THE CONCEPT OF BULK STORAGE PROCESSING AND ITS IMPLICATIONS TO INDUSTRY

Robert C. Pearl
University of California, Davis, California

The purpose of this paper is to provide a general introduction to the topic of bulk storage processing, to describe the overall concept of bulk storage processing, and to review why the concept has become of greater interest to the fruit and vegetable processing industries. Further, I wish to suggest some major changes in present harvesting, handling, and processing systems that will be required for adaptation of the bulk storage processing technique in the fruit and vegetable processing industries.

The bulk storage concept

The concept of bulk storage processing is simple. The term essentially tells what is to be done, i.e., processing of raw product so that it can be stored in bulk for probable additional processing before it moves to the product user. It is the processing of raw materials into a biologically stable form that can be stored in large bulk containers. In turn, it also implies that they may be made available over a period of time as desired or needed for further processing or modification into the final form desired by product users.

The concept is not entirely new. Modified forms of bulk storage have been used for many fruits and vegetables. A few examples are:

1. The freezing of products such as peas, cut corn, and green beans and the packaging of these products in 1,000 to 2,000 lb. bins for repackaging into smaller containers and fabrication of mixed products.
2. The holding of fresh olives and cucumbers in salt brine for processing at a later date.
3. The freezing of fruits such as strawberries, cherries, peaches, and apricots and packaging into bulk containers (55 gal drums, 1,000 lb. plus bulk bins, etc.) for further processing into jams, jellies, pies, and ice cream at a later time.
4. The freezing of speciality items for pickling for processing throughout the year. The disadvantage here is that some of the pickle specialities loose their bright and desirable appearance after pickling. There is an advantage from the quality standpoint of being able to process or pickle throughout the year rather than just at the time of raw product harvest.
5. The freezing of field run fruits for further processing into fruit puree or baby food.
6. The dehydration of fruit puree for later reconstitution and manufacture into baby food and juice drinks.
7. The heat processing of tomato paste and packaging it into 55 gal drums for further processing at a later date. Recently there has been the introduction of systems that allow the use of larger containers, but only for tomato paste. There has also been recent success with the packaging of heat processed tomato chunks into 55 gal drums.
8. The storage of apples in controlled atmosphere storage for processing into final products at a later date.

The examples just given give a general notion of how the industry has used bulk holding techniques that utilize the control of "processed product environment" by chemical modification, temperature modification, dehydration, pasteurization or sterilization, and subsequent protection from re-contamination by micro-organisms.

We are quite encouraged in California about the possibility of mechanically harvesting and immediately freezing boysenberries in the field as the fruit comes off of the vine. We have been working experimentally with a mechanical boysenberry harvester with a cryogenic freezer on the harvester so that the fruit is immediately frozen. If this system proves to be feasible, a very fragile crop like boysenberries can be harvested and handled, preserving the characteristics present at harvest without subsequent physical or chemical changes.

Why is bulk storage processing important

In recent years there have been advances in heat processing technology. Processing plant cost structures have changed significantly. Transportation cost relationships, as well as changing marketing factors, have narrowed the margins of profits for many processing firms. Consequently, in an effort to maintain their comparative position, fruit and vegetable processing industries have had to evaluate whether they should process the raw product into final product form as quickly as possible, modify the processing system so that manufacture of the final product can be delayed, or final process the product at a second location that may be several thousand miles from the area when the raw product was produced.

The objective, therefore, is to reconsider fruit and vegetable processing systems and determine the feasibility of introducing bulk storage processing techniques in a form that has not been used hitherto.

What changes are required

There are many changes that must be made in changing from immediate processing into final product and storing in containers destined for movement to the user as compared to first processing for bulk storage and processing into final product later and packaging into containers destined for movement to the user. It is usual to go through the following steps in a traditional processing system for fruits and vegetables.

1. Removal (harvest) of the raw product from the plant.
2. Placement of product in field container for moving to processing plant.
3. Transportation to the processing plant.
4. Minimum storage at the processing plant.
5. Processing of raw product into final product form and packaging into containers that will go to the home or institutional user.

The bulk storage processing system requires:

1. Removal of raw product from the plant (picking).
2. Placement of product in field container for moving to bulk storage processing plant (or possibly in field processing at time of harvest).
3. Bulk storage of raw product in a form that will at some later date and or location be further processed into the form destined for the home or institutional use.
4. Storage of the product in the most feasible package which may be 55 gal drums, 1,000, 5,000, 50,000 gal tanks, etc., under conditions that will preserve the product in the desired form until additional processing is carried out.
5. Possible transportation of the bulk storage processed product from the bulk storage processing plant to another location for additional processing.
6. Final processing, at a later time and possibly place, into the product that will go to the consumer or institutional user in the container desired.

Implications to the fruit and vegetable processing industry

There are many advantages that may make bulk storage processing more feasible than traditional methods of immediate processing into final product.

1. The possibility of being able to more easily dispose of process waste by removing it in the area of production and returning it to the fields. It is also likely that waste disposal problems through use of "garbage farming," or other techniques, may be more economical in rural areas than in the metropolitan areas where sophisticated processing plants are frequently located.
2. Improved production scheduling of processing plants by enabling greater year around use of a portion of the processing line.
3. Reduction of cost of handling with a raw product that is available for only a limited time each year.
4. The possibility of growing raw products in many production areas remote from processing plants that require heavy equipment investments.
5. The improvement of final product quality by being able to hold the partially processed material in the most desired storage condition. For example the holding of frozen fruits and vegetables for jam manufacture. Items like strawberries when manufactured into jam

quickly loose their desirable color, but can be held in the frozen state with a slower loss of color.

6. The opportunity to determine final product form from a particular raw material at a time when the marketing situation is better known.

7. The opportunity of moving items like cling peaches to be sold as canned halves in foreign countries where there may be a high import tariff on the sugar in the final product.

Summary

Improved technology, changing costs of processing, higher transportation costs, and changes in marketing situations have caused the fruit and vegetable processing industry to reconsider how, when, and where they carry out the various steps to change the fresh product into a processed product ready for the home or institutional user. In turn, the fruit and vegetable processing industry has become more competitive and processors are finding it more and more necessary to carefully consider cost of operation and make cost saving changes. The consideration of bulk storage processing allows fruit and vegetable processors and growers the opportunity to consider and perhaps use a system that will decrease or eliminate certain costs occurring from inefficiency as well as increase the overall profitability of the processing system.

TECHNICAL DEVELOPMENTS IN BULK STORAGE PROCESSING[1]

Philip E. Nelson
Purdue University, Lafayette, Indiana

Those familiar with the fruit and vegetable processing industries are aware of the serious problems of the seasonal processor. The short and hectic harvest season produces a number of conditions that reduces the effectiveness of these horticultural industries. Some of the more serious problems include the following:

1. Short supply of labor
2. Processing bottlenecks
3. Over production of certain products
4. Large capital investment
5. Sizable inventory expenses
6. Large warehousing costs
7. Large waste disposal load over a short period of time
8. Raw product scheduling

In order to compete in today's markets, the processor must be an innovator. New ideas and new technical developments must be continually implemented.

Looking back, one finds an industry that has made tremendous strides in the past 50 years. New cultivars and cultural practices, improved processing equipment and production lines, and streamlined warehousing and marketing practices have managed to keep the fruit and vegetable processing industry constantly growing with continued improvement in product quality. However, many of the above mentioned problems still confront the processor even with the past innovations. A radical, new input of technology is needed to meet the demands of today's markets.

BULK STORAGE PROCESSING

We have undertaken an investigation of bulk storage technology in cooperation with an industry sponsored grant from The Bishopric Products Company, Cincinnati, Ohio. The initial investigation involves tomato products.

Bulk storage as the name implies is holding a large unit of food under storage conditions that prevent spoilage and decomposition. The stored product is held for later remanufacture and/or is reduced into consumer size packages. The concept is simple but the technology required to assure product protection under bulk storage conditions is considerably more demanding.

Aseptic thermal processing

Refinements in the thermal preservation of foods have continued since Nicolas Appert's first preserving of food with heat in 1810. Aseptic processing and packaging have emerged as a technique which preserves foods by sterilizing the product and container individually. This is in contrast to in-container sterilization where the product and container are jointly subjected to the sterilization procedure.

Aseptic processing was originally conceived and developed to enhance and improve the quality of many heat sensitive products. In many instances and with bulk storage in particular, the size of the container is such that it is impossible to sterilize the product without greatly reducing quality.

The basic processes involved with aseptic processing include 1) sterilization of the product, 2) sterilization of the container 3) filling of the sterile container with the cooled, sterile product and 4) maintaining asepsis while in storage. One of the more successful processes has been the Dole Aseptic Canning System. In this process the container is the common sanitary can. Packaging aseptically in drums has also been proven successful. Such a process has been applied to products including tomato paste and puree, pizza sauce, apricot and banana puree, as well as other acid and non-acid products. However, very little information concerning the processing of products for storage in larger units is available.

The most comprehensive report of bulk storage is that of M.S. Dixon *et al.* (2). In a U.S. patent filed in 1958, they established broad conditions for holding sterile tomato product in large tanks. They did not elaborate on the method used to sterilize the product but devoted their patent to a procedure of sterilizing the tank and maintaining asepsis.

Tomato processing

Considerable amount of research has been devoted to processed tomatoes and tomato products. Factors affecting quality have been most commonly studied. Nutting *et al.* (13) found that when canned tomato products were held at elevated temperatures greater stability of flavor, color and ascorbic acid were observed in the less concentrated materials. Luh *et al.* (9, 10) recommended storing 26% total solid tomato material below 77°F. These researchers also found that quality of tomato juice is largely dependent on cultivar, maturity, methods of processing and storage conditions of the processed juice. They suggested that when ½ of the ascorbic acid was depleted, a notable poor flavor was observed. Their study showed the storage life of tomato juice to be 29 days at 131°F, 98 days at 113°, 188 days at 95° and 541 days at 68°.

The desirability to quickly inactivate pectic enzymes was noted by McColloch *et al.* (12), and others. Other process variables that affect tomato juice quality have been reported to be the size of the finisher screen openings and the quantity of total heat treatment (5, 6). In general, products processed by "high temperature - short time" methods yielded better color and greater vitamin retention(3, 4, 8). Leonard *et al.*, (7) compared the heat treatment given tomato juice concentrate by HTST aseptic canning procedures and by conventional heating methods. They found the conventional treatment had more than 4X the heat treatment than the aseptically filled product received because of the delayed cooling. In later studies, Luh *et al.*, (11) suggested that the shelf life of processed tomato paste was related to 1) aeration of the product during manufacture 2) failure to inactivate enzymes quickly enough, 3) slow cooling, and 4) storage temperature.

A study on the settling of tomato juice showed an inverse relationship between the degree of settling and the gross viscosity (14). It was suggested that settling is a matter of close packing of particles rather than a simple sedimentation.

Microbial spoilage of tomato products has also received considerable attention. Bowen *et al.* (1) found no spoilage in canned tomatoes at pH 4.3-4.4 when heated to a center temperature of 200-204°F. However, Sognefest and Jackson (15) have reported that 250° for a period of 0.7 min. was required for the sterilization of tomato juice.

ALTERNATIVES IN BULK STORAGE PROCESSING

In order to develop a simple system which could be readily introduced into present processing lines with minimal equipment investment and yet, provide for finished product flexibility, investigation relative to the feasibility of storing single strength tomato produce was initiated. The objectives were to develop a technically and economically sound process for bulk storing tomatoes over several months to a year. Involving the basic principles of aseptic processing, a total system was designed and constructed.

[1]Journal Paper No. 4349 Purdue University Agriculture Experiment Station.