Literature Cited

1. AOAC. 1965. 10th Ed. Method 38.012 p. 744.
2. Baker, R. A. and J. H. Bruemmer. 1972. Pectinase stabilization of orange juice cloud. J. Agr. Food Chem. 20:1169.
3. Braddock, R. J. and J. W. Kesterson. 1975. Quality changes of enzyme-treated citrus pulp wash liquids. Proc. Fla. State Hort. Soc. 88:292.
4. ——— and ———. 1976. Enzyme use to reduce viscosity and increase recovery of soluble solids from citrus pulp-washing operations. J. Food Sci. 41:82.
5. ——— and ———. 1979. Use of enzymes in citrus processing. Food Technol. 33(10):78.
6. Godfrey, T. 1978. Enzymes in food processing. Internat. Flavors & Food Additives 9(4):163.
7. Krop, J. J. P. and W. Pilnik. 1974. Effect of pectic acid and bivalent cations in cloud loss of citrus juice. Lebensm.-Wiss. U. Technol. 7(1):62.
8. Praschan, V. C. 1975. Quality control manual for citrus processing plants. Intercit., Inc. Safety Harbor, FL.
9. Rombouts, F. M. and W. Pilnik. 1971. Pektolytische enzyme in der Fruchtsaftindustrie. Flussiges Obst. 38(3):93.
10. Seaver, Joan L. and Z. I. Kertesz. 1946. The browning (maillard) reaction in heated solutions of uronic acids. J. Amer. Chem. Soc. 68:2178.
11. Ting, S. V. 1967. Nitrogen content of Florida orange juice and concentrate. Proc. Fla. State Hort. Soc. 80:257.
12. ———. 1970. Alcohol-insoluble constituents of juice vesicles of citrus fruit. J. Food Sci. 35:757.

Proc. Fla. State Hort. Soc. 94:273-276. 1981.

TECHNOLOGIC AND ECONOMIC CONSIDERATIONS OF CITRUS CONCENTRATE STORAGE[1]

F. E. STEGELIN
University of Florida, IFAS,
Food and Resource Economics Department,
Gainesville, Florida 32611

P. G. CRANDALL
University of Florida, IFAS,
Agricultural Research and Education Center,
700 Experiment Station Road,
Lake Alfred, Florida 33850

Additional index words. orange juice concentrate, bulk, reconstitution, pound solids, utilization, aseptic packaging, tank farms, drum storage, warehousing and storage costs.

Abstract. **Industry shifts to bulk tank storage have been partially triggered by the increased economic and operating efficiencies of tank farms over drum storage. The citrus industry has also observed a 92% increase in the level of bulk utilization since the 1977-78 season, an increased amount of concentrate reconstituted outside Florida, an increase in new and reset commercial acreage planned or planted in Florida, and increased competition from imported concentrate to meet a growing consumer demand for citrus products, especially single-strength juices. These issues give cause for managerial involvement in evaluating concentrate storage needs and techniques. The technical analyses in quality control and product standardization for concentrate storage, including alternative Brix concentrate levels and temperatures above 20°F are available as is the equipment needed for the manufacture of citrus concentrate.**

Technologic and economic considerations for storing citrus concentrate by drum, tank, and bag-in-box are presented to aid managements of small and/or potential processors evaluate their future in citrus concentrate storage.

Every gallon of 60-65° Brix citrus concentrate produced by Florida processors may be stored for extended periods of time prior to consumption. Additional storage may be used for bulk concentrate imported to supplement the concentrated orange juice produced from Florida fruit and used to manufacture frozen concentrated orange juice (FCOJ). Several factors are inherently evaluated by management in deciding how and in what form to store citrus juices.

Major considerations in these decisions, according to industry participants and published comments, include: 1. the number and volume of product categories to be inventoried; 2. product handling and transport characteristics; 3. product standardization and quality protection during storage, including uniformity of the concentrate, stratification of product, concentrate loss from blending, sanitation concerns, and microbiological risks; 4. storage space utilization; 5. types and amounts of existing storage; and 6. the costs of storage and warehousing, including investment and fixed costs as well as variable costs (1, 2, 10, 13). The focus of this paper is on describing drum, tank, and bag-in-box storage of citrus concentrate by various technical and economic considerations to aid managements of small processors and/or firms considering entrance into the processing subsector evaluate their citrus concentrate storage decisions.

Drum Storage and Tank Farms

There are several bulk storage techniques and containers used for storing citrus concentrate; however, the most prevalent bulk storage types are drums and tank farms. A comparison of these two types is presented for one million gallons of 65° Brix concentrated orange juice. The comparison includes a relative economic investment evaluation as well as a general discussion of relative advantages and disadvantages of each type of bulk storage. The composite cost approximations were supplied by representatives of various citrus concentrate storage facility manufacturers as well as citrus processors who either have recently installed additional concentrate storage facilities or have made inquires into the costs of storage expansion, but who prefer to remain anonymous.

Drums

Storage in 55-gallon drums has the advantages of handling, storing, and subsequently shipping relatively small amounts of blended concentrate—as little as one drum—thus tailoring one's merchandising program to smaller receivers. Drum storage is versatile because a number of products can be blended and inventoried separately. Drum storage also has an advantage of low initial capital requirements, pri-

[1]Florida Agricultural Experiment Stations Journal Series No. 3581. The cost figures and comparative statistics for the drum, tank, and bag-in-box concentrate storage methods were supplied by various Florida citrus processors, manufacturers representatives and IFAS personnel. The authors appreciate the interest expressed by these individuals in providing this information for this paper.

marily variable costs of drums, liners, lids, and labor although cold storage and additional dry drum storage space in warehouses is needed. The investment in a dry drum warehouse can be considered an opportunity cost of using drum storage as opposed to using it for some other enterprise.

The disadvantages of bulk storage in drums include: 1. the requirement for palletized storage; 2. the low product density and wasted space in the warehouse due to cylindrical drums on rectangular pallets, the depth of pallets, and fork lift truck aisles; 3. the need for additional dry storage space and inventory control for drums, liners, lids, rings, bolts, and pallets; 4. maintenance and replacement costs of drums; and 5. the approximate 20% energy loss attributed to the cooling of drums and the increased energy needed to store the finished product in drums approximately 18°F colder than necessary in tank farms. The latter energy consumption is due to a USDA requirement that finished product of frozen concentrated citrus products be stored at 0°F or below (12). Drums are normally stored in finished product warehouses because the warehouses are available and the extreme cold temperature makes the drums more solid and less likely to buckle and cause the collapse of the stack. Additional disadvantages of drum storage include the reduced accuracy and difficulty of inventory control, approximate 1/2 to 2% of the concentrate lost in the liner or not retrieved when the drums are emptied by the receiver, the relatively large labor force needed for seasonal filling labor and year-round warehousing personnel, the energy lost and extra cost involved in shipping product in drums weighing 42-47 pounds each, the costs to recondition the drums due to repeated slow freezing and thawing, and the increased chance of product contamination, such as paint chips from the barrel.

The Florida processing, warehousing, and selling costs per gallon of 45° Brix concentrate in drums are available (7). The trends for the oranges solids price and the processing, warehousing, and selling costs are depicted in Figure 1. The warehousing costs exclude the variable costs of drums, liners, lids, labor and associated expenditures as well as the investment costs and fixed costs attributed to bulk storage in drums or tank farms.

Assuming one million gallons of 60-65° Brix concentrate in 0°F storage is needed, the following cost example is presented for comparison purposes. One million gallons of 62° Brix concentrate can be stored in 19,000 barrels, each holding about 52.6 gallons. The current expected cost of a drum over its useful life is $18-20 each, and assuming 2-2 1/2 uses per drum with reconditioning after each use, the per use cost of drums, lids, liners, bolts, pallets, and strapping rings, for 1,000,000 gallons is $152,000 [19,000 barrels x ($20/2.5) = $152,000], excluding the reconditioning cost. Drum storage also involves the use of two warehouses—one for cold temperature storage of the finished product and another building for dry drum, low product density storage. Current estimates by builders of drum storage warehouses for completed construction of —5°F storage are $38-42 per square foot. Storing four drums per pallet and stacking four pallets

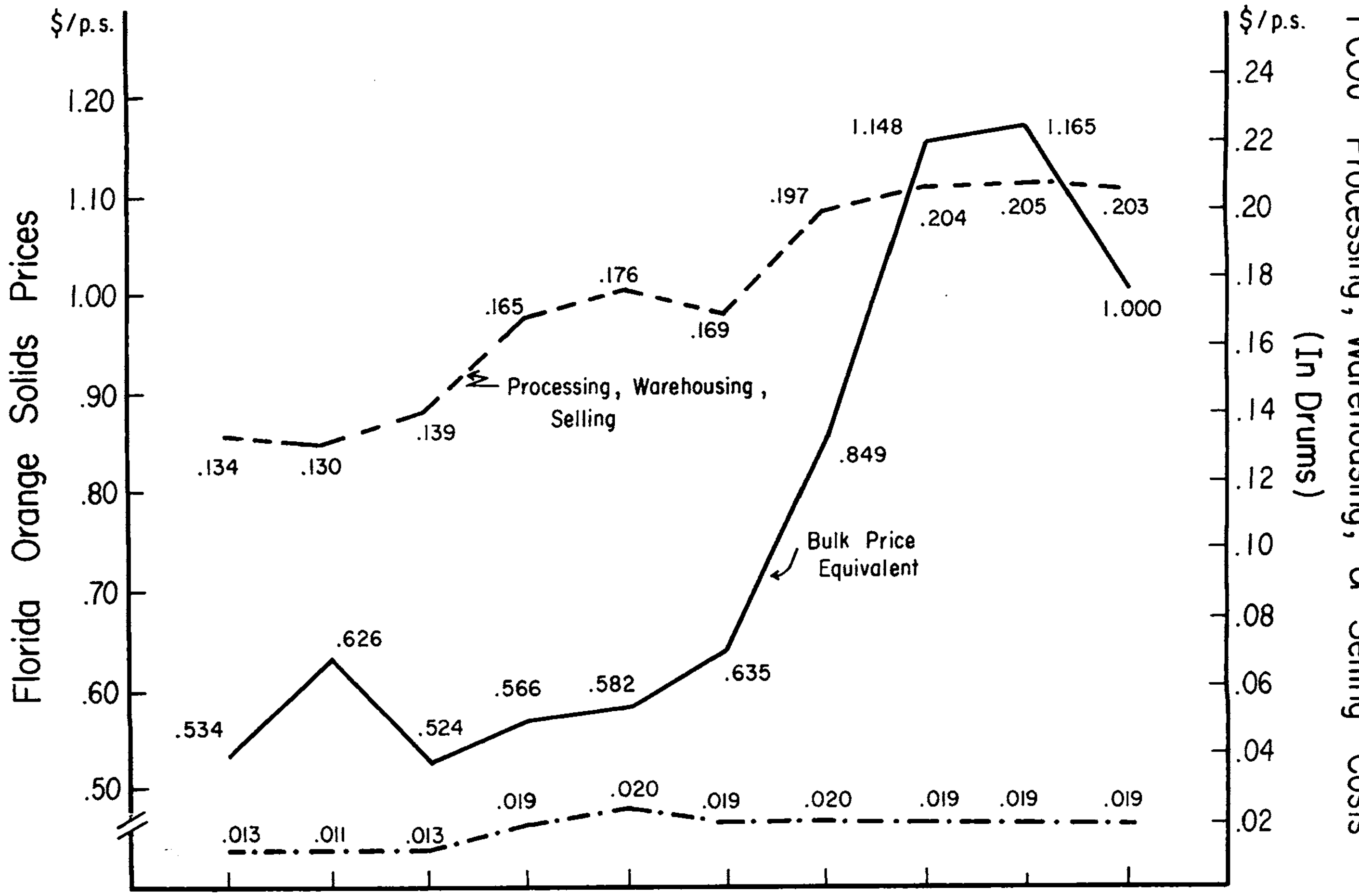

Fig. 1. Orange pound Solids and Processing, Warehousing, and Selling Costs.
Source: (5, 6, 7).

high places 16 drums on a floor area occupied by a standard pallet (52 inches x 48 inches) or about one square foot per drum. With 19,000 drums at one square foot per drum, 19,000 square feet of cold temperature warehouse floor space is needed; adding approximately 15% unoccupied space (for 12-foot alleyways and 6-foot air circulation breeze-ways) equates to 21,850 square feet of warehouse. By using the top of the quoted cost range ($42 per square foot) a warehouse for cold drum storage would cost $917,700. Assuming $32 per square foot (the lower of the cost quotes) for constructing a comparably sized dry storage warehouse, an additional warehouse investment of $640,000 should be made. Labor, supervision, and fringe benefits associated with the drum operation would total nearly $100,000 annually and product loss attributed to filling and dumping drums adds an additional $98,610 [1,000,000 gallons x 1-1/2% loss x 6.574 pound solds/gallon x $1.00/ps = $98,610]. Assuming 80°F ambient and 0°F storage for drums versus 18°F storage for tanks, drum storage requires at least one-fifth more energy (Δt 18/80 = 22.5) which is electrical energy that is currently more expensive than fue oil or natural gas energy. Many of these costs can be amortized over five years to decrease the annual out-of-pocket expenses.

Tank Farms

The rationalization for citrus processors to shift from drums to tanks has been primarily based on increased operational efficiency and decreased operating expenditures. Advantages include increased storage space utilization because 20-23% more bulk product can be stored in tanks versus drums occupying the same storage area, a reduction of inventories in lids, liners, drums, pallets and dry drum storage space, and increased ease and accuracy of product inventory. Additional advantages of bulk tanks include: 1. smoother and faster storage and retrieval; 2. increased flexibility in packaging; 3. reduced product loss attributed to blending and drum dumping, and possibility of reduced quality degradation from thawing abuse; 4. labor savings both in terms of needing fewer people (approximately one-half the labor force used in drum storage) and labor primarily for seasonal operations rather than throughout the year; and 5. an approximate 20% energy savings on refrigeration. A relative overall operational savings of $.20 to $.27 per gallon of stored concentrate in tanks versus drums can be realized, according to processor representatives.

The principal disadvantages to storing citrus concentrate in bulk tank farms lie in the high initial investment of the specialized equipment, which may involve the additional acquisition of process control computer hardware and software, and the relatively high cost of borrowed capital (the interest rate). Current estimates for a complete tank storage facility (building, tanks, pumps, pipes, and manual controls) for one-million gallons (ten-100,000 gallon tanks) indicate an investment of approximately $1.000 to $1.05 per gallon of capacity, or a one million dollar investment. An additional $300,000 expenditure for computer equipment would be realized if the tank farm operation had computerized process control. A tank farm has been normally amortized over a 20-year period but the 5 year write-off on depreciable assets effective 1981 increases the reported annualized fixed costs.

There is a possible additional investment in a drum storage warehouse and the associated costs described earlier if a citrus processing plant handles and ships small quantities of bulk concentrate and needs a cold storage facility and appropriate containers. These costs have not been included because the situation may not warrant such an investment, but managements should be cognizant of such possible expenses. Although fewer people are employed, the tank farm operators are specialized labor earning a higher wage, yet an estimate for labor and fringe benefits is about $42,000 per year, excluding additional maintenance and repair labor. Estimated operational costs for utilities, depreciation, taxes, insurance and interest are not included in this report because they are different for each situation but they should be included in any investment analysis. Industry reports indicate a five-year payback is possible on a tank farm at current pound solids prices and interest rates. Reiterating, the operational efficiencies and economies of scale attributed to tank farms make concentrate storage in bulk tanks not only feasible but attractive.

Other Materials Handling Possibilities

There are several alternatives to drum and tank storage of citrus concentrate. Some of these options are not new facilities nor containers; rather, they are new technological alternatives to storing concentrate at near 0°F temperatures and at 60-65° Brix. These alternatives include storing at a higher degree Brix or storing at higher temperatures. There have been reports of quality degradation trade-offs from either increased Brix levels or increased storage temperatures. However, current research has shown the value of storing highly concentrated (72° Brix) citrus juice at temperatures above 32°F. There is approximately a 14% savings in storage costs for a more highly concentrated product and about 16% savings in the electrical energy consumed in frozen storage by storing at 32°F (4), (8).

An example of a new container for Florida processors to store 62° Brix concentrate is the bag-in-box which has been used to varying extent in European markets but not domestically in the United States (license pending). Sales licenses have been granted in the United States to aseptic container manufacturers, however initial indications reveal limited applications to storing concentrate at 65° Brix levels aseptically. Aseptic containers are primarily for final product distribution of single-strength juices or drinks to consumers (3) and not for intermediate storage of concentrated juice at elevated Brix levels. Aseptic containerization and distribution is a systems approach for preparing a final label product rather than as a storage technique for concentrate; therefore, there will not be extensive discussion of aseptic containers. There will be, however, a discussion of the bag-in-box concept for storing 60-65° Brix citrus concentrate.

Bag-In-Box

The current concept utilizing this technology is for storing 60-65° Brix concentrate aseptically at temperatures higher than those now being used (9). If a 300-gallon container were used as intermediate storage before final product processing, a filling machine and aseptic heating and cooling equipment would be needed at an approximate cost of $275,000. For storage of one million gallons of product, about $417,000 worth of bags and boxes would also be required. A warehouse for storage would also be needed; however, the final commercial storage temperature for the bag-in-box concept has not been determined. Consequently, a dollar cost of such a warehouse is not presented but the range of costs would be anticipated between the cold storage warehouse and the dry storage warehouse described for drum storage, specifically $640,000 to $920,000.

Packaging costs have been reported to be 50% less than with drums (11) and a savings of 30 cents per gallon compared to aseptic drum containers (reported on industry brochures). Given the extensive use of aseptic techniques in Europe for several years and the rapid rate of increase in the consumption of fruit juices and soda pop alternatives in Canada and the United States, the aseptic packaging system may provide a viable alternative to drum storage of citrus concentrate products.

Summary and Implications

For the small citrus processor or potential concentrate processor, the issue of how to store bulk citrus concentrate is paramount in managerial decision-making. Not only are there alternative containers (drums, tanks, aseptic packaging) but also alternative forms or Brix levels and alternative refrigeration or temperature levels. A generalized comparison of technical and economic considerations for citrus concentrate storage in drums, tank farms, and the bag-in-box concept indicated little economic differentiation in total investment for each storage alternative over the expected economic life of the facility. Economic, operational, and managerial efficiencies gave tank farms and the bag-in-box incentive advantages over drum storage. However, due to the experimental nature of the aseptic bag-in-box, tank farm storage seems more appropriate for commercial concentrate storage. The major considerations of product handling and transport characteristics, product standardization and quality control, storage space utilization, and the relative investment costs of storage and warehousing were presented for each system as to their relative advantages and disadvantages, with principal emphasis in drum and tank storage. Due to the operational efficiencies of tank farms, this storage method appears most appropriate for firms with bulk citrus concentrate.

There are four processed citrus faces in the supermarket—the frozen goods (FCOJ), the diary case (chilled or pasteurized single-strength), the canned goods (pasteurized products), and the beverage section (juice drinks and soda pop alternatives). Processor and merchandising managements must monitor consumer consumption and demographic patterns of trends of these four product lines as they pertain to the firms' storage of citrus concentrate. Managerial participation in financial, labor, procurement, and marketing decisions should also assist the evaluation of appropriate concentrate storage needs and methods tailored to the firm and to the product.

Literature Cited

1. Bailey, C. L. 1975. Material handling via citrus bulk tank farm. Proceedings of the 15th annual short course for food industry (energy conservation and its relation to materials handling in the food industry). University of Florida, Gainesville.
2. Bielig, H. J. 1980. Storage and transport of fruit juice concentrate in large containers. Fluessinges Obst. Technical University, Berlin. 47"343-6.
3. Bobroff, Bob. 1981. Fruit drink taming pop market in west. Orlando Sentinel. August 29, 1981:1C.
4. Crandall, P. G., C. S. Chen, and T. R. Graumlich. 1981. Energy savings from storing a high degree Brix orange juice concentrate at elevated temperatures in an inert atmosphere. Presented at International Society for Citriculture, Tokey. November, 1981.
5. Florida Citrus Mutual. 1981. Annual statistical report, 1979-80 season. Lakeland.
6. Florida Citrus Processors Association. 1981. Statistical summary, 1979-80 season. Winter Haven.
7. Kilmer, R. L. and R. C. Hooks. 1981. Estimated costs of processing, warehousing, and selling Florida citrus products, 1979-80 season. Food and Resource Economics Information Report 144. University of Florida, Gainesville.
8. Kormann, W. 1978. UHT processing of fruit juice lowers refrigeration cost. American Dairy Review. January 1978, 40:24-26.
9. Orbell, J. A. 1980. Aseptic bag-in-box packaging. Food Technology. September 1980:56-7.
10. Ratcliff, M. W. 1974. Bulk storage of citrus juice concentrate. Transactions of the 1974 citrus engineering conference. University of Florida, Gainesville.
11. Smittcamp, R. E., J. H. Truxell, and K. Robe. 1981. Aseptic-pack fruits retain color, flavor, save 30% processing energy. Food Processing 42(1):86-8.
12. United States Department of Agriculture. 1981. Product and storage temperatures—frozen fruit and vegetables. Food Safety and Quality Service, Fruit and Vegetable Quality Division, Processed Products Branch. Memorandum File Code 130-A-41, March 1981.
13. Wynne, O. B. III. 1980. Bulk storage and inventory control of citrus concentrate. Proceedings of the 20th Annual Short Course for Food Science (Energy Use and Conservation in Citrus Processing). University of Florida, Gainesville.

Proc. Fla. State Hort. Soc. 94:276-279. 1981.

EFFECT OF FINISHING VARIATIONS ON QUALITY AND YIELD OF JUICE FROM FROZEN ORANGES[1]

S. M. BARROS, R. D. CARTER, P. J. FELLERS AND S. V. TING
Florida Department of Citrus,
Agricultural Research and Education Center,
700 Experiment Station Rd., Lake Alfred, FL 33850

R. L. MANSELL
University of South Florida,
Department of Biology,
Tampa, FL 33620
AND

J. T. GRIFFITHS
Florida Citrus Mutual,
P. O. Box 89, Lakeland, FL 33802

Additional index words. flavor, limonin, immunoassay.

Abstract. **During the 1980-81 season 5 harvests of 'Pineapple' and 4 of 'Valencia' oranges were extracted similarly and tested with both soft- and hard-finishing variations. All harvests except the first two for 'Pineapples' were made after the January 13, 1981 freeze. Single strength juice samples were analyzed for physical, chemical and organoleptic characteristics. Reported results include correlation matrices and a statistical summary. Results showed finisher-setting variation produced no significant differences in juice flavor. A flavor prediction equation for all varieties and treatments was determined with a coefficient of determination (r^2) value of 0.770.**

During the Juice Definition Program (JDP) (1, 2, 3) initiated by the Florida Department of Citrus in the early 1970's, numerous analyses were made of the constituents, and characteristics of single-strength orange juice in an effort to determine a means of measuring "over extraction" and determine several factors that showed substantial differences between high and low juice recoveries, which were also significantly associated with flavor score. Only limited information on the direct effect of finishing was reported and freeze

[1]Florida Agricultural Experiment Stations Journal Series No. 0000.