with some suggestions to improve the processes Int. Soc. Citriculture pp. 827-830.

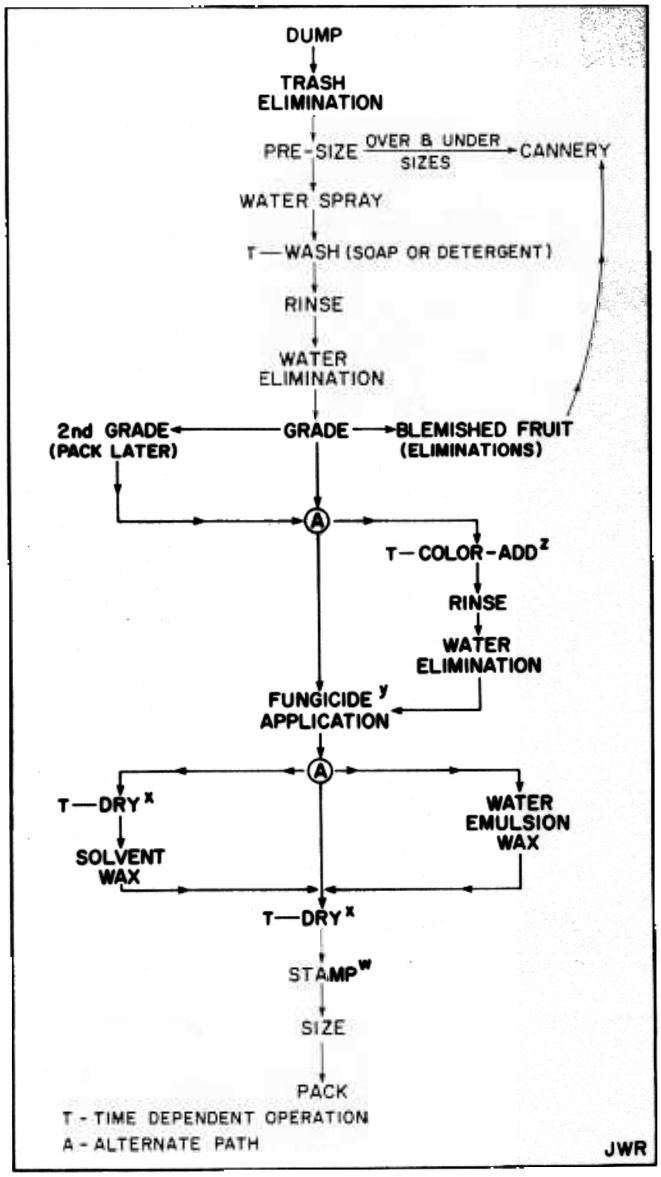

Figure 1. Unit operations in typical Florida citrus packinghouse (6).

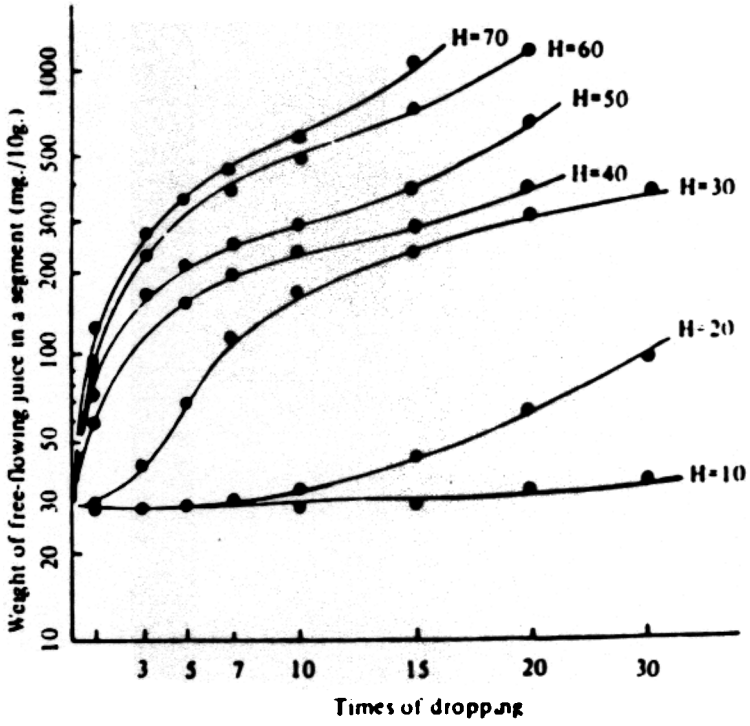

Figure 2. Effect of dropping height and number of times dropped on the breakage of juice sacs (H = dropping height, cm) (7).