INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES
UNIVERSITY OF FLORIDA

FLORIDA COOPERATIVE EXTENSION SERVICE

PACKINGHOUSE NEWSLETTER

W. Wardowski, Editor
CREC
700 Experiment Station Road
Lake Alfred, Florida 33850
Phone (813) 956-1151

Packinghouse Newsletter No. 167
March 15, 1992

Key Index Words: Citrus Packinghouse Day, Packing Density, Precooling, Reefers, Transportation, Trucks.

PACKING DENSITY

Bill Miller
Citrus Research & Education Center
Lake Alfred

How much does the fruit packing arrangement alter the packing density in filling a pallet bin? What about a packed carton? Obviously, if fruit were cubic, a 100% packing density could be achieved given proper inside dimension for the container. However, citrus fruit tend to be spheroidal with oranges close to a perfect sphere, sphericity - 0.98. The ideal Florida grapefruit resembles a sphere with truncated ends at the stem and blossom ends. This results in a lower sphericity, approximately 0.92 (Miller, 1987).

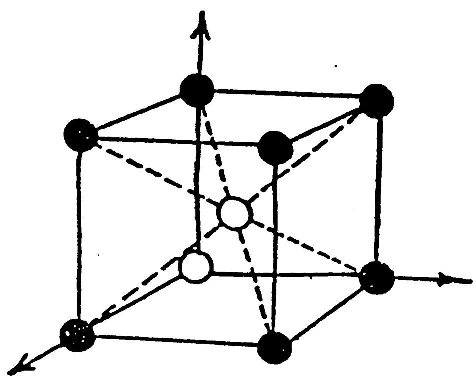
For this packing density analysis, let's assume that we have perfect spheres. If we place them in an exact row and column configuration in a box, the packing density is 53%. Of course, we know that this can be improved via nesting (the second layer sitting in the pockets created by the first layer). This configuration is called body centered cubic and results in a packing density of 60% (Fig. 1). The packing density can be further enhanced by a face centered cubic configuration where a packing density of 74% is achieved (Fig. 2).

To find what might be expected for citrus, scaled-down tests were performed with small nylon balls (3/8 and 1/4") and plexiglas boxes that were dimensionally ratioed to pallet bins. The 3/8" and 1/4" diameter balls would represent 4.5" and 3.0" diameter fruit (i.e., grapefruit and oranges). The boxes were filled with balls and the packing densities were obtained by both weight measurements of the nylon balls and filling the void space with water. Only very minor differences were noted for various mix ratios of the two ball sizes.

Mix ratio	Packing density
100% @ 3/8"	63.9%
75% @ 3/8",25% @ 1/4"	64.5%
50% @ 3/8",50% @ 1/4"	64.3%
25% @ 3/8",75% @ 1/4"	63.7%
100% @ 1/4"	64.9%

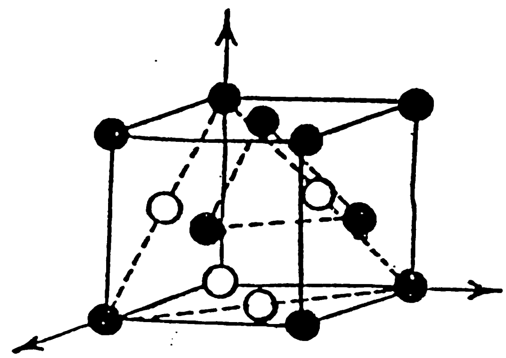
The Institute of Food and Agricultural Sciences is an Equal Employment Opportunity - Affirmative Action Employer authorized to provide research, educational information and other services only to individuals and institutions that function without regard to race, color, sex, or national origin.
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS, STATE OF FLORIDA, IFAS, UNIVERSITY OF FLORIDA, U. S. DEPARTMENT OF AGRICULTURE, AND BOARDS OF COUNTY COMMISSIONERS COOPERATING

Figure 1.



BODY-CENTERED CUBIC ARRANGEMENT
(●-visible, O -hidden)

Figure 2.



FACE-CENTERED CUBIC ARRANGEMENT
(●-visible. O -hidden)

These packing density results are consistent with a previous work report on metal shot where a 62.5% value was reported (McGeary, 1961). Interestingly, McGeary also reported that at least a seven-fold difference is needed between small and large spheres before any difference in void-filling of the small spheres into spaces between the large spheres is noted. What this really means for citrus in pallet bins is that the known weight difference between grapefruit and oranges comes from the fruit weight density differences, not from variations in packing density due to the size variation between oranges and grapefruit.

When the containers become smaller (e.g., field boxes or fiberboard cartons), wall effects can become significant and the packing density may fall to the 50% range (Peleg, 1983). Taking our accepted standards for Florida oranges, we find this trend. A Florida field box is 4800 in^3 and holds 90 lb of fruit. A pallet bin is 43,500 in^3 and holds 900 lb of fruit. On a packing density basis with an assumed specific gravity of oranges at 0.96, the packing density for a field box is 54% and for a pallet bin, 60%. The advantage to pattern packs such as the face centered cubic is noteworthy as the optimal 74% packing density may be approached. Also, with higher packing densities, more contact points between fruit are found which, in turn, reduces any contact pressure. Twelve contact points are found for the face centered cubic configuration, but a random fill averages approximately seven contact points between spheres.

References

McGeary, R. K. 1961. Mechanical Packing of Spherical Particles. J. Amer. Ceramic Soc. 44(10):513-522.

Miller, W. M. 1987. Physical Properties Data for Postharvest Handling of Florida Citrus. Applied Engr. in Agric. 3(1):123-128.

Peleg, K. 1983. Produce Handling, Packaging and Distribution. AVI Publishing. Westport, CT.

REFRIGERATED TRUCKS ARE NOT PRECOOLERS

Will Wardowski and Bill Grierson, Professor Emeritus
Citrus Research and Education Center, Lake Alfred

Sometimes simple things are not obvious. We were called upon by a trucker who was threatened with financial penalties because his refrigerated truck had failed to cool down a load of warm, late season, grapefruit in the course of a 24-hour trip from the Indian River to New Jersey. "That's easy" we thought, reaching for the Packinghouse Newsletter index. To our astonishment, never in the 166 newsletters published over the last 26 years have we spelled out that reefer trucks are not precoolers. So, instead, we quoted an article in Citrus and Vegetable Magazine (Sargent, 1991), two U.S.D.A. authors and one from Sunkist in Fresh Citrus Fruits (Hale et. al., 1986), the U.S.D.A. handbook on shipping tropicals such as grapefruit (McGregor, 1987), and the University of California's text on Postharvest Technology (Mitchell, 1975).

Refrigerated semi-trailer vans ("reefer trucks") are basically designed to maintain the temperature of a load, not to cool it down. (Strange as it may seem, it takes a lot less refrigeration capacity to hold a load of frozen concentrate of -10°F (-23°C) than it does to cool a load of fresh fruit from 80 to 60°F).

When the load starts at 70°F and the outside temperature gets steadily cooler as the truck goes north, the truck's unit may well achieve considerable cooling. But when fruit is loaded at 85°F and the weather remains warm on the trip north (as it often does later in the season), the typical truck unit is hard put to do much more than cope with heat leakage and the heat of respiration generated by the warm fruit.

Most shippers and buyers of fruit are, to a certain extent, gamblers. Sometimes loading warm fruit in a reefer truck for a haul in warm weather may be a losing gamble. It is best to precool warm citrus fruit to the desired shipping temperature. When fruit have to be shipped in warm weather and no precooling facilities are available, we suggest that: 1) time from picking to shipping be reduced to the absolute minimum, 2) trucks have their cooling units running prior to loading in order to cool the truck body, and 3) consideration be given to very early morning loading to allow the packed fruit to lose some of its field heat during the night.

References

Hale, P. W., W. R. Miller and J. Ross. 1986. Packaging and utilization. Chap. 16 in Fresh Citrus Fruits. Eds. W. F. Wardowski, S. Nagy and W. Grierson. AVI Publishing Co.

McGregor, Brian M. 1987. Tropical Products Transportation Handbook. U.S. Dept. Agr., Agr. Handbook No. 668.

Mitchell, F. Gordon. 1975. Cooling horticultural commodities. Chap. 7 in Postharvest Technology of Horticultural Crops. Eds. A. A. Kader, et al. Univ. of Calif. Special Pub. 3311.

Sargent, Steven A. 1991. Applying precooling principles to vegetable handling operations. Citrus and Veg. Mag. 54(11):10-15.

THIRTY-FIRST ANNUAL CITRUS PACKINGHOUSE DAY

THURSDAY, SEPTEMBER 10, 1992
CITRUS RESEARCH AND EDUCATION CENTER
700 EXPERIMENT STATION ROAD
LAKE ALFRED, FL 33850

Citrus Packinghouse Day is scheduled Thursday, September 10, 1992 with registration beginning at 8:30 AM and the program beginning at 9:30 AM. Tickets for lunch may be purchased at registration. There is no meeting registration fee and reservations are not required.

Equipment displays will be in the afternoon. Exhibitors are encouraged to register soon. Phone (813) 956-1151 for W. Miller or W. Wardowski to obtain an exhibitor registration form.

AVAILABLE PUBLICATIONS

Available from Dr. W. Wardowski, CREC, 700 Experiment Station Road, Lake Alfred, Florida 33850

Automatic Density Measurements for Quality Sorting of 'Marsh'Grapefruit, by W. M. Miller and W. L. Verba. 1990. Proc. Fla. State Hort. Soc. 103:241-244.

Produce Bagging by Weight - an Analysis Using Bootstrap Simulation, by W. M. Miller. 1991. Applied Engineering in Agriculture 7(4):429-432.

Estimated Costs of Processing Bulk Citrus Concentrate and Citrus Feed in Florida, 1988-89 and 1989-90 Seasons, by Ronald P. Muraro and W. F. Wardowski. 1992. Food and Resource Economics Extension Notes, EN-25, Univ. of Fla. Coop. Ext. Serv.,

The Polygalacturonases and Lyases, by J. K. Burns. 1991. Chapter 9, pp 165-188 in The Chemistry and Technology of Pectin, Academic Press

Irradiation: looking for the needle of truth in the haystack of nonsense by Bill Grierson. 1992. Citrus Industry 73(1):46-47,49-52.

Some thoughts on advertising Florida citrus by Bill Grierson. 1992. Citrus Industry 73(2):33-34,36.

Available from Dr. M. E. Wisniewski, USDA, ARS, Appalachian Fruit Research Station, Kearysville, KY 25430

Biological Control of Postharvest Diseases of Fruits and Vegetables: Recent Advances. 1992. HortScience 27(2):94-98.