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THE ESTIMATED COSTS
ASSOCIATED WITH CONVERTING
TO ASEPTIC PROCESSING AND PACKAGING FROM A TYPICAL
CONCENTRATED ORANGE JUICE SYSTEM

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Major professor

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THE ESTIMATED COSTS ASSOCIATED WITH CONVERTING TO ASEPTIC PROCESSING AND PACKAGING FROM A TYPICAL CONCENTRATED ORANGE JUICE SYSTEM

By

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ABSTRACT

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The analysis's objective is to determine an appropriate aseptic technology which can produce semi-liquid particulate food for retail sale and to demonstrate its quality integrity as well as cost elements versus presently utilized practices.

Frozen concentrated orange juice is identified as the food subject by desirable aseptic food determinants. The current FCOJ system is assessed.

Concentrated orange juice's optimum sterilization method is proven to be an aseptic design. The best presently available aseptic processing and packaging system is chosen from economic guidelines.

Total system-wide costs for the model indicate that converting to aseptic production increases costs $49,100 yearly. All cost saving reductions arise in 12 and 16-ounce portions.

Actual conversion to this model aseptic concentrated orange juice (ACOJ) system is not recommended without further analysis. Additional areas of study and ongoing research into aseptic technology are advised because current and future economic pressures toward aseptic production equipment developments may offer improved ACOJ processing cost reductions.

ACKNOWLEDGMENTS

I wish to thank the following individuals who made this study possible: Dr. Paul Bankit who as my major professor provided guidance and direction to my work; Dr. Aaron Brody of Container Corporation of America who directed me to important cost items as well as offering sound advice; Dr. Mark UeBersax who as the second committee member gave me initial industry leads and a food science perspective on the committee; Mr. Wayne Wagner of Peninsular Products Company for bringing a business world viewpoint to the committee; Mr. Fred Johnson who brought a lifetime of aseptic industry experience to my research; Mr. Bob Halladay of Associated Grocers for allowing me the opportunity to witness the warehousing environments, as well as providing brokerage and retail costs; and Mr. Steve Eisler of Cherry Central Cooperative for supplying integral warehousing expense data.

Most importantly, I thank my parents, Dr. and Mrs. William C. Lundquist, and my wife, Nancy, who provided the necessary love and understanding which assured the study's success.

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INTRODUCTION

The application of ultra high temperature short time (UHTST) processing and packaging to higher viscosity, particulate matter food is a largely uninvestigated area offering substantial savings potential. This study seeks to identify the economic results of converting from more conventional food processing and packaging methods to aseptic systems. The research develops and evaluates an aseptic and a non-aseptic process/package system for an identical product. The thesis hypothesizes that some aseptic production cost saving advantages exist over the traditional process. A reduction in distribution charges is the major impact of utilizing aseptic technology. Since the industrial revolution, industry has concentrated on lowering production costs and has largely ignored its distribution systems. Distribution channels have expanded concurrently causing today's retail food product costs to be 20 to 40% distribution-related. Therefore by implementing aseptic technology to those products with limited shelf lives and requiring controlled temperatures, food manufacturers can obtain production and distribution cost reductions resulting in increased profit at current or lower retail prices.

There are many inherent factors bearing on this analysis. These factors are built upon in a logical progression testing the study's hypothesis on a specific retail food item. Section 1 assesses the aseptically produced food product qualities demanded by market needs. The thesis assumes from cited literature that excessive nutrient damage does not occur and that the reconstituted or sterile food is stable throughout its lengthened shelf life after processing and packaging.

Shelf life is the expected amount of time a product will spend as a finished good after production and prior to consumption. Each processing and packaging system produces a product with specific attributes. The outlays required to manufacture these attributes are quantifiable by a special economic/engineering model allowing a profitability comparison between product/process/package alternatives with differing shelf lives. Large scale distribution environment cost reduction is available, because refrigeration or freezing is no longer required and weight savings result from the light paper, foil and plastic materials. However, some aseptically produced foods require refrigeration to limit temperature-activated enzymatic and non-enzymatic degradation. The frozen concentrated orange juice (FCOJ) consumer portion market is identified as the study's target for aseptic conversion. Aseptic concentrated orange juice (ACOJ) and FCOJ product, market and production parameters are addressed to provide verification of aseptic processing's and packaging's application to concentrated orange juice (COJ).

Section 2 considers the general aseptic processing characteristics for all food types. From this foundation, an optimum ultra-high-temperature sterilization system for COJ is designated. In true aseptic processes, the ultra high temperature (UHT) applied for a short time produces a food free from further microbial growth while retaining more nutrient value than the commonly used retort sterilization or hot fill methods. The sterile product is then filled into a sterile package in a sterile atmosphere at room temperature. Anything short of this description is not a true aseptic process. Aseptic processing is also termed ultra high temperature short time (UHTST) processing. Aseptic production, in this text, refers to this true aseptic processing and packaging definition. The thesis assumes that the food processor has the necessary resources to fund the capital investment in new equipment. Another processing factor is the food's viscosity, the amount of shear force a product exhibits as a flowing resistance. Presently aseptic processing of consumer goods is mainly being applied to liquid products of low viscosity, e.g., milk and juice. However, the temperature inherent in the aseptic process can be high enough to lower a food product from its normal viscous or semi-liquid state to the processable limits of liquid viscosity. The thesis assumes this Newtonian fluid property is a factor altering product flow characteristics under UHT conditions. These factors along with particulate matter effects are discussed in detail.

Section 3 develops a compatible aseptic packaging system for the consumer portion COJ market. The thesis assumes that the concentrate can be run at a safe, legal and efficient speed producing a true aseptic package of consistent high strength. Cited sources verify this process/package system assumption, since actual aseptic line testing is not available.

Section 4 calculates the estimated costs incurred by converting to aseptic processing and packaging from a representative Florida FCOJ production and distribution system. Cost comparisons are made on a yearly basis and on a concentrated 45° Brix volume. Both systems are constructed from a total system cost minimization outlook.

Section 5 examines the cost advantages and disadvantages of aseptically processing and packaging retail portion COJ. Shortcomings of this study, further recommendations for research and final conclusions are discussed. Research into regionalized U.S. ACOJ production facilities, higher output aseptic packaging units and more gradual conversion cost effects may identify the best form of aseptic processing and packaging implementation in the retail FCOJ market. An aggressive aseptic research effort by Florida FCOJ processors is recommended to undertake this challenge now, since future energy and competitive pressures will force some form of aseptically produced COJ implementation.

Thus the study develops the most viable aseptic processing and packaging system for COJ from currently available suppliers in order to investigate and identify specific cost advantages and disadvantages versus a typical Florida FCOJ processor. Therefore, the research will demonstrate the importance of aseptic technology to FCOJ processors desiring to remain competitive in the retail pack FCOJ industry.

Section 1:

Aseptic Production Market Needs, An Economic Model For Comparing Different Shelf Life Products, And The FCOJ Retail Market As A Viable Aseptic Target

For the study to proceed correctly, the economics of aseptic production systems must be considered. In other words, is aseptic production a sound alternative for every company? Obviously it is not the best capital investment for every manufacturer because each company operates under different internal constraints. What then determines whether a corporation should enter into the aseptic production? This answer and the development of a model to quantify the determinates for management decision making are addressed in the following discussion. Then the frozen concentrated orange juice (FCOJ) retail market is chosen as a suitable target for aseptic production and this investigation.

Market Needs

Food products interrelate throughout their shelf lives with three major factors: distribution characteristics, social environment determinants and production variables,

Figure 1. Upon closer examination, a product's success hinges on how well its attributes match or support a summation of these three factors termed market needs. Failure of any of the spokes leads to product inadequacy and its associated losses. Only when aseptically produced attributes

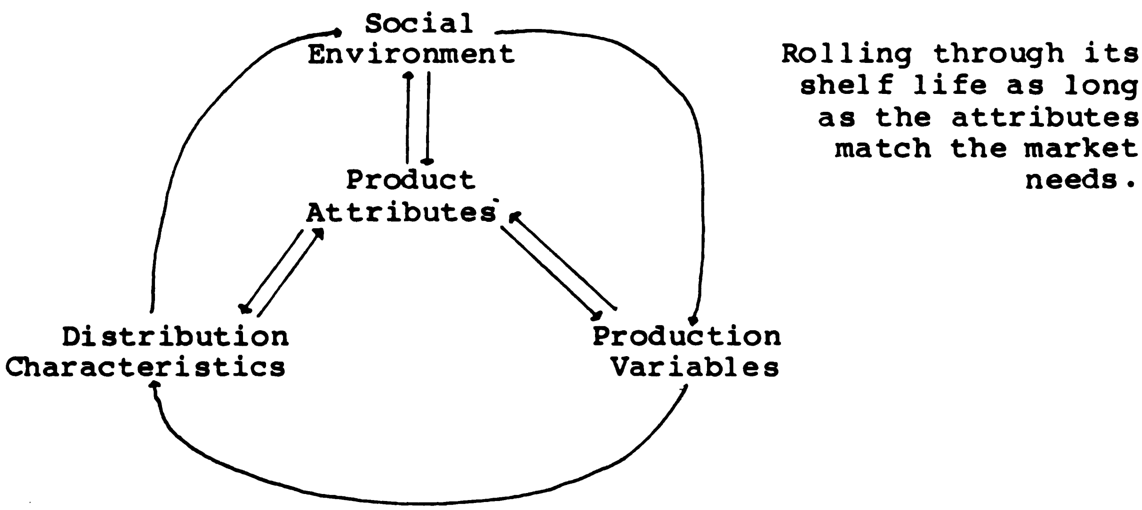

Figure 1. The Product Wheel of Fortune

can better satisfy total market need should a company consider a switch to aseptic production. These are the identical decisions that are made under any major process or package conversion.

The total market need is determined by marketing research of the three previous factors for a specific product. Ultimate project feasibility is based on a strong, stable consumer demand and on attaining increased profits to support large capita. investment. Distribution characteristics refer to the finished goods transportation and storage framework. Product attributes influence the distribution structure. Products gaining weight through the channel, such as ready-to-serve chilled juice, are best structured with a breakbulk or reconstitution point nearest to the consumer. Thus this reconstitution occurs at local dairies. Microbiological, enzymatic and non-enzymatic degradation limit shelf life thereby determining the channel environment. A product's profit margin and the amount of marginal costs contained in total system costs often dictate whether economies of scale exist.

The production variables are largely related to the food's manufacturing environment. To achieve efficient output, the most important production ingredient is developing a well coordinated production line. Line machines should be arranged in slightly decreasing output rates from start to finish to ensure the operation of each machine near its maximum output level. The use of accumulation devices between critical functional sites can also increase expensive equipment utilization.

The social environment is composed of all the possible ethical outcomes, hopefully increased consumer demand through improved need satisfaction, resulting from adding or switching to a new production technology. Every consumer interest group's and all foreseeable legislation's influence on consumer attitudes must be thoroughly investigated. The customer's lack of information and thereby his attitude can be favorably enhanced if involved companies take positive roles in educating the consumer about the technology's realities. In this way, food processors can make it difficult for consumer interest groups to over emphasize a new process's shortcomings while ignoring its advantages causing issuance of restrictionary regulations. By the same method, the concerned governmental agencies can be brought over to industry's side if all processors demonstrate that consumer protection and service is an utmost company goal. Since all business activity centers on serving the public, at a profit in the long run, first-rate consumer satisfaction should be a common goal for all companies entering a developing industry. Sharing indepth research explaining both advantages and disadvantages with consumer interest groups, governmental agencies, and each other can develop an environment of favorable consumer attitudes. Education-oriented advertising and promotion can directly aid this development. Constructive feedback from the government and consumers can hasten industry improvements as well. New product price, quality and competition are also main determinates of success or failure.

<u>Aseptic product attributes and market need compatibility</u>

Product quality, whether taste or some other sensory value, is often the key food attribute ingredient. OCEAN SPRAY has discovered through its own marketing research that product quality is the single most critical determinate in attaining repeat purchases of its aseptically produced foods. Every company requires brand loyalty to maintain stable profit margins. OCEAN SPRAY also found price discounts only achieved initial trials.[1] Aseptic processing produces a product of increased nutritional value when compared with retorting or hotfilling. The convenience aspect of unit portion aseptic foods can be stressed. Thus, to obtain repeat purchases, the utmost importance must be to produce the highest quality aseptically produced food possible. This goal coupled with a reduced retail price allows the best avenue for successful fulfillment of social environment demands.

Depending on the established market needs, aseptic products can be manufactured at low to high speed and volume to achieve profitability. This study demonstrates later in Section 4 that aseptic product distribution channel savings are the major expense reduction generated by aseptic production of COJ. The extended aseptic product shelf life can allow less frequent retailer resupply assuming the retailer has extra storage facilities and is willing to receive larger quantities per shipment. The larger volume shipments may be accepted because of quantity discounts and ambient temperature storage capability. For the same output as a limited shelf life food plant, the aseptically producing

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[1] James E. Tillotson, "Presentation of OCEAN SPRAY's Experience in Aseptics," Packaging Expo 1982, McCormick Place, Chicago, IL., November 17, 1982.

plant can supply a larger market area if the consumer incorporates the extended product life into his or her buying behavior. This is being attempted by selling aseptically packaged foods in multi-packs. At this point, the processor must assure himself that a constant and sufficiently large demand exists across the whole expanded market area for the aseptically produced product. If demand is verified, the expanded market area will necessitate the addition of intermediate warehouses to efficiently breakbulk into less than truckload quantities close to final retail markets.

Aseptic production requires sterility maintenance in most phases of plant operation. To assure sterility, aseptic production equipment is commonly automatic and continuous. The high acquisition cost of aseptic food processing and packaging equipment and building, approximately $2,000,000 for this study's model plant, requires optimum utilization of the capital investment. To optimally utilize the machinery, production must be maintained near each machine's upper limit of output. Only strict adherence to cleaning, repairing and operator training accomplishes high aseptic production.[2] Table 1 outlines the various industries where moderate to highly successful aseptic conversion has already occurred in only two and one half years since regulatory approval.

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[2] R. Bruce Holmgren, "Going Aseptic Demands Total Control of Sterility," Package Engineering 28 (February 1983):63.

Table 1. Successful Aseptic U.S. Retail Food Markets

Food Industry
1. Ready-To-Serve Fruit Drinks
2. Ready-To-Serve Citrus and Fruit Juices
3. Citrus and Fruit Concentrates
4. Fluid Milk
5. Flavored Milk
6. Pudding
7. Fresh Fruit Pieces
8. Tomato Paste

Aseptic production economics

The identification of operating ecomonies of scale is of critical importance to set the initial output rate and to indicate expansion opportunities. First the difference between fixed and variable costs must be defined. Variable costs per unit increase under higher outputs and their annual magnitudes thus vary with the output rate. Average fixed costs decrease at higher outputs and their yearly magnitudes are independent of the production rate. Marginal cost is the amount by which total cost increases per additional unit of output. Thus, marginal costs are by definition variable costs. Table 2 identifies the marginal production area costs which increase at higher outputs eventually resulting in diseconomies of scale. Aseptic economies of scale are achieved when marginal costs decrease and fixed costs are a high proportion of total cost.

Table 2. Aseptic Marginal Costs

1. Materials
2. Maintenance
3. Energy, electrical and gas
4. Steam
5. Cooling water
6. Hydrogen Peroxide
7. Floor area in plant and warehouse
8. Labor
9. Transportation
10. Machine parts and supplies
11. Warehousing

Diseconomy creation is easiest to conceptualize graphically. Most products portray a "U-Shaped" total cost curve, meaning the least cost per unit appears at moderate output. Figure 2 shows a typical "U-Shaped" total cost

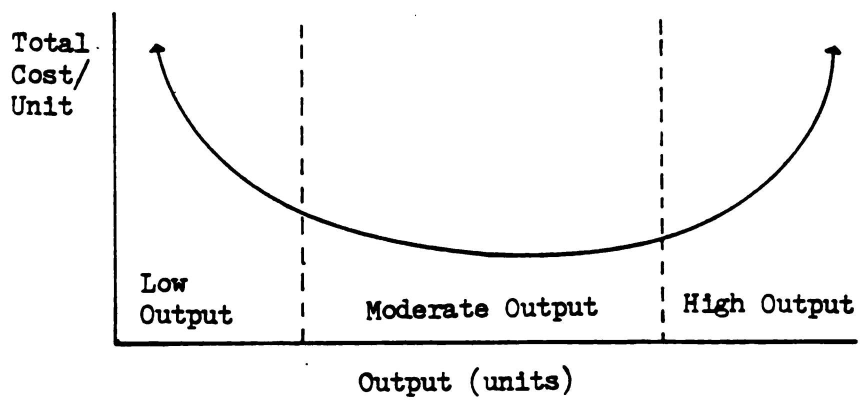

Figure 2. Aseptic Total Cost Per Unit Curve

curve for aseptic processing and distribution. At low output levels, average fixed costs decrease faster and compose a greater portion of the total cost per unit than marginal costs per unit. The marginal cost portion gradually begins to overtake the constantly decreasing average fixed costs, which are decreasing at a decreasing rate, until the slope is zero. At outputs beyond this position, marginal cost increases outweigh any average fixed cost decrease leading to diseconomies of scale for a particular product/process/ package combination.

Failure to properly separate marginal fixed and marginal variable expenses can skew economy of scale or cost calculations. Figure 3 demonstrates the implications of cost misassignment. This misrepresentation arises when too many marginal cost functions are assumed to be fixed. Thus the total cost per unit curve is skewed to the right from inaccurate data interpretation. The diseconomies of scale are then shifted out of the relevant production output picture.

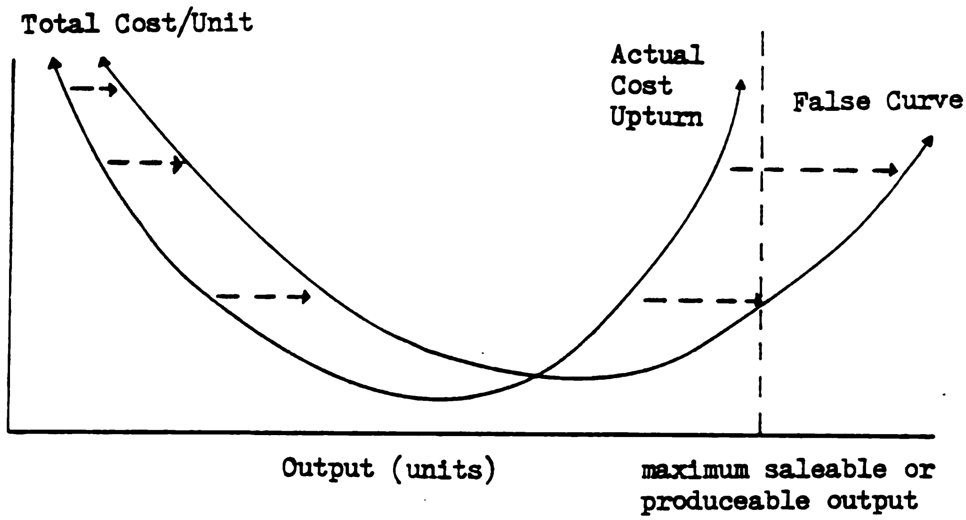

Figure 3. Skewed Total Cost Per Unit Curve

Since the existence and value of economies of scai e in aseptic operation are unknown at this point, an appropriate output must be determined for this analysis. This study compares system costs at a typical representative output rate. Indication of operating economies is best investigated after a cost reduction is proven, since a total cost analysis requires variable and fixed cost delineation.

An aseptically produced product's profit margin is important to achieving a successful new product introduction. Aseptic production of a moderate to high profit margin product provides a quicker payback period at a given output. Low profit margin products require extremely high volumes on the expensive aseptic equipment to achieve the same payback period. Thus, the lower the inherent risk of aseptic production for moderate to high profit margin food products, such as fruit drinks, has been an important factor behind the first highly-successful aseptic products being HI-C and HAWAIIAN PUNCH.

<u>Aseptically produced food characteristics and market requirements</u>

Aseptically processable and packagable foods can be classified into two types, particulate food and liquid food. A liquid food's physical structure provides it with the least temperature and shear loads during sterilization. Liquid product viscosity is not a problem unless gelling occurs after processing, common in high sugar content foods. Certain processing equipment modifications can reduce gelation.[3] Today many aseptic equipment manufacturers commonly

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[3] R.G. Sargeant, U.S. Patent #3366497, January 30, 1968, cited by J.K. Paul, <u>Fruit & Vegetable Juice Processing</u>, Noyes Data Corporation, 1975, p. 47.

offer a group of base systems each capable of sterilizing different products at varying outputs. When purchasing aseptic equipment, the user should keep in mind any future product additions, because some aseptic machines are quite limited in product adaptation.

All aseptically produced foods possess a group of common differences, because of their sterility, from their non-aseptic counterparts. Aseptic production allows ambient temperature storage and transportation. Some aseptically produced foods still require refrigeration to remain edible for six months. Sterile food can be distributed with canned goods. As previously discussed, the extended shelf life can allow market expansion by lowering the number of shipments and handlings.

Varied aseptic production savings result between food groups, because of the differences in traditional processes utilized for liquids and particulates. Liquids are usually flash-pasteurized at high output over 10,000 liters per hour.[4] Aseptic production can offer no quantum leaps in output over this rate. On-line sterilizers operate faster than the packaging equipment. A single sterilizer will feed two to four or more aseptic packaging machines. Several packaging machines provide accumulation if a single packaging unit goes down.

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4 Norm Kosaric et al., p. 170.

The second food type, particulate and/or viscous products, is usually retorted at 250^{o}F, less severe if the food is acidic, for seven minutes at the slowest heating point. Aseptic processing utilizing 50-80% of its steam for product heating, is considerably cheaper than retorting.[5] For particulates up to 4.0mm. cubes, aseptic processing can save money over retorting. Sterilization and filling systems have not been commercialized which handle particulates over 4.0mm. Energy requirements increase rapidly with particle diameter.[6]

Aseptic processing and packaging technology is not a trend, but an unalterable evolution in the marketplace descending from convenience and energy pressures. Competition forces the affected industry members to adapt. Aseptic production's high cost equipment desires year around use to accelerate the payback period. Thus the chosen product or product line should be in nonseasonal stable supply to the processor. However, if compatibly seasoned products are available to fill in production gaps, variably seasoned foods are acceptable for aseptic production.

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5 M.R. Okos & C.C. Chen, "Energy Considerations For Aseptic Processing Systems," Proceedings of the Aseptic Processing and the Bulk Distribution of Food Conference, Purdue University, (15-16 March 1978):94.

6 Personal communication with Mr. V.R. Carlson of ASTEC INCORPORATED, December 13, 1982.

An Economic Model

A simple comparative costing and profitability model is now developed to provide management with a means to quantify in dollars the affect of aseptic production on a food's profit margin. The model attempts to evaluate all added benefits and costs on a product attribute basis. This type of model is best solved by an engineer with a solid background in business as well as food processing and packaging. Food packaging engineers can best accomplish the solution. An accurate solution requires an understanding of aseptic production from a total systems outlook and an intimate knowledge of shelf life analysis. The model can be utilized for decision making between any basic process/package systems, but it is especially suited to decisions involving switching to processes producing extended shelf life products. For comparisons of identical shelf lives and outputs, this model is unnecessary and total costs can be directly compared for analysis.

All companies are interested in profit margin expansion. Implementing aseptic production can offer the innovative manufacturer a lead over its competition. Since some food products compatible with aseptic production have a strong year around market demand and a large profit margin, capital investment in these markets can increase long term business profitability.

Presently no models exist or have been employed in assessing aseptic systems versus the current processing methods which take into account all of the added shelf life days on the distribution environment. Commonly both production systems under analysis are compared and evaluated over the shorter non-aseptic production system's shelf life.[7] Such assumptions destroy the study relevancy because aseptic production's primary benefit to all channel members is an extended shelf life at an equal or increased product quality. The value obtained from the economic model can be visualized as a constant on a scale allowing easy comparison to determine the most cost effective choice. Formula 1 collects system costs aggregating these among shelf life days.

$$(1)\quad \frac{\text{Total System Cost}}{\text{Shelf Life in Days}} = \frac{\text{All Resource Inputs (\$/unit product)}}{\text{Total Shelf Life Days}}$$

In Equation 1, resource inputs include those into and during production as well as those inputs up until the consumer consumes the product. Shelf life days is the time span between production and consumption. The resource input cost per unit values must be compared at equal output rates, since differences in outputs would be incompatible. Inconsistent output variable costs per unit can be reconciled by obtaining aseptic cost estimates at the company's present non-aseptic output level, assuming an aseptic comparison to

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[7] Norm Kosaric, et al, "Ultra-High-Temperature Milk: Production, Quality, and Economics," <u>CRC Critical Reviews in Food Science & Nutrition</u> 14 (February 1981):178.

the current system. In any case, total costs per unit must be determined at equivalent outputs before implementing the model.

Formula 1's utility does not end here. The attainable increase in profit at the present retail price per unit for the least cost alternative is easily calculated from Formulas 2, 3, 4 and 5, respectively. The formulas are designed to display aseptic production savings with a positive sign and increased aseptic costs within parentheses as negative.

$$(2)\quad \frac{\text{Aseptic Savings (Cost)(\$/unit)}}{\text{Shelf Life Day}} = \frac{\text{Present Total System Cost}}{\text{Shelf Life Days}} - \frac{\text{Aseptic Total System Cost}}{\text{Shelf Life Days}}$$

$$(3)\quad \text{Total Aseptic Savings (Cost) (\$/unit)} = \frac{\text{Aseptic Savings (Cost)}}{\text{Shelf Life Day}} \times \text{Aseptic Shelf Life Days}$$

$$(4)\quad \text{Present Profit (\$/unit)} = \text{Present Average Profit Margin (\% of retail)} \times \text{Present Retail Price (\$/unit)}$$

$$(5)\quad \text{New Profit at the Same Retail Price} = \text{Present Profit (\$/unit)} + \text{Aseptic Savings (Cost) (\$/unit) (Eq.\#3)}$$

In some instances where time is limited and some cost data common to both alternatives is unattainable, Formula 2 can be modified to compare only differences between the two choices as in Formula 6. The calculations then proceed

$$(6)\quad \frac{\text{Aseptic Savings (Cost)(\$/unit)}}{\text{Shelf Life Day}} = \frac{\text{Present System Differential Cost}}{\text{Shelf Life Days}} - \frac{\text{Aseptic System Differential Cost}}{\text{Shelf Life Days}}$$

exactly as above from Equations 3 to 5. If an increased profit margin appears from Equation 5, then the total system profit for the new system is improved over the present system's profit by the indicated amount. Whenever possible, calculations should be performed on the total cost basis in Equation 2 versus the differing cost basis in Equation 6. A differing cost basis analysis compares only those costs that differ between compared systems and ignores the costs common and identical to both methods. Collecting all expenses for each alternative may require more time, but it is usually more accurate.

The validity of the obtained increased profit margin is only as accurate as the expense and time value factors composing the solution. The determination of relevant cost data from all business areas requires the investigator's ability to communicate effectively with all departments. In addition to accurate cost definition and allocation, the total system costs must be assembled from a total system outlook and not a specific cost center minimization viewpoint. The latter results in an unbalanced cost per output evaluation, while the former allows the most cost effective operation of all constituent processes together in harmony. Only the total system cost minimization outlook can provide an unbiased comparison.

Shelf life quantification

Accurate shelf life determination is just as vital as accurate cost collection for the economic model to provide correct indication of the cheaper product/process/package system. Presently three procedures exist for shelf life measurement, two of which are precise enough, but only one offering reduced time as well. Accelerated testing is widely employed by those development engineers seeking a quick solution. Accelerated testing attempts to determine a correlation to real ambient shelf life from accelerated storage conditions. Recent studies have proved the accelerated procedure inadequate when comparing differing product and package systems, which it is most commonly used for.[8] Many companies ignore this accelerated testing shortcoming and continue to use it anyway because of its simplicity. Normal storage stability testing is accurate, but time constraints usually rule it out for product/package system development. A relatively new technique shelf life simulation modeling has proved timely and acceptable in accuracy ($\pm$ 10 to 15%). Dr. Steven Gyeszly refined the process and describes the simulation model approach.[9] This study recommends utilizing the simulation model technique to determine any product/package system shelf life during product/package development. Once in production the actual shelf life can be attained by normal storage stability testing. The study's cost comparison in Section 4 assumes a

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[8] S.W. Gyeszly, W.H. Clifford, and V. Manathunya, "Accelerated Tests Versus Calculations Based on Product/Package Properties," Package Development & Systems (September/October 1977):29.

[9] S.W. Gyeszly, "Shelf Life Simulation," Package Engineering, 25 (June 1980):70.

probable shelf life developed later in this section and in Appendix 1 and Table 9, because simulation modeling is beyond the thesis's immediate scope.

FCOJ As A Viable Aseptic Target

This investigation considers the effect of aseptic processing and packaging on frozen concentrated orange juice (FCOJ). FCOJ is a high demand and a very competitively-priced product thereby fitting the previous economic market provisions. The present concentrate necessitates temperatures near $0^{o}F$. throughout its shelf life to prevent food degradation. Aseptic production of FCOJ is not likely to extend its shelf life, because $40^{o}F$ refrigeration is still required and no real incentive exists for the consumer to shift purchase behavior (see COJ distribution discussion and Appendix 1). The study assesses the cost implications of a complete conversion to aseptic concentrated orange juice (ACOJ) production for a representative hypothetical Florida manufacturer. The following discussion validates FCOJ as a practical candidate for aseptic production.

FCOJ economics

From 1959 to present, over 90% of U.S. processing oranges have been grown and processed in Florida, because Florida growers have continually expanded grove acreage and yield, Figures 4 and 5. Also Florida processors test and implement production with new technical developments. Since over 90% of the nation's processing oranges are processed

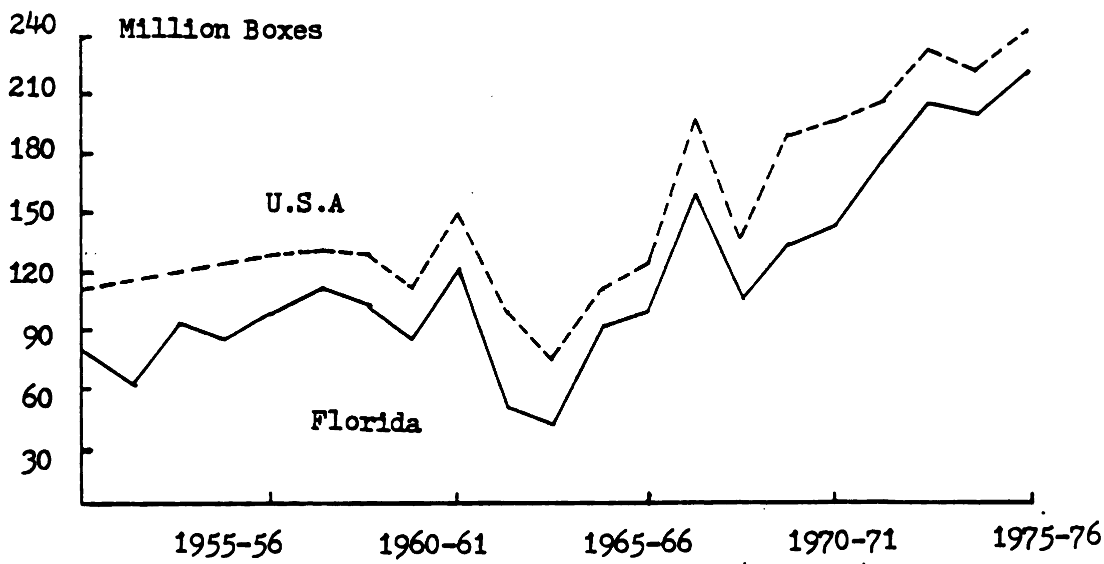

Figure 4: Orange Growth-U.S.A. Versus Florida

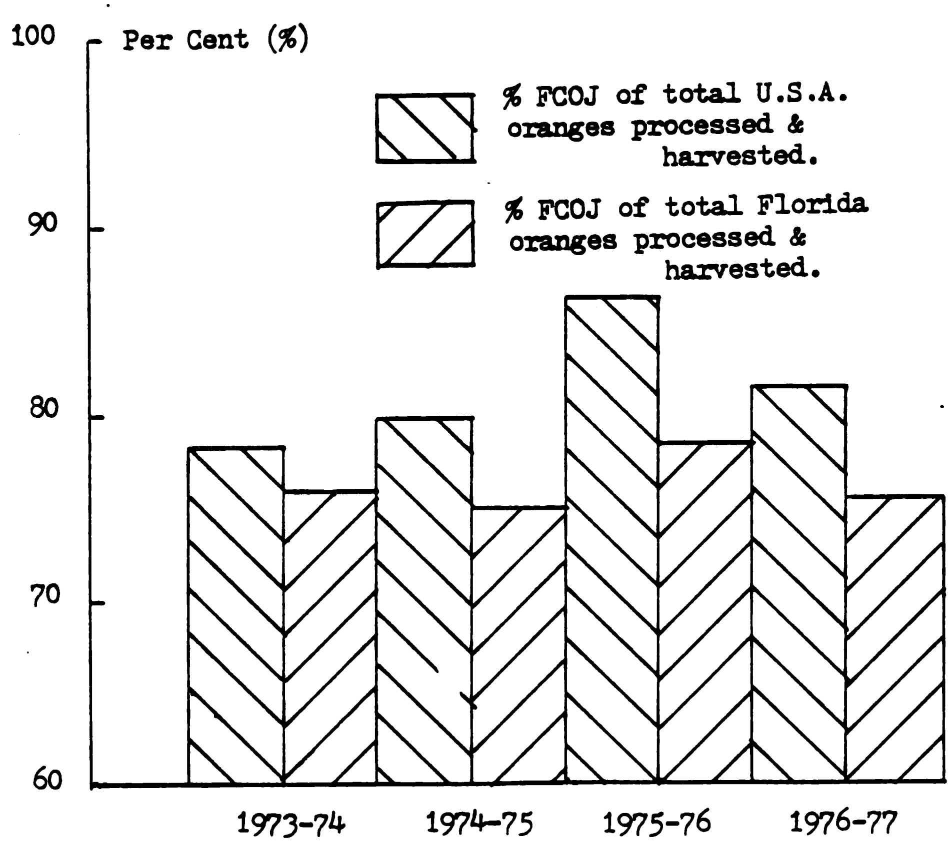

Figure 5: % FCOJ Portion of Oranges Processed & Harvested By Year

into juice and FCOJ in Florida, the aseptic production of COJ provides an opportunity to enter the retail COJ processing industry.[10] Regionally situated aseptic FCOJ plants receiving bulk Florida or imported FCOJ could accomplish the restructuring. Florida began commercial packing of canned pasteurized single strength orange juice (SSOJ) in 1929 and FCOJ in 1945. Due to quickly adapted production innovations and industry expansion, Figure 6 shows Florida's dominance

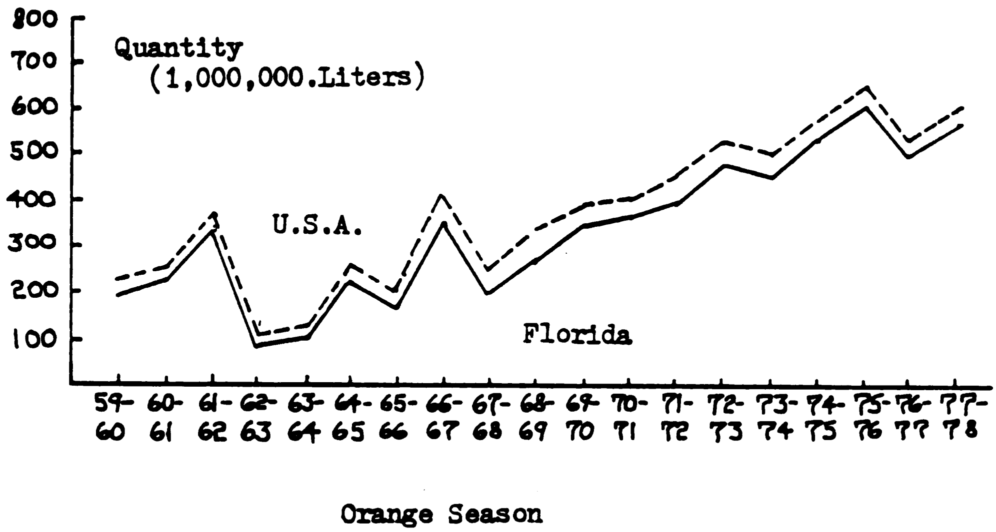

Figure 6. Packs of FCOJ - U.S.A. Versus Florida

in FCOJ.[11] Florida processors presently grow and manufacture oranges at high output and they should be interested in technologies which could allow them to increase profits. The Florida climate is specially suited for cultivating oranges which produce the highest juice quality, thereby ensuring most domestic juice oranges are grown in Florida.

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[10] Dr. Phil Nelson, Fruit & Vegetable Juice Processing Technology, AVI Publishing Company, 1980, p. 11 and 12

[11] Ibid., p. 17.

Florida orange juice and concentrate companies have further strengthened their control of the orange juice and concentrate market by importing nearly as much orange concentrate as is produced in Florida. [12] Importation originates from all other domestic orange producing states as well as Brazil, Israel and other foreign countries.

FCOJ & ACOJ quality factors

The social environment participants will be largely concerned whether the reconstituted aseptically produced SSOJ will have equal product attributes to both pasteurized and regular reconstituted four-fold (45°Brix) concentrate. Thus concentrated orange juice's ability to be processed and packaged aseptically at a saleable quality is now addressed from a food science aspect.

Textural effects

A key aseptic concentrated orange juice (ACOJ) quality factor is its textural or structural integrity. This is commonly termed mouth feel. Unclarified COJ products consist of non-Newtonian serum and particles. The serum is composed of low and high molecular weight substances. The serum's non-Newtonian flow behavior results from the high molecular weight pectins within the serum. Thus depectinized serum is a Newtonian fluid. The resulting texture of FCOJ or ACOJ is largely influenced by these flow properties during sterilization.

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[12] Private industry sources.

Mizrahi has investigated the effects of high shear rates and high temperatures on FCOJ at 50 to 70^{o}Brix. To properly assess these two factors, he determined the shear rate and temperature effects on reconstituted particle size and viscosity as well as textural or "mouth feel" considerations. The fine particles, pectin, in orange juice, 0.05 to 300um., make up the orange juice cloud. The cloud is responsible for the correct flavor, texture and color of orange juice. Thus aseptic production of orange juice concentrate must not cause noticeable COJ cloud. Cloud loss generally results in an almost clear, sour-sweet reconstituted orange juice of no sensory value. Mizrahi found four types of particles in orange juice clouds under electron photomicrography, Table 3. Mizrahi determined each particle's influence on the orange juice cloud stability.

Table 3. SSOJ Particles

1. Regular - intensely colored, smooth-surfaced particles, 1.0um. diameter, probably chromoplastids.
2. Irregular - light colored, rough-surfaced rag-like particles, 2.0 to 10.0um. in size, pulp fragments.
3. Oil Spheres - attached to irregular particle surfaces, 1.0um. diameter.
4. Needles - 0.5 to 10.0um. long and 0.05 to 0.5um. thick.

The regular particles provide color to the cloud. Oil spheres stabilize the particle cloud by lowering its density closer to the serum density. The serum is composed of pure liquid with no particles. The irregular and needle-like fragments give the juice its viscosity. Heat treatment stabilizes the juice cloud by increasing the serum viscosity. The serum viscosity increases results from sanding down the irregular and needle-like particles under high flow rates.[13] FCOJ has thin flexible particle dimensions up to 1mm., but almost all particles are smaller than 0.1mm.[14]

Differences in juice production techniques and oranges themselves result in altering particle characteristics.[15] To maintain a uniform juice product of stable cloud, production mechanisms must be adjusted to meet these variations.

Most liquid foods, including citrus concentrate, contain sizeable particulate matter producing a variable viscosity and are classified non-Newtonian fluids. Non-Newtonian fluids exhibit the characteristic pseudoplastic properties of decreasing product viscosity with increasing shear or flow rate. ^{o}Brix (total solids to liquids ratio) and total pectin content are the two highest FCOJ factors in determining concentrate viscosity or cloud.[16] Mizrahi and

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[13] Shimon Mizrahi & Zeki Berk, "Physico-chemical Characteristics of Orange Juice Cloud," Journal of Science in Food Agriculture 21 (May 1970):251.

[14] Bela Buslig & Robert Carter, "Particle Size Distribution in Orange Juice," Proceedings of the Florida State Horticultural Society 87 (1974):304.

[15] Personal communication with Mr. Dave Meharg of BLOCPAK INCORPORATED, February 15, 1983.

[16] Rouse et al., "Viscometric Measurements & Pectic Content of FCOJ for Citrus Futures," Proceedings of the Florida State Horticultural Society 87 (1974):293.

Berk discovered three shearthinning, viscosity lowering at high flow rates, mechanisms in 60 to 65°Brix FCOJ, Table 4.

Table 4. COJ Shearthinning Mechanisms

1. Thixotropic - reversible by rest.
2. Thermally Reversible - pectin gel recovers upon heating and resting.
3. Irreversible - viscosity loss due to irregular coarse particle sanding down.

Irreversible destruction occurs only at relatively high flow rates and stresses, while the other two happen over the whole shear rate and stress range. Orange juice changes from Newtonian to pseudoplastic at approximately 20°Brix. Pseudoplastic or non-Newtonian refers to viscosity lowering more dependent on shear forces and less on temperature. The attainable irreversible destruction reaches a maximum value, yield stress, for a given shear rate after which duration is irrelevant.[17] Aseptic production's thermal effect reduces polymer fractioning in high sugar concentrations, a pectinized serum, at high temperature lowering the pectin's, this study's particulate, temperature/viscosity sensitivity.[18] Summarizing shear rate does not effect the basic COJ medium, but only the structure formed by the suspended particles or pulp. Aseptic processing of COJ must not significantly

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[17] Shimon Mizrahi & Zeki Berk, "Flow Behavior of COJ," <u>Journal of Textural Studies</u> 1 (April 1970):347.

[18] Elfak et al., "The Viscosity of Dilute Solution of Guar Gum & Locust Bean Gum With and Without Added Sugar," <u>Journal of Science in Food Agriculture</u> 28 (1977):895.

degrade these pectin and pulp fragments which directly influence the reconstituted orange juice cloud properties.

Flavor factors

Juice flavor is measured by taste panels to discover a target flavor composition. This composition can then be quantified by measurement of juice maturity, the Brix-Acid Ratio. Brix is determined by a Brix hydrometer or refractometer. Brix is often temperature corrected. Degrees Brix is directly proportional to the sugar contect. Sugars contribute 70% of the soluble solid material in concentrated orange juice (COJ). Acidity is the total titratable acid expressed as a percent of citric acid. Generally as a fruit matures, the flavor rises from a low-bitter Brix/Acid(B/A) ratio to a higher-sweeter B/A ratio.

After evaporation concentration, previously extracted or commercially supplied orange essence is often added back into the concentrate to replenish evaporation concentration flavor loss. Since the processable oranges mature at different time intervals with different flavors, orange juices are blended together to provide uniform flavor prior to concentration. Essence improves high quality concentrate more than low quality concentrate.[19] In 1974 50% of the FCOJ manufactured contained aqueous essence.[20] An optimum essence addition level exists after which its benefits

[19] Dr. Phil Nelson, p. 63.

[20] Ibid., p. 64.

diminish.[21] Thus blending of concentrate with recovered essence and cutback juice, the highest quality juice, largely determines flavor quality along with the concentration process. The addition of aseptic processing and packaging on top of concentration must not cause a noticeable loss of the aqueous and oil essences.

Color determinates

Color of the reconstituted orange juice is another critical quality factor. The color of any citrus juice is dependent on the amount of carotenoids present. Carotenoid is chiefly contained within chromoplasts from the outer flavedo. Figure 7 depicts the structural terminology of

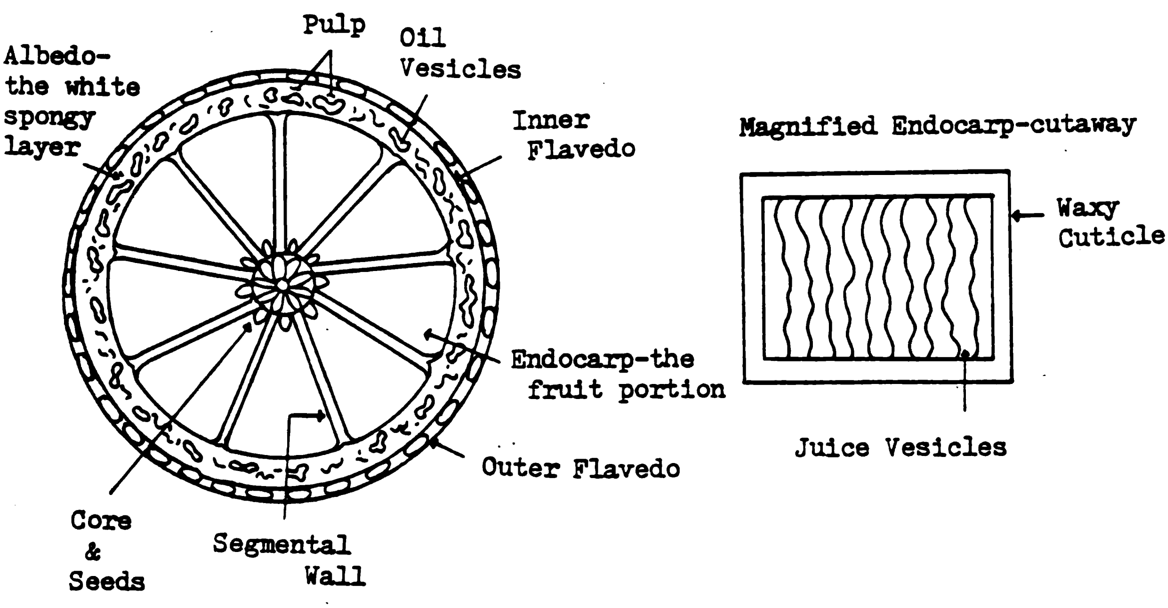

Figure 7. Orange Structure

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[21] Dougherty et al., "Effect of Essence Enhancement & Storage on Flavor of FCOJ," Journal of Food Science 39 (1974): 855.

oranges. Juice color is corrected via juice blending prior to concentration. Browning of the orange juice non-enzymatically and enzymatically is the main color determinant and often limits the overall shelf life of the juice or concentrate. Browning is accelerated by the higher orange juice concentrations in FCOJ. Browning is reactivated after sterilization by temperatures over 40°F. Addition of small amounts of stannous ions can improve orange juice color shelf life over 200% at 100°F. storage.[22] If only a short shelf life up to two months is desired, ambient temperature distribution is acceptable for color. For additional time, 40-50°F refrigeration is necessary to obtain the six month requirement (see Table 9).[23]

Nutritional content

Many consumers rely on orange juice as a daily vitamin C, ascorbic acid, source. A six-ounce glass of SSOJ has 80 mg. of ascorbic acid. Critical factors in ascorbic acid degradation are storage temperature, solids content, container barrier properties to light and oxygen, and the amount of oxygen and water in the juice at packaging.[24] Aseptic production must maintain most of the ascorbic acid content. Vitamin C loss from flash pasteurization of SSOJ

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[22] J.K. Paul, p. 200.

[23] Kanner et al., "Storage Stability of Orange Juice Concentrate Packaged Aseptically," Journal of Food Science 47 (1982):430.

[24] Dr. Phil Nelson, p. 71-2.

is less than 1.5%.[25] Thus aseptic processing is likely to not effect the vitamin C concentration greatly. The commonly used aseptic surge tanks are advisable only if the tank headspace is flushed with sterile nitrogen gas to prevent reintroducing oxygen to the concentration and accelerating vitamin C loss. However, ACOJ again requires 40-50^{o}F refrigeration to vitamin C loss for a six-month time frame.[26] Table 5 lists the U.S. Recommended Daily Allowances of nutrients and their percent of this in SSOJ.[27] Under the

Table 5. U.S.R.D.A. and Percent of R.D.A. in SSOJ

Nutrient	Nutrients (mg.)	% of R.D.A. per 177ml. serving
Ascorbic Acid	60.0	131.0
Folic Acid	0.4	20.3
Thiamin	1.5	9.8
Vitamin B_6	2.0	4.9
Magnesium	400.0	4.9
Copper	2.0	4.4
Pantothenic Acid	10.0	3.3
Phosphorus	1000.0	3.3
Riboflavin	1.7	2.4
Niacin	20.0	2.0
Calcium	1000.0	1.8
Vitamin A	3.0	1.4
Iron	18.0	1.1
Zinc	15.0	0.7
Potassium	-	-

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25 I. Saguy, I.J. Kopelman, & S. Mizrahi, "Simulation of Ascorbic Acid Stability During Heat Processing & Concentration of Grapefruit Juice," Journal of Food Process Engineering 2 (September 1978):222.

26 Kanner et al., p. 430.

27 Ting et al., "Nutritional Assay of Florida FCOJ For Nutritional Labeling," Citrus Science and Technology 1, AVI Publishing Company, 1977, cited by Dr. Phil Nelson, Fruit and Vegetable Juice Processing Technology, AVI Publishing Company, p. 74.

U.S. nutritional labeling regulations (F.D.A. 1973), significant nutrients, those supplying greater than 10% of R.D.A., may be required on food labels sometime in 1984. Thus suitable package printability for labeling is important. The low oxygen contents attainable in aseptic orange juice concentrate by deaeration after sterilization, by a 0% oxygen headspace content after packaging, and by a 40°F distribution temperature will be assumed to prevent vitamin C loss along with browning and flavor degradation.

Government regulations

The U.S. Department of Health and Human Service's Food and Drug Administration has set standards of identity for orange juice products. Table 6 lists the standards defining single strength orange juice (SSOJ).[28] Quality grades are based on three factors: color, flavor and defects. Color

Table 6. U.S. Grade Standards for FCOJ

Grade Type	Color Score	Defect Score	Flavor Score
A Fancy-consumer grade	36-40	18-20	36-40
B Choice	32-35	16-17	32-35
C Standard	NONE	NONE	NONE
D Substandard	0-31	0-15	0-31

[28] Hendrix et al., "Quality Control, Assurance & Evaluation in the Citrus Industry," Citrus Science & Technology 2, AVI Publishing Company, 1977, cited by Dr. Phil Nelson, Fruit and Vegetable Juice Processing Technology, AVI Publishing Company, p. 70.

is measured by U.S.D.A. Color standards or by the use of a Hunter Citrus Colorimeter. Flavor score is founded on three subfactors: ^{o}Brix, Brix/Acid ratio and taste evaluation. Orange juice with a Brix/Acid ratio of 17 to 54:1 is acceptable, below 14:1 gives a tart taste.[29] Defects relate to the deviations from pure juice due to additives. Common additives are pulp content, minimum juice content, oil content and certain juice blending agents. Most major fruit processing areas have their own orange regulations too. The industry regulations apply to incoming orange quality control factors and the government rules as juice quality assurance. Fruit should be intact and not overly ripe. Fruit should also be free of drops, splits, mold and insects. Industries can always prevent excessive government regulation by policing each other.

FCOJ target market

Table 7, established on data from Simmons Market Research Bureau defines FCOJ's target market and the recent market share of each FCOJ manufacturer.[30] Brand loyal customers always buy a specific brand regardless of other factors. Table 7 indicates a large degree of brand substitution in the retail FCOJ market. JOHANNA FARMS in New Jersey is presently aseptically producing 45^{o}Brix COJ into

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[29] J.K. Paul, p. 53.

[30] SIMMONS MARKET RESEARCH BUREAU INC., 1979, FCOJ Section, P-18, p. 389.

Table 7. FCOJ Target Market Demographics

1. 67% of all U.S.A. households use FCOJ.
2. Of total households there are heavy to light users.
   a. 17.1% use 4 to 10 glasseses per day
   b. 25.5% use 2 to 3 glasses per day (Glass = 6 Ounces)c. 15.8% use 0 to 1 glasses per day
3. Psychographics

Characteristic	Heavy User (%)	Medium User (%)
18 to 49 years old	69.1	55.3
Employed (full- part-time)	46.3	48.7
Married	76.1	70.9
Parents	60.4	39.2
Children (any age & amount)	89.3	51.1
White	85.0	92.0
Regionality	More in NE & S	Less Pacific & E Central

4. Market Breakdown: shows extensive brand substitution.

Brand Name	Total Market Share (%)	Brand Loyal MKT Share (%)
Minute Maid	69.1	15.3
Others - each less than 1%	11.5	5.2
Treesweet	10.4	4.5
Tropicana	9.0	4.0
Sunkist	9.6	3.9
Bel-Air (Safeway)	5.7	3.0
Snowcrop	6.5	2.8
Donald Duck	5.7	2.8
A & P	4.1	1.9
Top Frost	5.3	1.8
Kroger	3.7	1.8
Pathmark	1.4	1.0

one liter BRIK PAKs for institutional sale.[31] SUN GLO POP in Grand Rapids, Michigan is also aseptically producing 45°Brix COJ in one liter BRIK PAKs but for retail sale. Based on all the previous evidence, this study assumes that COJ can be aseptically processed and packaged meeting all social environment constraints and market needs through the appropriate ACOJ system developments in Section 2 and 3. The current FCOJ production techniques are documented next as a basis for understanding the hypothetical Florida FCOJ processor's cost estimation and comparison in Section 4.

FCOJ production factors

Production environment characteristics relevant to the non-aseptic and to the aseptic COJ are illustrated in Figure 8. The COJ production process illustrates general system adaptability to aseptic production. Large trailer trucks containing 500 corrugated orange cartons dump their loads down a chute. The cases are opened and a single layer of fruit flows along an inclined roller conveyor providing hand inspection at 30 fruit per second per grader.[32] Mechanically-assisted inspection methods have been developed to reduce the manual labor required and to accelerate fruit grading. Once graded and separated by quality, the fruit is conveyed to well ventilated storage bins. Storage time varies between 12 and 72 hours befo e processing. The

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[31] JOHANNA FARMS & SUN GLO ACOJ sample products.

[32] Dr. Phil Nelson, p. 45.

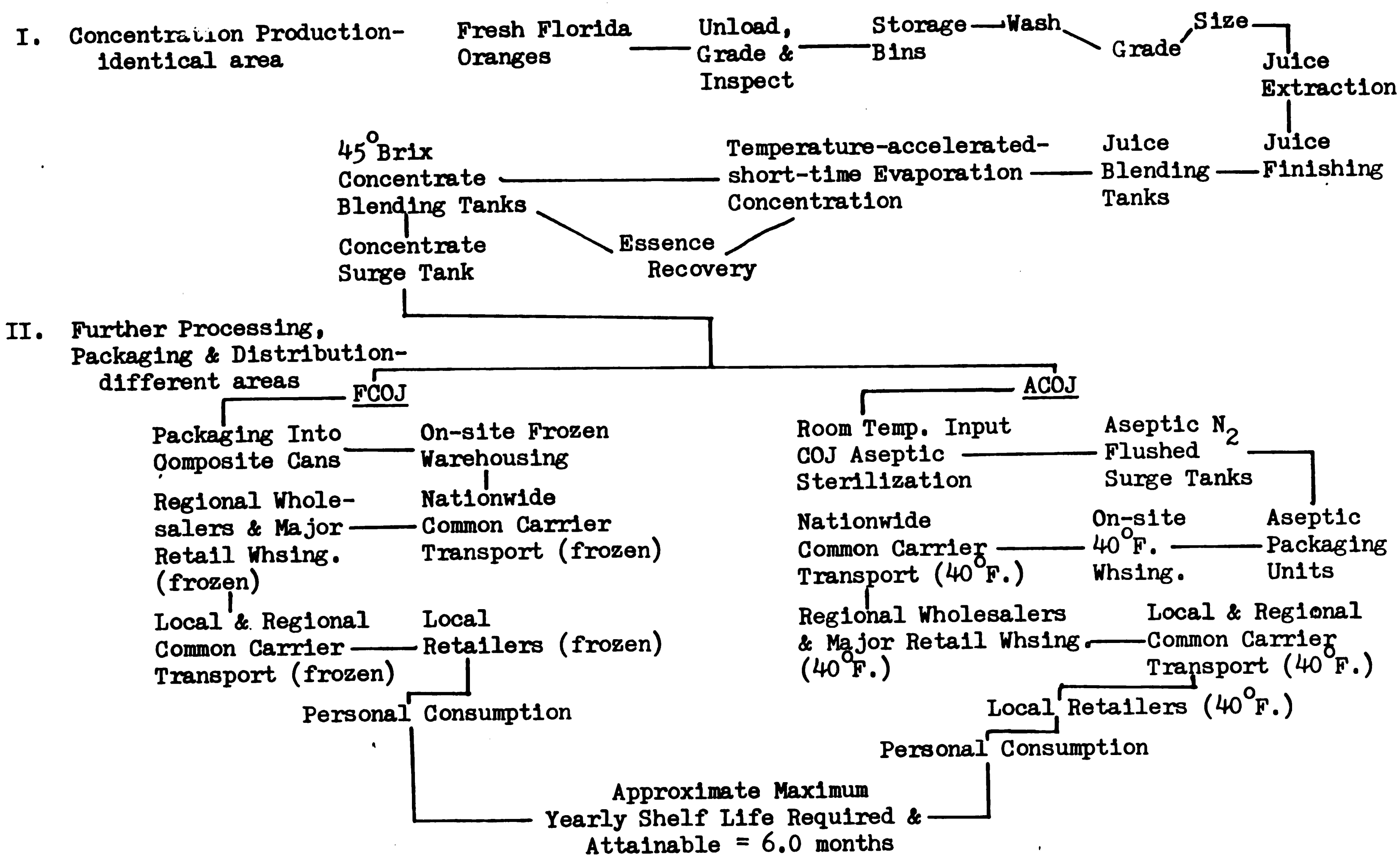

Figure 8: FCOJ & ACOJ Production & Distribution Flows

oranges are a maximum of a few days old when received by the processor. The oranges are then 2 to 6 days old when processed into juice or concentrate.

Actual processing starts when fruit is conveyed from the bins to washing, grading and sizing areas. Fruit is soaked in detergent for a short time, scrubbed with revolving brushes and rinsed with water. Secondary inspection occurs to eliminate any residual damaged or misgraded fruit. Then fruit is automatically sized and then rolled to the appropriate juice extractor.

Two types of extractors are commonly utilized, FOOD MACHINERY CORPORATION (FMC) Citrus Juice extractors and BROWN Extractors. Figure 9 depicts the reaming action of the FMC juice extractor cups.[33] Juice yield and properties

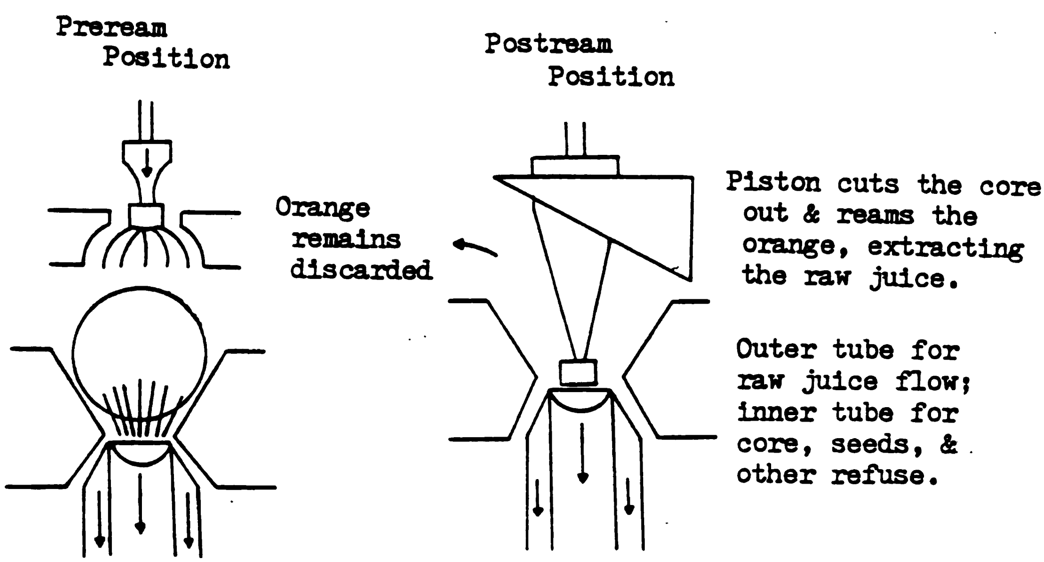

Figure 9. FMC Extractor Cup Reaming

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[33] Ibid., p. 54.

are controlled by prefinishing strainer-tube holes and the height to which the orifice tube rises within the strainer tube. Peel oil and aqueous matter is rinsed away by sprayed water to a finisher producing an oil emulsion. The volatile essence containing oil is centrifuged from the emulsion for later addition to the concentrate to replenish lost flavor. Brown extractors tend to produce a high quality juice of lower peel oil content than FMC counterparts. Upon extraction, juices are finished to remove seeds, peel, pulp and rag particles. Finishing is accomplished by filters or screens arranged in series through which the rough juice is refined. The actual juice quality achieved varies directly with the operator's skill. For all extractor/finishers squeeze or ream pressure is the critical operating parameter. Raising pressure releases increases juice quantity and maintains quality up to a point. Excessive pressure results in inadequate juice attributes. Fruit growers desire excessive pressures, since this increases juice yields thus increasing their payments from the processor. Processors like the quantity extraction, but they must keep the required consumer quality in mind. Regulations, based on equipment guidelines, are generally followed to satisfy everyone concerned.

Once finished, the juice is pumped to stainless steel blending tanks. Typically juice is processed from a range of orange species each possessing differing flavor and textural qualities as well as maturity variations during the seven-month harvest period. The blending tanks allow some degree of juice uniformity to be achieved.

Concentration is generally accomplished by either low temperature falling film or temperature accelerated short time evaporators (TASTE). The low temperature evaporators require plate or tubular heat exchangers prior to evaporation to inactivate destructive enzymes, yeasts and molds. The TASTE systems incorporate heating as part of its multi-effect concentration process. Evaporators remove water to a desired concentration or Brix level. As of 1977, all but two Florida citrus plants operated TASTE units. TASTE systems can pasteurize and concentrate the juice at $100^{O}C$. Juice passes through TASTE units once within minutes versus the low temperature cyclical concentration method's one to two hours. TASTE equipment range in capacity from 9,000 to 36,000 Kg. of water vaporization per hour. The system is very energy efficient necessitating only one kilogram of steam to vaporize three kilograms of water. This study assumes the use of the TASTE method. Table 8 describes the advantages and disadvantages of TASTE systems.[34]

Table 8. TASTE Attributes

A. TASTE Advantages -
   1. Short juice residence time
   2. Evaporated juice of low microbe content
   3. Low initial cost
   4. Easily cleaned

B. TASTE Disadvantages -
   1. Single cycle results in concentration variation
   2. Concentrate blending must occur later
   3. High temperature requires frequent cleaning.

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[34] Ibid., p. 61.

During any evaporation concentration process, volatile essence flavor components are lost with water vapor. Vaporization of the juice in the second stage of TASTE liberates a water vapor containing oil and aqueous essences. These oil and aqueous flavor components are condensed for later addition to the concentrate in the concentrate blending tanks. The blending tanks are kept at 35°F. Flavor can also be revived by adding cutback juice or addback concentrate to the concentrate in the blending tanks. Essence recovery is most often used, because it is the cheapest flavor restorer and is particularly suited to producng high Brix frozen concentrate. Essence recovery is low cost, since it is a natural byproduct of the TASTE concentration process. Addback concentrate and cutback juice can compensate for the variable Brix TASTE output. High Brix frozen concentrate, greater than 57 °Brix, is shipped in 15,000 gallon insulated common carriers to chilled juice processors all over the country. This would be the incoming raw product for a regionalized aseptic concentrate orange juice manufacturer, and it is the incoming raw product for regional chilled single strength orange juice (SSOJ) packagers.

Having corrected flavor and concentration variations, the FCOJ is ready for retail packaging. The concentrate is further chilled to between 24 to 20°F. prior to packaging which is very costly. FCOJ freezes solid at 18°F. Packages are produced in 6, 12, 16, and 32-ounce sizes. Since the most recent available COJ processing cost data was collected from the 1979-80 growing and processing season which included only a small amount of 32-ounce packaging, only the 6, 12 and 16-ounce portions are investigated in this analysis. This research assumes the processor buys and does not make the retail composite cans. Presently only a few of the largest FCOJ processors fabricate their own packages and cost information was not readily available for FCOJ processor composite can fabrication. Aluminum material costs have led to adopting polyethylene (PE) inner-coated paperboard bodies with aluminum ends. Plastic tear strips around the aluminum to paperboard seam supposedly allow easy opening.

Filling of the viscous, small particulate is achieved by piston fillers. Prior to sealing the second lid to the package body, steam is injected to lower headspace oxygen content, to sterilize the lid, and to form a partial vacuum. The filled cans are then quickly frozen to 0°F. for warehouse storage.

Distribution environment

Aseptic and non-aseptic COJ distribution systems differ slightly. Both originate at a Florida concentrate producer. FCOJ in the unit packages at 45 °Brix is shipped in insulated, freezer common carriers direct to regional wholesalers and major retailer warehouses nationwide. ACOJ is identical to FCOJ distribution except only 40°F. refrigerated transport and storage is utilized. Oranges are harvested and processed only seven months of the year, so the excess FCOJ is stored in on-site freezer warehouses prior to nationwide shipment. The maximum shelf life the FCOJ and ACOJ experiences prior to shipping is approximately five months. Appendix 1 illustrates the shelf life quantification for the two systems. Table 9 summarizes the yearly average shelf

Table 9. COJ MKT Demanded Shelf Life Summary

Percent of the Year the Shelf Life is Acceptable	Shelf Life in days demanded at the environmental condition by the distribution market: Frozen	Refrigerated	Ambient
58.3 (7/12 months)	32	32	42
66.7 (8/12 months)	62	62	72
75.0 (9/12 months)	93	93	103
83.3 (10/12 months)	123	123	133
91.7 (11/12 months)	154	154	164
100.0 (12/12 months)	184	184	194
Maximum Demanded =	6.0 months	6.0 months	6.4 months
Minimum Demanded =	1.0 months	1.0 months	1.4 months
Mean Demanded =	2.2 months	2.2 months	2.5 months

lives as well as their ranges over a season for each possible environmental condition. These are the shelf lives demanded by distribution channel members. Since browning reactions cause unsatisfactory color and flavor after two months time at ambient conditions, Table 9 eliminates uncontrolled environment distribution for the study's ACOJ system. Thus ACOJ requires refrigeration to remain saleable for the maximum off season shelf life, approximately 6.0 months. Identical shelf life values for the FCOJ and refrigerated ACOJ arise, because little incentive exists for the consumer to alter FCOJ buyer behavior. COJ is likely bought once a week on every grocery trip. Warehouse, grocery and consumer COJ inventory turnover rates sum up during the orange season to create the minimum 32-day shelf life (Appendix 1). Because of the identical full season six-month shelf lives, the cost collection and comparison in Section 4 need not follow the earlier developed model and can be compared directly.

COJ output parameters

To facilitate the designation of an optimum ACOJ processing and packaging operation as well as cost estimation, an equal and representative output level of FCOJ is developed. Data from Kilmer and Hooks provides the basis for aseptic and non-aseptic COJ production line development.[35]

Since oranges are harvested and processed seven months of the year, this is the available yearly production time frame. Assuming the common COJ processor six production days per week with four weeks per month, 170 days of COJ processing and packaging time per year is identified. The COJ distribution time frame remains year around. The 1982-83 orange crop is estimated to be identical to the 1979-80 season's volume, so it is a good approximation of the 1982-83 orange crop.[36] The 1979-80 season's average Florida FCOJ processor created 4,527,915 gallons of 45 ^{o}Brix

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[35] Richard Kilmer & R. Clegg Hooks, "Estimated Costs of Processing, Warehousing and Selling Florida Citrus Products, 1979-80 Season," Economic Information Report #144, University of Florida at Gainesville, May 1981, pp. 4-6.

[36] Private industry estimates.

retail FCOJ. 1,816,029 gallons of bulk were also produced for later reconstitution into single strength juice. Thus 26,635 gallons per day and 10,682 gallons per day of retail and bulk COJ are processed respectively. Summing the two daily rates and assuming a two shift 14 of 16 hours per production day, the TASTE juice concentration unit processes 2,666 gallons per hour.

Retail FCOJ needs are filled in ten hours of production with the remaining four hours left for bulk production. Table 10 describes the probable aseptic operation at this early development stage. The FCOJ line is included for comparison.

Table 10. Aseptic and FCOJ Operational Layouts

ACOJ	FCOJ
1. TASTE Concentration Unit	1. TASTE Concentration Unit
2. Concentrate Blending Tanks	2. Concentrate Blending Tanks
3. Concentrate Surge Tank	3. Concentrate Surge Tank
4. Aseptic COJ Sterilizer	4. Composite Can In-feed Unscrambler and Cleaner
5. Aseptic Packaging	5. Piston Filler
6. Package Checkweigher	6. Composite Can Seamer
7. Tray Erector/Packer/Sealer	7. Package Checkweigher
8. Tray Shrinkwrapping & Tunnel	8. Case Erector/Filler/ Sealer
9. Palletization	9. Palletization
10. Finished Goods Storage (40°F.)	10. Finished Goods Storage (0°F.)

This study's FCOJ line is specifically identified for cost estimation purposes. Composite cans are assumed to be bought from a supplier, the most common situation although it is diminishing.[37] Thus FCOJ packaging is a deposit-fill-seal operation. A NEW ENGLAND MACHINERY COMPANY composite can unscrambler and cleaner is specified along with a PACK WEST MACHINERY COMPANY piston filler to deposit the FCOJ. ANGELUS SANITARY SEAMER's Model 61-H seams the aluminum lids with the pull tabs onto the filled composite cans. INTERNATIONAL PAPER COMPANY's Model CA-109 case erector/filler/sealer is also designated for the study's FCOJ line. Two of each of the seamer and case erector/ filler/sealer are necessary to handle the TASTE concentration output.

An additional ACOJ production line stipulation is made now. Since a second set of aseptic surge tanks to buffer the aseptic COJ sterilizer from the TASTE concentration unit would be costly and concentrate blending tanks are already there as a buffer, the ACOJ sterilizer is mated to the TASTE output and not to the ACOJ packagers. This lowers the operations overall labor requirements. This excess ACOJ is accumulated in nitrogen-flushed aseptic surge tanks. Two 6,000 gallon aseptic surge tanks provide the necessary accumulation capacity plus a 7.2 percent safety margin. The slower operating ACOJ packagers gradually make up the difference once the upper line operations shut down for the day. Section 2 can now address all sterilization systems from an equipment standpoint to identify the most currently acceptable sterilizer for concentrate orange juice (COJ).

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[37] Dr. Hooks & Dr. Kilmer, pp. 4-6.

Section 2:

Determination of an Optimum ACOJ Sterilization System

Before the paper investigates sterilization methods, we need to discuss the most important factor inherent to all these systems. What is sterility? Webster's New Collegiate Dictionary defines sterilization as, "to free from all living microorganisms."[38] This statement is an ideal goal, but verification of total sterility on a commercial basis is impossible. There will always be a very small percentage of heat resistant spores which will survive most heat processes (the Logarithmic Order of Death Concept). Marriner showed another sterility concept, "to be free from microorganisms which cause defects," to be unsatisfactory. The sterility concept utilized for this project is that of Marriner, "The product must be free of microorganisms which can cause deterioration and/or multiply."[39] Thus small numbers of nonreproducing, nondestructive microorganisms are allowed. Our concept can be further defined as commercial sterility. This analysis validates aseptic technology as the best sterilization operation for COJ, as well as identifies the optimum ACOJ system.

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38 Webster's New Collegiate Dictionary, fifth edition (1977), s.v. "sterilization."

COJ Sterilization Parameters

Now that the foundation of the sterilization process has been laid, the best COJ process methodology is constructed around the necessary parameters. Table 11 identifies these process goals. The most critical of the requirements

Table 11: COJ Sterilization System Goals

1. Rapid sterilization, low temperature load and minimum particulate shear down.
2. High flow rates equivalent to TASTE output.
3. Compatible to current aseptic packaging units.
4. Simple design.
5. Automated controls, but some product flexibility.
6. Ability to handle concentrates and other citrus fluids.
7. Low worker hazard.
8. Reliable manufacturing and proven aseptic integrity.
9. Acceptable investment and operating costs.
10. Long continuous sterile production without cleaning.

is rapid sterilization and cooling producing little permanent product degradation. Processing towards this goal results in a higher quality product than presently available within most food product groups. To achieve high speed sterilization, rapid rates of heat transfer into and out of the product must occur. Heat transfer of semi-liquid particulates is basically a physical reaction, although some chemical reactions do occur at higher temperatures. The semi-liquid small particulate food product must be heated quickly to sterilization temperatures, held long enough for full particulate heat penetration and cooled rapidly preventing product deterioration. This exposes the food to a

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[39] F.W. Marriner, "Aseptic Processing & Packaging Quality Control," The Australian Journal of Dairy Technology 32 (September 1977):102-103.

low temperature load. Also the COJ sterilizer must not shear down or degrade the pulp fragments which form the cloud structure.

For the system to be commercially acceptable, the sterilization process should operate continuously at a high rate approaching TASTE concentration volumes. Rapid processing in the food sterilizer allows the sterilizer to be mated to the high volume TASTE concentration system. The economics of the sterilization process requires continuous output, since repeated line stoppages are cost prohibitive.

Further economical considerations include an uncomplicated design. Lower maintenance costs and less operator training result from design simplicity. The sterilizer should be highly automated, so it requires fewer operators or the same numbers present commercial processes (retorts and pasteurizers) in a product class. With automation a trade off exists between higher production speeds with low labor costs and line flexibility to adapt to changing market demands. The most efficient sterilizers handle a single type of food class, so flexibility to sterilize a variety of food classes is not recommended. Thus automation is not a flexibility problem. Cleaning-In-Place (C.I.P.), automated resterilization after sterility loss, greatly simplifies procedures.

Last but not least, every sterilizer must be safe for plant workers and assure sterile food processing. The system must offer suitable safeguards against allowing contaminated product passage to the filling station. Appropriate product sampling ports allowing quality control measures can be incorporated into the system's design. For line operators the sterilizer should run without undue worker hazards requiring elaborate safety precautions like clean rooms or gas masks. In other words the sterilization medium must be easily containable within the sterilizer and possess little operator risk if production leaks occur. Incorporating automatic flow diversion valves, limiting the amount of seals and utilizing sterile steam seals improves sterility confidence. A sterilization process qualifying under the previous constraints would be immediately acceptable for present commercial sterile COJ production.

Available Food Sterilization Processes

Having determined the optimum sterilization characteristics, all food sterilization processes are now considered. All methods can be categorized by sterilization mechanism or agent. The oldest method heat sterilization has two main sub-groups. The commonly used retort method differs from the more recent aseptic method in that the retort system sterilizes the food after filling and sealing into its package. This is known as in-batch sterilization since in at least one he ting procedure, sterilization, the food is heated in a hermetically sealed package. Aseptic production sterilizes the food before filling and sealing into its package in a continuous process heating the food in many thin layers.[40] This is termed in-flow sterilization. There are advantages and disadvantages with each system.

Retorting developed out of Pasteur's and other's work into actual production just prior to 1900. Retorting entails packaging the preheated product and sealing it in. Then the whole product/package system passes into an autoclave. The autoclave subjects the product to a high enough temperature via steam or hot air pressure for sufficient time duration to effect proper microbial kill for a given product. Finally the product/package system is cooled to room temperature usually by a potable water bath. To avoid severe product destruction, mainly on outer layers and to prevent insufficient time-temperature for microbial death, complicated heat transfer properties and their equations for each product/package system must be developed, implemented and closely controlled.

The main disadvantage of retorting is the processing time wasted waiting for the required heat transfer into and out of the product and package. Modern innovations attempt to reduce the dwell time.[41] Still the time required for a single unit to be processed is excessive in comparison to newly developed aseptic systems. Nickerson & Ronsivalli tate, "Commonly packages are heated for seven minutes at

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[40] B. von Bockelmann, Supplement to the Proceedings of the International Conference on U-H-T Processing and Aseptic Packaging, North Carolina State Raleigh, November 27-29, 1979, p. 236.

[41] John Nickerson & Louis Ronsivalli, Elementary Food Science (second edition), AVI Publishing Company, Westport, Connecticut, 1980, p. 152.

250°F. at the slowest heating point.[42] Dwell time can easily expand to 20 or 30 minutes for conductive particulate products when the heating up and cooling down time is added into processing time. Also high pressure, temperature and relative humidity systems require metal and glass, usually the most costly materials to acquire and ship. Retortable pouches, multilayer high temperature stable coextruded plastics and aluminum foil laminates can greatly reduce retort dwell time, but the pouches are difficult to handle without puncture and to seal hermetically on production lines at high speeds.

High temperature short time (HTST) sterilization occurs quickly like aseptic processing, but it is still a retort method sterilizing after the food is hermetically sealed in a metal or glass container. Commercial sterilization is reached at 280°-300°F. in 15 to 45 seconds usually with steam. HTST is the best retort method for homogeneous liquid. Conductive particulate products cannot be sterilized by HTST because there is insufficient time for heat penetration through the metal or glass and into the particles. Possibly retort pouches filled with semi-liquid small particulate products could be sterilized by HTST, but research was unavailable in this area.

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42 T.R. Ashton, "The Ultra-High-Temperature Treatment of Milk and Milk Porducts," <u>World Animal Review</u> 23 (1977):38.

Single strength juices because of their 3.0-3.3 pH are commonly packaged by hot-filling. Hot fill processes sterilize the juice continuously at 210°F. for 30 seconds and fill the food into a metal can, glass bottle or plastic laminate pouch while still hot. The heat of the juice or fruit drink is relied upon to sterilize the inside of the package during filling. Cooling of the juice creates a partial vacuum in the headspace as in retorting. The slow cooling after filling can overcook the product, causing stackburn, and must be monitored closely. Cool potable water baths are often used directly after filling and sealing to accelerate the cooling process. Thus hot-filling produces a shelf stable package.

Aseptic processes

Ultra high temperature short time (UHTST) aseptic systems, being continuous flow sterilizers, differ from in-batch methods. Aseptic systems have three necessary components: 1. the food product is sterilized by itself, 2. the package and possibly lidding material are sterilized by themselves, and 3. the presterilized product and package are joined by filling and sealing within a sterile atmosphere at room temperature. Aseptic food processing and packaging originated in the U.S. in 1930, Europe in early 1950, but only since February 1981 have plastic and paperboard-based aseptic packaging systems been domestically legal due to F.D.A. regulation. Quantum leaps in sterilization speeds versus in-batch processes occur with aseptic technology, since many small volumes of food product are heated to 284-302^{o}F. in two or three seconds directly or in 15 to 20 seconds indirectly.[43] Aseptic food processing allows fast sterilization with little product deterioration.

Other nonheating food sterilization systems are generally very expensive and difficult to operate at high volume. Infra-red radiation is probably the best of these. Radiation sterilization is costly to operate and will result in chemical and physical product and package material alteration.[44] Indepth testing is recommended to determine radiation effects for each food product. Suitable worker protection from radiation is required by regulation. Thus, infra-red radiation is not readily applicable to COJ sterilization. Microwave heating is the backbone of a non-aseptic Alfa-Laval Inc. process under development.

Only aseptic food processing results in a sterile product of highest quality. Commercial aseptic sterilization systems are available at efficient speeds with little operator or consumer hazards. However, large particulate food sterilization could be most quickly accomplished by mating a hot sterilization, aseptic processing, and a cold sterilization, microwave radiation. The food product would be sterilized by components with the larger particulate

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[43] Ibid., p.38.

[44] Joint F.A.O./I.A.E.A. Division of Atomic Energy in Food and Agriculture, Proceedings on the Enzymological Aspects of Food Irradiation, I.A.E.A., Vienna, 1969, p. 91.

matter sterilized by microwave and other homogeneous, liquid ingredients sterilized by aseptic processing. The minute particulate matter in COJ can be handled aseptically if the sterilizer's equipment design incorporates highly turbulent flows and high flow rates required for full particle sterilization.

Aseptic Food Sterilization

Aseptically sterilized food processing occurs in two separate methods: direct and indirect. Direct heating sterilizes by direct contact between the food and the sterilizing agent, usually steam. In indirect heating a heat exchanger surface separates the food product from the sterilizing agent.

Direct methods

Direct heating is separated into two opposite procedures: injection and infusion. With injection, culinary steam is injected into the food product line, while with infusion, the food product is pumped into the highly filtered steam. A time-temperature plot for a direct-injection method appears in Figure 10.[45]

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[45] H. Burton, "The Direct Heating Process for the Ultra-High-Temperature Sterilization of Milk," International Food Science and Technology Proceedings 10 (March 1978):131.

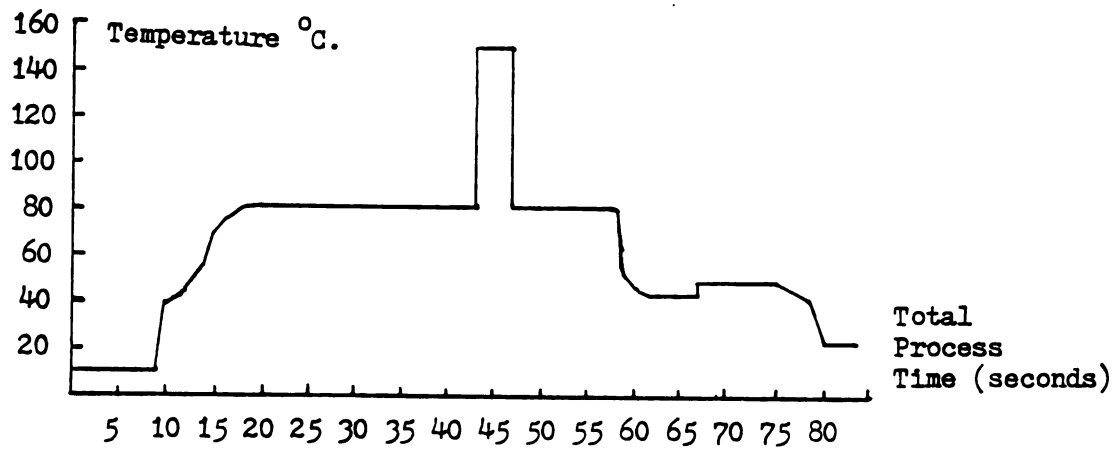

Figure 10. Direct Injection Sterilizer Time-Temperature Plot

Direct method products enter the processing equipment at 39 to 45°F. In both direct systems, preheating occurs by indirect plate or tubular heat exchangers raising the food temperature to 176°F. Next the steam contacts the food elevating its temperature to 284-302°F. causing sterilizing in two to three seconds. Having reached the sterilizing temperature, the food product traverses a holding tube of sufficient length to ensure sterility. Time to travel the holding cell is about another two or three second. Since a 10% product dilution occurs, the correct moisture content and cooling is accomplished simultaneously by evaporation cooling. Correct vacuum pressure control is actuated according to product sterilization temperature and the induced dilution factor thereby evaporating the excess water content.

All direct methods condense steam into the food product, so the steam must be sterile. The eventually sterile steam starts from a potable water source and enters a boiler. The boiler is only cleaned with certain chemical solvents. The boiler's "dirty" steam enters a cyclon filter and then is further cleansed by an active carbon filter. The steam is now sterile enough for its intended use. All piping materials for the food and the steam lines are stainless steel. Due to these constraints, sterile steam production requires the purchase and installation of a separate boiler system.

COJ does not require homogenization so its placement and operation is not addressed.

A few further comments on the two direct sterilization procedures. Steam is injected into the food either as small bubbles through minute holes in the injector or as thin sheets through slices in the injector. Most infusers incorporate the food product falling in many thin layers down through a steam chamber. Infusion systems achieve the quickest sterilization of the aseptic heat processes. Injected steam should separate the stainless steel injector surface from the product. Otherwise food burn-on deposits can develop at injector sites. These deposits block steam condensation and reduce run time between clean-in-place (C.I.P.) stoppages. Sterile steam pressure must be maintained higher than the food pressure, so the steam temperature is significantly above the required product sterilization temperature. In other words the steam cools as it condenses into the product. The induced overheating nearest to the injector is generally not a problem.[46] However, injected steam results in high turbulence around the injector, causing high heat transfer and some product degradation texurally.

Direct infusion heating designs invariably result in a pool of sterile products forming at the bottom of the steam chamber. To prevent unnecessary temperature load on the product, the heat process should allow a first in - first out (FIFO) flow. Another infusion related problem emanates from the high temperature, high pressure steam chamber. Most products contain a few parts per million of air which is released into the steam chamber upon heating. This adds to the overall pressure resulting in a steam-air mixture. The increased pressure causes an excessive processing temperature. The situation can be normalized by careful control of the main food outlet valve at the bottom of the steam chamber. The product pool can be allowed to drop until small drops of the steam-air mixture are released into the holding tube restoring proper pressure and temperature conditions. Considering all the small design differences between the injection and infusion methods, comparison is

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[46]Ibid., p. 132.

difficult between them. However, some advantages over indirect heat exchangers are readily apparent.[47]

Table 12. Direct Heat Merits

1. Lowest possible temperature load on the food.
2. Least permanent burnt flavor.
3. Lowest final oxygen content, less than 1.0ppm.
4. Longest run time between C.I.P.

Indirect processes

Three methods of indirect heat sterilization exist in the marketplace: plate heat exchangers, tubular (shell) heat exchangers, and scraped-surface heat exchangers. Figure 11 depicts the types of heat exchangers.[48] Each system's name accurately describes the shape of the heat exchanger surface. The plate heat exchanger has the highest utilization of heat exchange surface per factory space of the indirect units. The product passes in thin layers over approximately 30 thinly spaced heat exchanger plates separated by rubber gaskets. These gaskets provide easy inspection, but limit flow rates and are a possible source of contamination. One trip through a single sandwich of plates sterilizes the product. Unlike the plate system, the tubular and shell methods heat all around the product. In tube

[47] Dr. Bernhard von Bockelmann, "Some Principles of U.H.T. Processing," Tetra Pak International AB (in-house publication), 1978, p. 6.

[48] Ibid., p. 7.

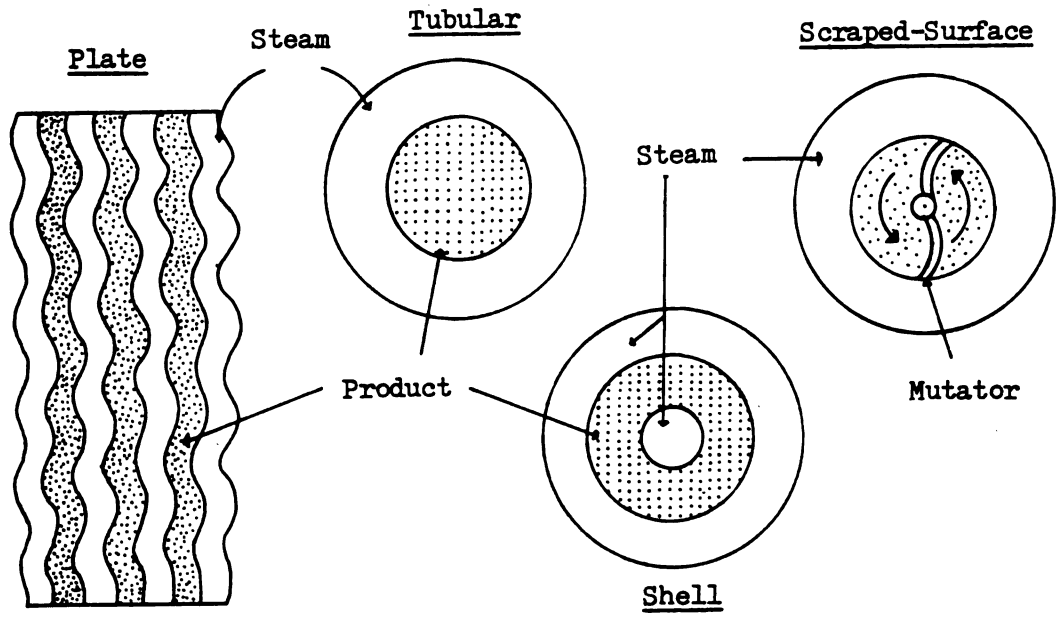

Figure 11. Indirect Heat Sterilization Methods

units the food is pumped through the center of a heated pipe. Shell systems heat products on the inner and outer sides of the food line. The scraped-surface procedure takes the tubular method one step further by adding extra agitation. A curved stainless steel pinwheel, the mutator, spins around the axis of the product flow direction like an auger. Very high energy costs and excessive purchase prices limit scraped surface use to sterilizing only large particulates and highly viscous foods.

A time-temperature plot for an indirect plate heat system is shown in Figure 12.[49] The product enters the processing equipment at 39 to 45°F., and it is preheated

49 H. Burton, "The Direct Heating Process for the Ultra-High-Temperature Sterilization of Milk," p. 131.

usually by the same later indirect sterilization method to 176°F. Like the direct methods, the indirect sterilizer time-temperature plots differ; some products are processed more efficiently with some indirect designs. In plate methods, sterilization reaches the same sterility temperatures as the direct systems but in 15 to 20 seconds. Holding tubes are then traveled for two to five seconds depending on product type and flow rate. The indirect systems make better use of regenerative cooling and heating, because of the exclusion of evaporation cooling. Sterile hot product often indirectly preheats the nonsterile cool food product. This regeneration of heat allows indirect aseptic processing to be cost competitive with faster output direct systems.

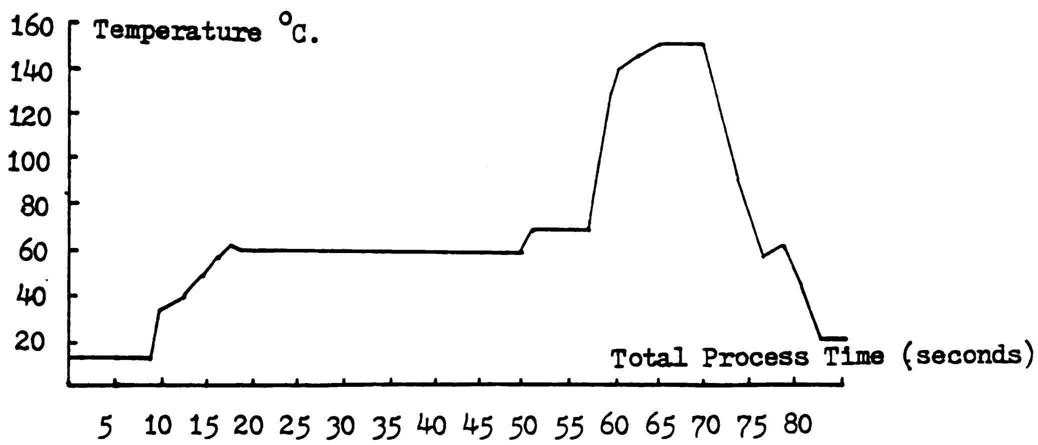

Figure 12. Indirect Plate Time-Temperature Plot

Product burn-on is a problem reducing the heat exchanger efficiency. This requires more frequent C.I.P. and resterilization than direct heating. However, indirect heating and the three main heat methods have some general advantages over direct heating and among each other, Table 13.

Table 13. Indirect Heating Merits

1. Lowest investment and operating costs.
2. Higher energy regeneration, 70-80% versus 50%.
3. Simplistic designs.
4. No heating agent requirements.

Plate Heating Merits

1. Least acquisition cost.
2. Easier equipment inspection.
3. Easiest to clean.
4. Turbulent flow at lower velocities.
5. Highest indirect output rates.

Tubular and Shell Heating Merits

1. Safest microbiologically.
2. Longest production runs.
3. Handles semi-liquid small particulates (up to 1500 centipoise).
4. Automatic C.I.P. easiest.
5. High flow rates and pressures.
6. Turbulent flow at only higher flow rates.
7. Output limits approximately 75 to 10,000 liters/hour.

Scraped Surface Heating Merits

1. Handles highly viscous and large particulate foods.

Indirect processes result in higher oxygen content than direct methods, because of the lack of evaporative cooling. COJ is very oxygen sensitive, so a dearator is required to retard browning and vitamin C degradation.

Currently 10 manufacturers marketing commercial aseptic food systems exist in the U.S.A. Table 14 identifies these producers, system types and investments associated with these. The highest prices correspond to fully automated systems.[50]

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[50] Private industry sources.

Table 14: Domestically Available U-H-T-S-T Aseptic Food Sterilization Systems

Sterilizer Properties	Sterilizer Manufacturers & Specific Sterilizer Models						
	APV EQUIPMENT CO.		ALFA LAVAL AB		CHERRY BURRELL CORP.		
Model name	UPERIZATION	JUICEMATIC	VTIS	STERITHERM	SPIRATHERM-NO BAC 100, 200, & 600	ARO VAC-NO BAC 1600 & 1700	PASILAC-THERM
Sterilizer type	Direct steam injection	Indirect plate	Direct steam injection	Indirect plate	Indirect tubular	Direct steam injection	Indirect plate
Food Capability	All pHs	Low pHs	All pHs	All pHs	All pHs	All pHs	Low pHs
Sterilizer Cost	\$320,000.- \$400,000.	\$120,000.- \$170,000.	\$500,000.- \$700,000.	\$500,000.	\$125,000.- \$250,000.	\$500,000.	\$NA.
Model name	SUPER-ULTRA-MATIC	JUPITER	USITHERM	CONTHERM	THERMUTATOR-NO BAC 1200, 1300, & 1400	UNITHERM	
Sterilizer type	Indirect plate	Indirect scraped-surface	Indirect plate	Indirect scraped-surface	Indirect scraped-surface	Indirect tubular	
Food Capability	All pHs	All pHs, viscous particulates	Low pHs	All pHs, viscous particulates	All pHs, viscous particulates	Portion packaging	
Sterilizer Cost	\$400,000.- \$500,000.	\$1,000,000.	\$150,000.- \$175,000.	\$NA.	\$250,000.- \$300,000.	\$150,000.- \$200,000.	

Table 14: Domestically Available U-H-T-S-T Aseptic Food Sterilization Systems

Sterilizer Properties	Sterilizer Manufacturers & Specific Sterilizer Models				
	CREPACO INC.	DASI INC.	CHEMTRON PROCESS EQUIPMENT CO.	FRAN RICA MFG. CO.	
Model name	ULTRATHERM DSH	FREE-FALLING-FILM	VOTATOR-CLEANWALL	ASEPTIC PRESSURE SYSTEM	ASEPTIC VACUUM SYSTEM
Sterilizer type	Direct steam infusion	Direct steam infusion	Indirect scraped-surface	Indirect scraped-surface	Direct steam injection
Food capability	All pHs	All pHs	All pHs, 100,000 centipoise & 5/8" cubes	All pHs, viscous particulates	Low pHs
Sterilizer cost	\$500,000.	\$40,000.- sterilizer only	\$2500./foot^2 of heat exchanger surface	\$500,000.	Under \$500,000.
Model name	MODEL CTA	ROTOPROS	VOTATOR-SAN LOC	QUADRASEPTIC	ASEPTIC PARTICULATE SYSTEM
Sterilizer type	Indirect tubular	Indirect plate	Indirect scraped-surface	Indirect scraped-surface	Direct steam chamber conveyor
Food capability	Portion packaging	All pHs	All pHs, lower viscosities than CLEANWALL & 5/8" cubes	Low pHs, viscous particulates	All pHs, large particulates
Sterilizer cost	\$140,000.- \$200,000.	\$2000./ft^2 of heat exchanger surface	Less than \$2500./ft^2 of heat exchanger surface	\$400,000.- \$500,000.	\$1,500.000.

Table 14: Domestically Available U-H-T-S-T Aseptic Food Sterilization Systems

Sterilizer Properties	Sterilizer Manufacturers & Specific Sterilizer Models		
...	ROSSI & CATELLI	STORK AMSTERDAM BV	M. SORDI CO.
Model name	STEMATIC LONGRUN	STERIDEAL	STERIPLAK
Sterilizer type	Direct steam injection	Indirect shell	Indirect plate
Food capability	All pHs	All pHs	All pHs
Sterilizer cost	$650,000.	$250,000.- $300,000.	$NA.
Model name		MINI-STERIDEAL	
Sterilizer type		Indirect tubular	
Food capability		Portion packaging	
Sterilizer		$NA.	

Having surveyed all the possible UHTST aseptic food sterilizing systems, choices among these can be made to meet our previously determined optimum system acceptability criteria. All of the aseptic methods provide continuous high speed sterilization of liquid products at economically safe levels of efficiency. However, only two indirect processes, tubular and scraped surface, can handle semi-liquid particulates. Of these two, tubular heat exchange best fulfills economic requirements. Two experienced suppliers of tubular heat exchangers exist, the STERIDEAL system and the SPIRATHERM process.

STORK-STERIDEAL Shell System

STORK-STERIDEAL UHT tubular (shell) sterilizers are produced by the GEBR. STORK & COMPANY'S APPARATENFABRIEK NV of Amsterdam.[51] All the shell heat exchangers are constructed from stainless steel. The system's high degree of induced turbulence and high pressure fluctuations result in efficient heat transfer. Since the tubing requires no gaskets, the extreme turbulence and pressure changes can be contained. The lack of gaskets necessitates all cleaning to be carried out in the automatic mode throughout the whole system. The only indication of the need to switch to C.I.P. is a gradual temperature decrease in the main sterilizer

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[51] H. Burton, "The STORK-STERIDEAL Process For Sterile Milk Production," American Dairy Review 8 (1967), cited by Naim Kosaric et al., CRC Critical Reviews In Food Science And Nutrition 14 (1981):163.

shell section resulting from product burn-on. A pump or homogenizer supplies the flow pressure. Early STERIDEAL units commonly operated at 2000 liter per hour.

Today these rates have increased to 8000 liters per hour because of design innovations. The STERIDEAL unit is a shell configuration in the final sterilization and cooling phases while tubular heat exchange in all other areas. The sytem consists of four distinct but completely integrated sections, greatly simplifying installation. A unique capability of the STERIDEAL are variable speed motors and control systems allowing variable output ranges. The STERIDEAL process was basically developed to sterilize milk products, but has not as of this writing been approved by the F.D.A. However, its approval is expected soon, because of the STERIDEAL's proven record in Europe.

Figure 13 depicts a common STERIDEAL line layout.[52] The product is pumped by a centrifugal pump (2) from the main supply tank (1) to a five cylinder positive displacement pump (3), by itself or as part of the homogenizer's pumping system. Output pressure fluctuations originate here from the low piston speeds of the multiple cylinder pump. If pumps having four cylinders and less are utilized, then excessively large pressure changes result. Air bottles, which are difficult to sterilize, are presently used to absorb the air pockets. The first tubular regenerator (5) preheats the product to 149°F. before the food passes

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[52] Ibid., p. 164.

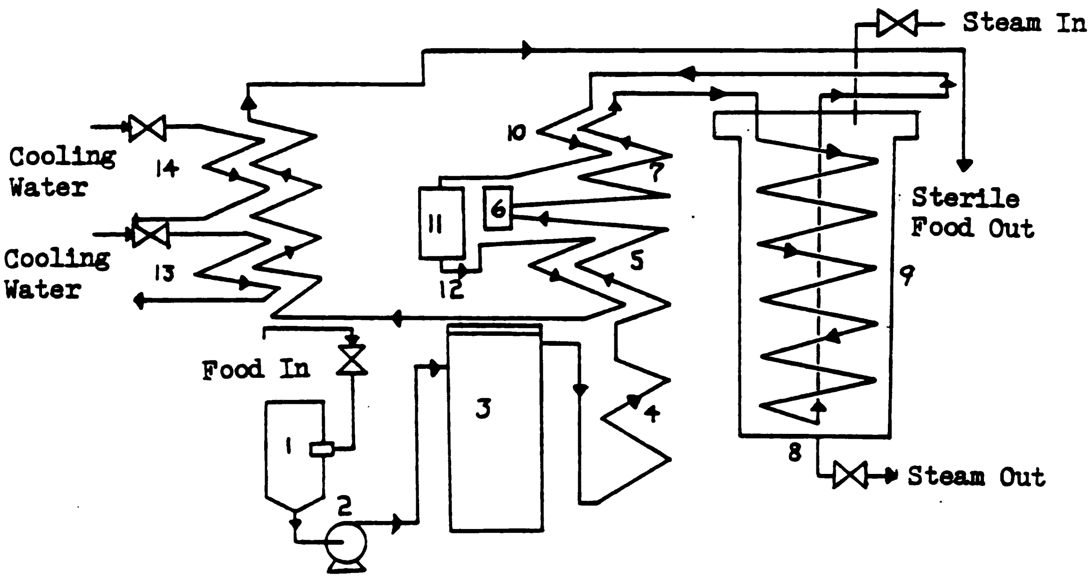

Figure 13. The STERIDEAL System

through the first homogenizing valve (6) at 300 pounds per square inch. A second regenerator (7) performs secondary preheating raising product temperature to 248°F. Next the food travels to the main shell heating area (8), where indirect sterilization occurs at 275-302°F. The correct indirect heat exchanger temperature is maintained by a pneumatically controlled steam inlet valve. Temperature sensors open a diversion valve transporting the semi-sterile product back to the main raw product supply tank, ensuring sterilization occurs. The now sterile product enters the cooling phase in the second regenerator (10), passing through the second homogenizing valve (11), and traversing the first regenerator (12) at 750 pounds per square inch and 86°F. Final cooling occurs indirectly via two chilled water baths (13, 14) just prior to aseptic packaging machinery entry.

The STERIDEAL system has been coupled to most current aseptic packaging machines.[53] Super-heated steam at 284-302°F. sterilizes the food indirectly and operates the machine's C.I.P. capability automatically. Product diversion valves in addition to their safety function are used to automatically shift the STERIDEAL equipment into the rinsing, cleaning and sterilizing cycle. Assuming proper operating conditions are maintained, the system can operate continuously from six to twelve hours. Run times can be extended by incorporating forewarming at 176°F. for five minutes with milk.[54] COJ would likely experience some forewarming benefits too. Different forewarming conditions can be determined for the COJ, thereby reducing the rate of product burn-on and increasing continuous run duration. The forewarming principle is incorporated in all indirect processes to reduce the inherent product burn-on onto the heat exchanger surface.

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[53] H. Burton, "The Effect of Forewarming on the Formation of Deposits from Separated Milk on a Heated Wire," <u>18th International Dairy Congress Proceedings</u> B:3 (1972):609.

[54] Ibid., p. 163

CHERRY BURRELL-SPIRATHERM Tubular System

The SPIRATHERM tubular heating process is manufactured by CHERRY BURRELL. The SPIRATHERMS are a series of gasketless, concentric, stainless steel tubing arranged spirally within heated chambers. SPIRATHERMS are termed NO BAC 100, NO BAC 200, AND NO BAC 600. Only the NO BAC 600 applies to the study's parameters, so the NO BAC 600 is addressed below. The heat transfer agent is a bactericide containing water completely separate from product's system thereby eliminating, unlike the STERIDEAL unit, the possibility of contamination via the Venturi Principle. The Venturi Principle demonstrates that a leak of high pressure sterile product into the lower pressure raw product line causes a back suction. Thus contamination can occur when utilizing sterile to raw product heat regeneration. Some regeneration is lost by employing bactericide impregnated water. Heat regeneration of approximately 70-75% is achieved. The SPIRATHERM cylinders are fitted with baffles to direct water flow maintaining high heat transfer rates. For efficient high temperature sterilization the steam must achieve and hold its flow velocity from 18 to 22 feet per second. For nonsterile SPIRATHERM areas, water flows from eight to twelve feet per second are acceptable. SPIRATHERM tubing can withstand 150 pounds per square inch. The schematic in Figure 14 illustrates the SPIRATHERM process.[55]

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[55] H. Burton, "The STORK-STERIDEAL Process for Sterile Milk Production," p.163.

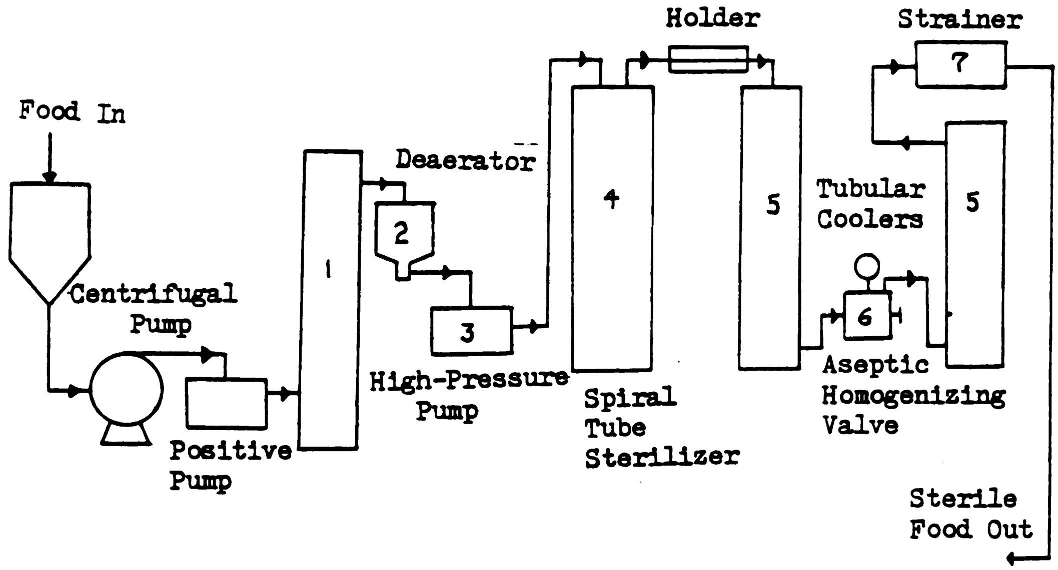

Figure 14. The SPIRATHERM NO BAC 600 System

Food product is pumped through a tubular or plate preheater (1) elevating the temperature to 158°F. Deaeration (2) occurs next allowing extended production time by reducing the product's air and oxygen content to around the level achieved by flash vacuum cooling in direct aseptic processing. Deaerating reduces the amount of product burn-on like forewarming and removes some off flavors. A high pressure pump (3) provides the system flow pressure. Steam sterilized SPIRATHERMS (4) cause sterilization at 280-302°F. A holding section of up to eight seconds ensures total heat penetration. Now entering the cooling area (5), the product temperature is lowered to 122°F. If the food requires homogenizing, the homogenizer (6) interrupts the cooling tubes where the product temperature is still 158°F. ACOJ would not require homogenization. A strainer (7) is situated directly preceding the filler to filter out burned-on particles and excessively large pulp fragments. In the case of ACOJ, this improves filler operation when sealing through the product.

The SPIRATHERM outlets have restricting orifices to create backpressure in the food line keeping its line pressure higher than the steam line pressure. The extra turbulence is required to effect efficient sterilization. The SPIRATHERM design utilizes regeneration preheating and cooling only with the NO BAC 600.

Optimum COJ Aseptic System Selection

Designation of the best aseptic system between the STERIDEAL and SPIRATHERM units is founded on the predetermined criteria. Both systems satisfy the sterilization with low temperature load requirement, because this is the basic design consideration for all aseptic systems. STERIDEAL and SPIRATHERM handle semi-liquid small particulates. Each design differs in relation to its components position which eventually impinge on continuous run time and overall line output. STERIDEAL employs a single pump to create all line pressure and turbulence, while SPIRATHERM utilizes two pumps. STERIDEAL achieves a more compact arrangement with the same output. Deaeration is required for ACOJ processing, and is commonly a part of the NO BAC 600. STERIDEAL and SPIRATHERM utilize two different methods to reduce particle formation, forewarming and deaeration respectively.

Forewarming is less costly from an energy standpoint, but not quite as effective as deaeration. The STERIDEAL design could add a deaeration step prior to sterilization and after homogenization for especially oxygen sensitive products. SPIRATHERM'S product tubes can withstand only about one-fifth as much pressure as STERIDEAL'S tubes, but the higher flow rates would be detrimental to COJ's reconstituted texture, color and flavor. STERIDEAL has a 70-80% heat regeneration level versus SPIRATHERM'S 70%. The SPIRATHERM NO BAC 600 has the greatest sterile integrity. Since this achievement and maintenance determines the frequency of C.I.P. (the highest process expense), so the NO BAC 600 can be operated cheaper than the STERIDEAL unit for aseptic production of concentrate orange juice.

Thus this study selects CHERRY BURRELL'S NO BAC 600 ultra high temperature short time system to sterilize 45^{o}Brix concentrated orange juice. Aseptic packaging systems are now investigated to identify an optimum aseptic concentrated orange juice (ACOJ) packaging system and to mate it to the NO BAC 600.

Section 3:

Selection of an Optimum

ACOJ Packaging System

Package Development

Packaging allows the separation of manufacturing and retailing creating a distribution environment between them. Without packaging, mass production would be impossible. Maintaining the product in an acceptably saleable condition throughout its distribution channel for a given length of time or shelf life is the fundamental purpose for every package. A systematic analysis of available package system characteristics during developmental stages can achieve the best match with product attributes and market needs. Most product attributes and market needs place a specific array of demands on the package. For each product/market need relationship, these demands must be quantified as the first step in package development. Upon prioritizing the demands, the package engineer can easily compare proposed systems and ascertain the optimum package system.

ACOJ packaging requirements

Aseptic concentrated orange juice attributes (ACOJ) and market needs appear in Table 15. Protection/ containment factors entail the package's ability to maintain a sterile internal environment via a hermetic seal throughout shelf life. To create a hermetic seal, the package material

Table 15. ACOJ and Market Demands on the Package System

- I. Protection/containment
  - A. Barriers
    1. Light-ultraviolet especially
    2. Water vapor
    3. Oxygen
    4. Organic volatiles
    5. Microbes
  - B. Hermetically sealable
  - C. Machineable
    1. Sterilizeable
    2. Strong material
  - D. Distributable
    1. Shock and vibration resistant
- II. Utility/convenience
  - A. Channel member wants
    1. Printability-labeling
    2. Handleability
    3. Safety-sterility integrity
    4. Uniformity

and its final form must possess high barrier properties in addition to providing effective closure. For the considered aseptic materials, heat/pressure or induction sealing can achieve closure. Aseptic packaging systems utilizing metal, glass and composite can packaging materials are not considered, because their higher cost and weight detract from aseptic material and distribution savings. Aluminum foil laminates and strong plastic coextrusions provide the necessary aseptic package rigidity. Aluminum foil, Saran and EVAL have low water and oxygen transmission rates. EVAL and Al foil possess the necessary organic vapor flavor component barrier properties. Saran can provide adequate protection with certain volatiles. EVAL must be kept dry to maintain a high barrier. Pinholding can render Al foil insufficient. ACOJ requires a translucent to opaque light barrier. From Section 1, COJ nutrient and quality retention requires these barriers.

Aseptic packaging systems must fabricate distributable packages. The package material and its package design must be shock and vibration resistant to the likely trucking, storing and handling inputs. Damage boundary determination and resonant frequency searches can accurately ascertain product/package fragility assessment. The package and its form-fill-seal or deposit-fill-seal machinery must be sterilizeable and provide effective sterility maintenance. Prerun and interrun resterilizations are the most cost intensive aseptic production operation. Production scheduling must minimize the frequency of line changeovers between differently labeled packages. Preventative maintenance, including processor safety factors on top of equipment and material specifications, can achieve the maximum continuous run times.[56] The filled package must have little or no oxygen in the headspace and in the sterile COJ as well. If hydrogen peroxide (H_2O_2) is utilized, then residual chemicals must be held to a tight minimum to prevent greatly accelerated browning.[57]

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[56] Homgren, R., p. 63.

[57] R. Johnson and R. Toledo, "Storage Stability of 55 ^{o}Brix Orange Juice Concentrate Aseptically Packaged in Plastic and Glass Containers," Journal of Food Science 40 (1975) :434.

Utility/convenience factors concern legal and saleability package requirements. The material and its package should allow distinctive graphics as well as fulfill legal labeling regulations. The packaging process should not needlessly endanger manufacturing personnel. Consumer safety of aseptic products is fundamentally based on its sterility. Package dimensions should provide easy handling for intended use by all channel members. The process must be capable of high speeds while maintaining package uniformity. All these factors must be attainable at an acceptable expense to the food processor and to the consumer who ultimately pays for the packaging system.

Assuming a company can afford the initial capital outlay for aseptic packaging equipment, the major aseptic packaging objective is achieving and maintaining package sterility. Thus, verification of sterility is desired. Incubation is the only widely accepted method, but is it time consuming, costly and statistically uncertain. To shorten incubation requirements, non-destructive finished goods testing is desired. A recent article describes a partial achievement of this goal. Specifically, the machine identifies and rejects grossly improperly sealed or pinholed packages by lack of sidewall deflection sooner than incubation.[58] To reduce the possibility of shipping a contaminated package, this study assumes the use of such a device.

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[58] Carl Andres, "Non-destructive Inspection of Aseptic Packaging," Food Processing 43 (January 1982):166.

Proper personnel training, preventative equipment maintenance, building sanitation and limiting all raw material contamination are also inherent to achieving and preserving product/package sterility over extended, economical and continuous runs.

Viable Aseptic Packaging Systems

Having constructed ACOJ packaging needs, the domestically available aseptic packaging systems are surveyed. These aseptic packaging methods meet ACOJ's needs in varying degrees. All aseptic packaging processes can be divided into two groups, paperboard-based and plastic-based. Within each group a further subdivision exists between form-fill-seal units and deposit-fill-seal systems. Tables 16 and 17 illustrate aseptic paperboard-based and plastic-based system characteristics respectively. Sketches and summations of these follow.

Aseptic paperboard-based packaging systems

TETRA PAK systems

The most prominent aseptic packaging systems are the TETRA and BRIK PAKS produced by TETRA PAK INTERNATIONAL AB of Lund, Sweden. TETRA PAK pioneered modern aseptic packaging with the introduction of the TETRA PAK machine in 1952 which went aseptic in 1958.[59] The TETRA PAK AT-500 is sold in the U.S. by MILLIKEN PACKAGING of White Stone, South

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[59] Anonymus, "Persistent Development," Tetra Pak (in-house publication)54:12.

Table 16: Paperboard-based Aseptic Packaging Systems

System Name:	TETRA PAK	BRIK PAK	BRIK PAK	SYSTEMPAK	LIQUI-PAK	COMBIBLOC
Model Number:	AT-500	AB-3	AB 8 & 9	Model 3500	820-A	cF 5.000, 6.000, & 10.000
Sources:	#1 & 3	#4, 7, & 8		# 5 & 7	#2	#6 & 7
Terms of Sale:	Lease equipment only, machine fee/1000pkgs, & purchase materials.			Same as TETRA & BRIK PAK.	Lease or buy, no machine fee purchase mtls.	Same as 820-A.
Labeling:	Rotogravure or flexographic on preprinted mtl. rolls.			Same as TETRA & BRIK PAK.	Any preprinted carton sleeves	Same as 820-A.
Layout:	VFFS 9x12x13'	VFFS 12x15x18'	VFFS-like SYSTEMPAK	VFFS 7x5x10'	HFFS 17x4x10'	HFFS 24x8x10'
Package Shapes:	Tetrahedral 7-22ml., 150ml., 300ml. 500ml. & 1L.	Brik, 178-284ml., 300ml 500ml.-1L.	Brik, AB-8= 12oz.-1L. AB-9=125-284 ml. Any vols. in between.	Brik, 200-250ml., 500ml.-1L.	Gable-top, 200ml.-1L.	Block, 200-250ml., 500ml.-1L.
System Weight:	9000lbs.	11,200lbs.	10,000lbs.	8500lbs.	10,000lbs.	cF10.=24,500lbs. cF5. & 6.=19,100lbs.
Package Rates Per Hour:	7-22ml=7200. 500ml-1L= 3600. Others in between= 4500.	Up to 250ml= 4500. & 3800. to 1L.	6,000. for all sizes.	Up to 250ml= 3500. & 3000. to 1L.	3600. for all sizes.	Up to 250ml either 5,000.or 6,000. & 10,000. up to 1L.
Operator Requirements:	1 up to 2 machines.			1/machine	1/machine	1 up to 2 machines.

Table 16: Paperboard-based Aseptic Packaging Systems

System Name:	TETRA PAK	BRIK PAK	BRIK PAK	SYSTEMPAK	LIQUI-PAK	COMBIBLOC
Model Number:	AT-500	AB-3	AB-8 & 9	Model 3500	820-A	cF5., 6., & 10.
Compressed Air Use (cfm):	8.7 @ 80PSI.	18 @ 85-128PSI.		21 @ 85 PSI.	4 @ 56 PSI.	cF5.=77, cF6.=67, cF10.=260; @ 88PSI.
Cooling Water (gal/min):	None	3.5		1.8	1.8	cF5. & 6.=6.5 & cF10.=13.0
Electrical Connection/ Consumption:	2KWH.	3-phase, 220 or 440V. 18KWH.		440V-60Hz. 20KWH.	40KVA.	3-phase, 440V-60Hz. cF5. & 6.=17KWH. cF10.=38KWH.
Natural Gas (cfh):	None	None	None	None	None	cF5. & 6.=228. cF10.=456.
Steam Use (Kg/h):	All use steam for prerun sterilization; Blocpak reported 48Kg/h. Under normal sterile packaging hot sterile air vaporizes H_2O_2 creating internal package sterility.					

Sources: 1. T. Ashton & A. Neitzke, "International Dairy Monograph on U-H-T Milk,", Prague, 1972, chapters 7 & 9.
2. LIQUI-PAK INTERNATIONAL INC., LIQUI-PAK 820-A Specifications.
3. Personal communication with Mr. Gerald Neher of Milliken Packaging.
4. Personal communication with Dr. Charles Sizer of BRIK PAK U.S.A. INC.
5. Personal communication with Ms. Barara Husum of INTERNATIONAL PAPER CO.
6. Personal communication with Mr. Dave Meharg of BLOCPAK INC.
7. M. Westerman, "Aseptics Choice Made Easy," Beverage World (July 1982): 68, 70-72.
8. Personal communication with Mr. Ron Miller of BRIK PAK U.S.A. INC.

Table 17: Plastic-based Aseptic Packaging Systems

System Name:	SERVAC 78	CONOFFAST	ASEPACK	METAL BOX FRESHFILL
Model Number:	AS & AL/AS	Aseptic Mode	2 & 24	SL-1 & ML-4
Terms of Sale:	Buy equipment, no royalites, & purchase mtls.	Lease equipment, royalties on mtls. & on equipment, purchase mtls.	Buy or lease equip. no royalties, & purchase mtls.	Like SERVAC 78.
Labeling:	Lid only-preprinted foil/plastic laminates, preprinted overwrap bags.	Cup-preprinted heat sealable paper or paperbacked foil. Lid-any heat sealable membrane.	Cup-preprinted wraparound paper for 4-sided, oval, & round shapes. Lid-like CONOFFAST.	Cup-preprinted or lithographed plastic Lid-like CONOFFAST.
Layout:	HTFS 37x16x9'	HTFS 26x8x8'	HTFS 26x4x7'	HFS SL-1=11x6x7' ML-4=19x5'-12x7'
Package Shapes:	Limited by mold area; base=21.6", diameter=19.6", & height=3.9" for AS & 1.8" for AL/AS.	Limited by mold area; base=1x1-6x6", diameter=1-6", & height=½-5".	Limited by mold area; height=4".	Limited by conveyor; diameter=3.3", base=3.3", & height=1.6-4.6".
System Weight:	45,500lbs.	18,000lbs.	A2=5,000lbs. A24=9,000lbs.	SL-1=14,000lbs. ML-4=30,000lbs.
Package Rates Per Hour:	Up to 48 filling heads; 1500 cycles/hr., 15ml=66,000, 500ml. is the economic limit (EL).	Up to 16 filling heads; 1500 cycles/hr; 29ml=20-50,000., 118ml=14-28,000., 237ml=10-20,000., & 473ml=8-15,000.*EL.	1200 cycles/hr., guaranteed 24,000/hr. in a 6x4 array, 236ml common.	2-stage filling/lane, SL-1=1800-3000/hr., ML-4=7200-12,000/hr, ML-6=10,000-18,000/hr.
Operator Requirements:	2/machine	1/machine	A2=1/machine A24=2/machine	SL-1=1/machine ML-4=2/machine

Table 17: Plastic-based Aseptic Packaging Systems

System Name:	SERVAC 78	CONOFFAST	ASEPACK	METAL BOX FRESHFILL
Model Number:	AS & AL/AS	Aseptic Mode	2 & 24	SL-1 & ML-4
Compressed Air Use (cfm):	85-142PSI. AS=292. & AL/AS=146.	132 @ 90PSI.	220L./hr.	80PSI. SL-1=2-10 & ML-4=4-20
Cooling Water (gal/min):	AS=1.3 & AL/AS=0.5	5.5	2.7	SL-1=8.3 & ML-4=20.
Electrical Connection/ Consumption:	45KVA.	440V-60Hz. 50KWH.	10KWH.	SL-1=12KWH & ML-4= 30KWH.
Steam Use (Kg/h):	All use steam for prerun sterilization; Bosch reported 50Kg/h. for the SERVAC 78. Under normal sterile packaging, hot sterile air vaporizes H_2O_2 creating internal package sterility.			

Sources: 1a. V. Carlson, "Aseptic Efforts Focus on Plastic, Cup-Style Packs," Package Engineering (January 1983):63-67.

1b. ASTEC INC., METAL BOX FRESHFILL SL-1 & ML-4 specifications.

2. BOSCH PACKAGING MACHINERY, SERVAC 78 AS & AL/AS specifications.

3. D. Liede & J. Dunn, "Aseptics: Sterile Packs with a Fertile Future," Packaging Digest (October 1982):107-126.

4. Personal communication with Mr. Scott Vivian representating BENCO U.S.A. INC.

5. Personal communication with Mr. Bob Kowlsch of BOSCH PACKAGING MACHINERY INC.

6. M. Westerman, "Aseptics Choice Made Easy," Beverage World (July 1982):68, 70-72

7. Frank Mechura, "Aseptics: Sterile Packs with a Fertile Future," Packaging Digest (October 1982):107-126.

8. Personal communication with Mr. V. R. Carlson of ASTEC INC.

9. Scott Vivian, "Aseptics: Sterile Packs with a Fertile Future," Packaging Digest (Ocotber 1982):107-126.

Carolina. This tetrahedron was the first successful flexible aseptic package and continues to perform well in small portion packaging applications. The tetrahedral shape takes a minimum of package material for a given volume of product. TETRA PAK's package material comes in two varieties as in the other BRIK PAK systems. The first a polyethylene/paper/polyethylene laminate is for non-aseptic applications. The second includes an aluminum foil layer for aseptic barrier needs. The process that creates this material is kept secret and is the subject of very intensive research by many companies. EX-CELL-O CORPORATION is presently producing the nearest polyethylene/paper/polyethylene/aluminum foil/polyethylene laminate to the BRIK PAK material. Hermetic seals are induction on all TETRA PAK sides with the side incorporating a plastic strip to prevent contaminant osmosis. Package material is sterilized by a 35% H_2O_2 waterbath which is evaporated off the inside of the tubed material. Automatic case packers and pull tab and straw applicators are also available from TETRA PAK INTERNATIONAL AB. Low to high pH foods have been successfully packaged aseptically by the AT-500. Figure 15 describes the tetrahedron's vertical form-fill-seal (VFFS) process.

BRIK PAK AB-3

In 1952 the BRIK PAK, or as it is known outside of the U.S., the TETRA BRIK, was designed. The BRIK PAK went aseptic in 1967. The AB-3 is marketed domestically by BRIK

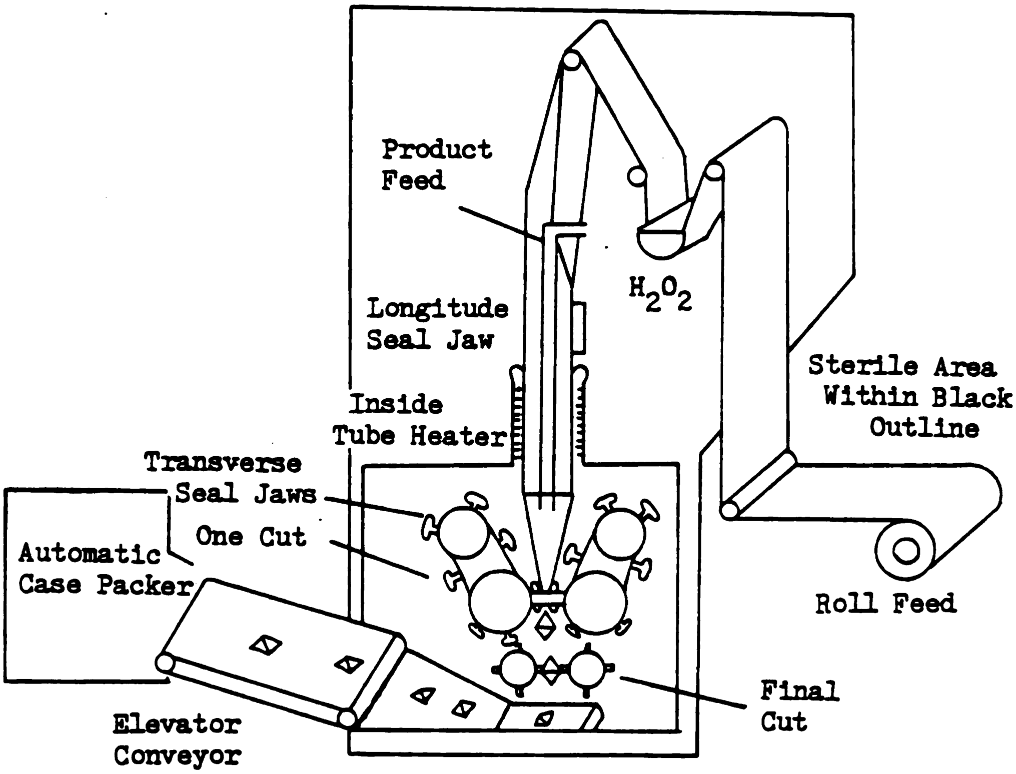

Figure 15. The TETRA PAK VFFS Process

PAK U.S.A. INCORPORATED of Dallas, Texas. TETRA PAK INTERNATIONAL sold more than 30 billion cartons in 1981, 17 billion of these aseptic. Also in 1981, 2,201 aseptic units, BRIK PAK and TETRA PAK, were operational worldwide.[60]

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60 Hellmut Kirchdorfer, "The Brik Pak-Age A New Era," The Brik Pak-Age 1 (in-house publication), Summer 1982, p. 3.

The BRIK PAK was developed for efficient handling. Hermetic sealing and package sterilization occurs identically to the AT-500 system. BRIK PAK makes tray erectors, shrink wrappers, shrink tunnels and straw applicators available. The AB-3 has aseptically packaged .1mm particulate low to high pH foods. The rectangular BRIK PAK VFFS system appears in Figure 16.

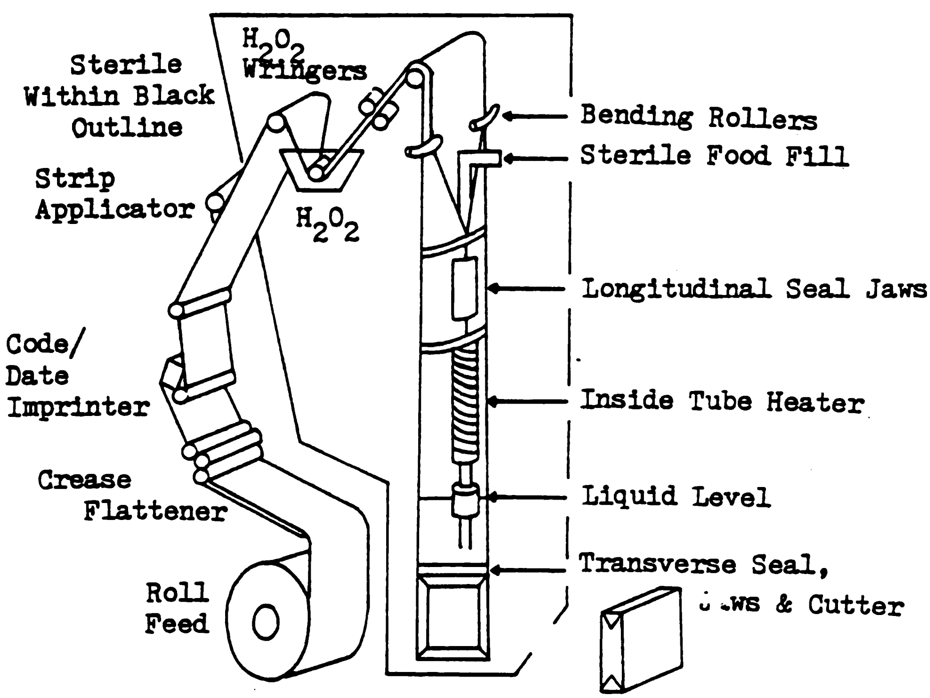

Figure 16. The BRIK PAK VFFS System

BRIK PAK AB-8 and AB-9

In October of 1983, the AB-3 systems will no longer be sold. Replacing the AB-3 are two similar units, the AB-8 and the AB-9 which seal and sterilize as well as use the identical packaging material as the AB-3 system. The first U.S. equipment will be installed in January 1984 with machine and material construction at the Denton, Texas facility originating in April 1984. Both systems are rated at 6000 units per hour, while achieving the same cost per thousand as the AB-3 systems. The AB-8 handles volumes from 12 ounces to one liter. Portions between 125ml and 284ml are slated for the AB-9. Jumbo rolls hold three hours of production capacity. Improved automatic C.I.P. requires only 40 minutes. Special package volumes are available for the first time by special order. These design modifications make BRIK PAK much more competitive with higher output aseptic packaging units.[61] Approximate acquisition and installation is $281,000 per unit with a cost per thousand packages of $47.98.[62]

INTERNATIONAL PAPER Model 3500 SYSTEMPAK

INTERNATIONAL PAPER COMPANY purchased patents and worldwide marketing rights to SYSTEMPAK, developed by

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[61] Personal communication with Mr. Ron Miller of BRIK PAK Inc.

[62] Private industry sources.

BUITONI of Perugia, Italy.[63] The Model 3500 went aseptic in 1977 in Italy. SYSTEMPAK's strengths are its compact size, fin seals and low H_2O_2 consumption. The fin seals reduce the possibility of microbial contamination because there are no external or internal paper edges exposed. BRIK PAKS utilize an internal plastic strip and COMBIBLOCS employ shaving, a longitudinal shaving of the internal surface material, to prevent contaminant osmosis. SYSTEMPAK utilizes a very similarly composed packaging material like the BRIK PAK material. Figure 17 depicts the SYSTEMPAK VFFS operation. A PE/Paper/PE/Al foil/PE laminate paperboard

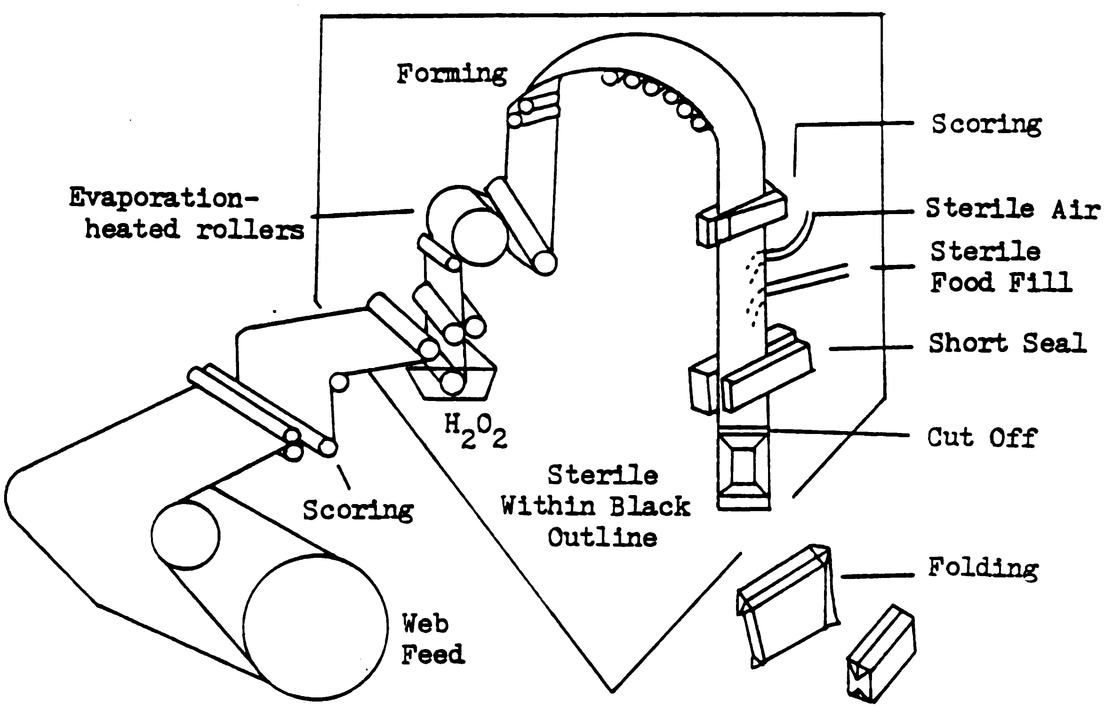

Figure 17. The SYSTEMPAK VFFS Operation

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[63] Marty Westerman, "Aseptics Choice Made Easy," Beverage World (July 1982):72.

specifically designed for aseptic packaging will be produced at a Raleigh, North Carolina plant starting in 1984.[64] This material is applicable to the EX-CELL-O and LIQUI-PAK systems described later. Currently available aseptic paperboard stock is actually designed for hot fill application. Thus INTERNATIONAL PAPER COMPANY will be the first domestic supplier of aseptic paperboard. A low 17.5% H_2O_2 water bath sterilizes the material with hot drums to score and create the sterile inner package atmosphere. The available auxiliary equipment and previously aseptically packaged products are similar to the BRIK PAK and TETRA PAK systems.

EX-CELL-O PURE-PAK N-LONG LIFE

The remaining paper-based systems are preformed blank-fed methods (deposit-fill-seal). EX-CELL-O CORPORATION'S PURE-PAK gable-top cartons are preformed and ethylene oxide sterilized after case packing at materials plants. This system is not aseptic, since a completely sterile environment is not maintained within the EX-CELL-O equipment. However, the clean EX-CELL-O packagers extend product shelf lives. As the cartons are opened by the user, 35% H_2O_2 is sprayed into the erected side sealed carton. The bottoms are heat sealed by natural gas, while the top is heat and pressure sealed after steam flushing the filled carton headspace. Residual H_2O_2 is evaporated by heat. Changeover is only five to ten minutes tooling. Hot fill grade PE/

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64 Anonymus, "A Big Vote for Aseptic Paperboard," Packaging Digest (March 1983):6.

Paperboard/ PE/Al foil/PE gable-top blanks are available from INTERNATIONAL PAPER COMPANY, CHAMPION INTERNATIONAL and WEYERHAUSER COMPANY. A new web-fed block of brik style machine may be under development. Approximately 100 PURE-PAK N-LONG LIFE machines are operating worldwide since their introduction in 1967.[65] Figure 18 illustrates the clean PURE PAK NLL system.

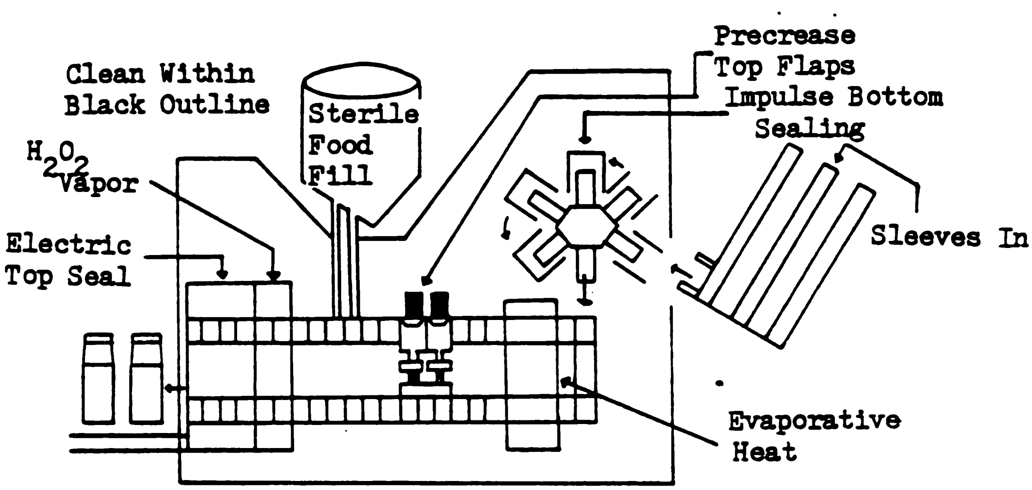

Figure 18. The PURE PAK NLL System

LIQUI-PAK 820-A

LIQUI-PAK INTERNATIONAL BV produces the LIQUI-PAK aseptic packager which is marketed in the U.S. by LIQUI-PAK INTERNATIONAL INCORPORATED of St. Paul, Minnesota. Ultra-violet light accompanying a low 0.1% H_2O_2 concentrate spray has a synergistic microbial killing effect. This is an

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65 James Russo and Robert Bannar, "Aseptic Packaging: How Far Will It Go?," Food Engineering 53 (March 1981):7.

important technical advance making the 820-A the only paperboard-based aseptic packager to meet H_2O_2 residual guidelines prior to package sterilization. A hermetically sealed, plastic positive displacement bellows accomplishes filling into bottom-sealed, aluminum foil/polyethylene/paperboard, gable top cartons. The bellows are easily

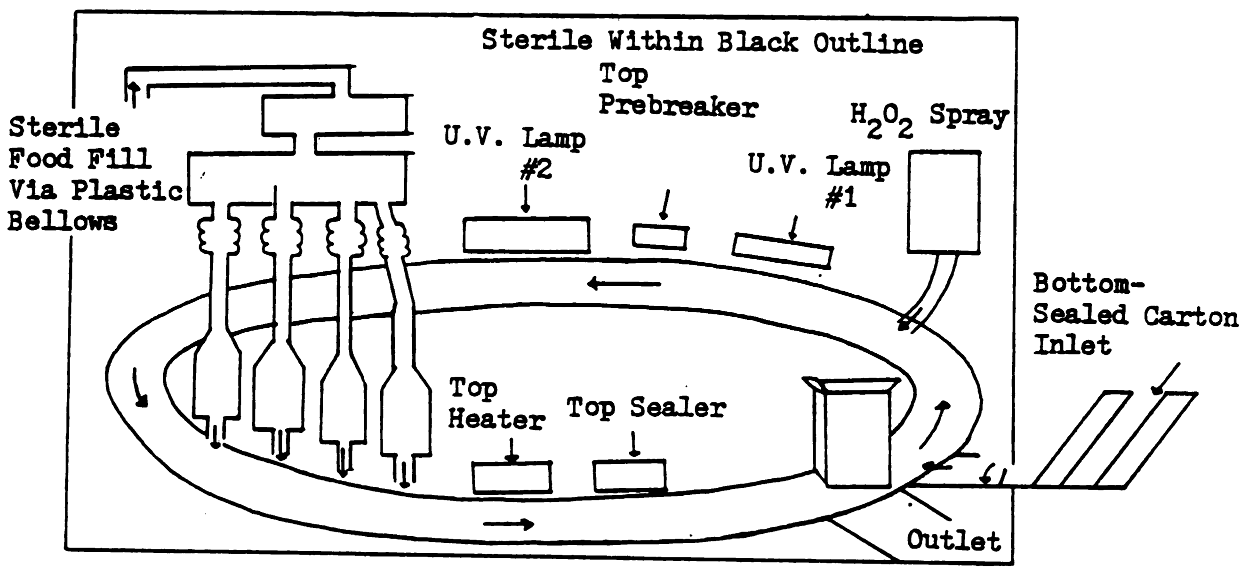

Figure 19. The LIQUI-PAK HFS Process

replaced and the system has full C.I.P. (clean-in-place) capability. A sterile steam flush is available. The 820-A went commercially aseptic in 1981. Only low acid products are presently being aseptically packaged with the 820-A. Figure 19 outlines the LIQUI-PAK horizontal fill-seal process.

COMBIBLOC cF 5.000, 6.000 and 10.000

Blocpak Incorporated, a division of PKL PAPIER-UND KUNSTSTOFF-WERKE LINNICH GmbH of West Germany, manufactures an array of horizontal-form-fill-seal HFFS equipment. The packages produced tend to be square on length and width dimensions. The PE/Aluminum foil/PE/Paperboard/PE material is supplied by PKL, but will soon be domestically available under license from RJR ARCHER INCORPORATED in Columbus, Ohio. High speeds up to 10,000 BLOCPAKS per hour are attainable even for one liter sizes. Very amenable paper-based system terms of sale and operation are BLOCPAK system ingredient. Available aseptic package equipment suppliers are becoming negotiable on certain terms of sale in order to remain competitive with BLOCPAK. The BLOCPAK cF 10.000 aseptic operation appears in Figure 20. Since this system does not seal through the product, larger particulates can be packaged than with the BRIK PAK machines. BLOCPAK is second behind BRIK PAK in operational aseptic units world-wide. Acquisition and installation including tax, duty and freight charges run about $436,000 with a cost per thousand packages of $50.30 for the cF 6.000 model.[66]

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[66] Private industry sources.

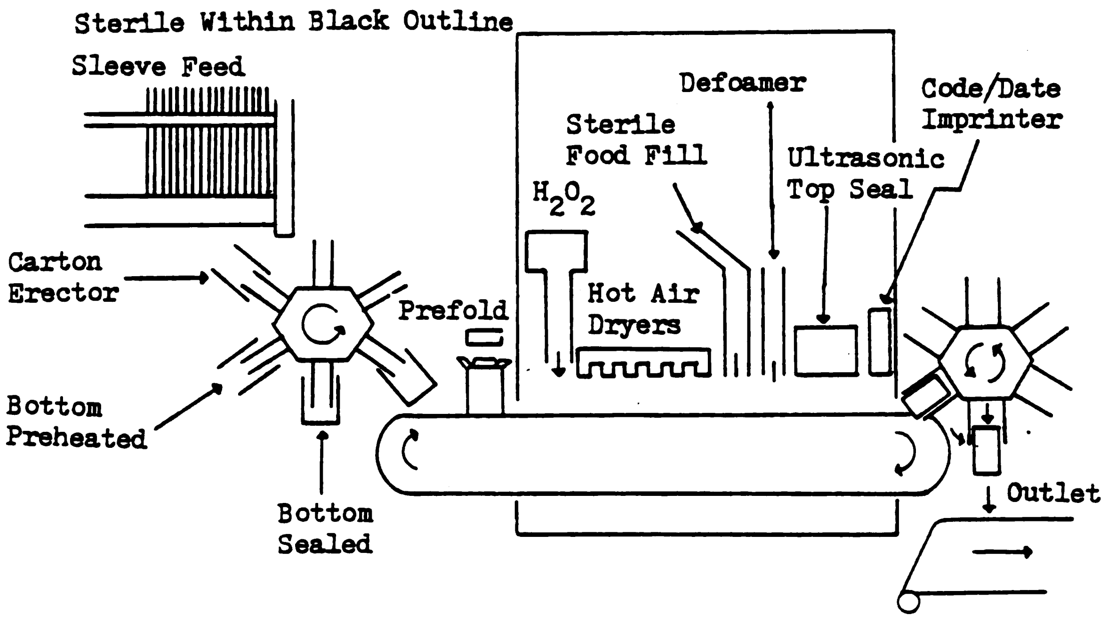

Figure 20. The BLOCPAK cF 10.000 Operation

<u>Aseptic plastic-based packaging systems</u>

The domestically available plastic-based aseptic packaging systems are now assessed. Table 17 exhibits their characteristics. Since all these systems do not seal through the product, small particulates can be hermetically heat sealed inside the thermoforms as long as the particles can be kept out of the heat sealing area. High barrier co-extruded plastic is supplied by BALL PLASTICS CORPORATION, COBELPLAST (CONTINENTAL CAN COMPANY U.S.A.) AND COMPOSITE

CONTAINER CORPORATION. As before the web-fed processes are discussed first.

SHASTA BEVERAGES CAPRI SUN Fruit Drink is produced under license from Germany's DEUTSCH SI SI-WERKER. The pouch is a free-standing gusset-bottom AMERICAN CAN CO. design. The material is a PE/Al foil/PP laminate akin to retort pouch material.[67] This is a hot fill system utilizing similar U-H-T-S-T food sterilization systems, but then the hot filled fruit drink to sterilize the inner pouch surface achieving a shelf stable product.

BOSCH SERVAC 78 AL/AS

BOSCH PACKAGING MACHINERY'S HOFLIGER & KARG division manufactures two aseptic thermoform-fill-seal machines and is sold in the U.S. by BOSCH PACKAGING MACHINERY in Piscataway, New Jersey. Both systems are operationally identical but are designed for different materials. The SERVAC 78 AS handles plastic coextrusions and the SERVAC 78 AL fabricates aluminum foil/plastic laminates. BOSCH went aseptic with the SERVAC in 1980 but had previous aseptic packaging systems on the market since 1975. The SERVAC is nearly maintenance free and fully enclosed streamlining operational procedures. All other aseptic packaging equipment surveyed is electro-mechanically and pneumatically actuated; only the

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[67] James Peters, "Cost, Consumer Appeal Spur Development of Flexible, Foil Laminated Packages," Food Product Development (November 1979):34.

SERVAC is hydraulically driven. Nitrogen headspace flushing is available. A 50% H_2O_2 50°C water bath sterlizies cup body material while only a 35% H_2O_2 water bath sterilizes the lidding material. Figure 21 outlines the SERVAC 78 AL/AS process. The SERVAC is the largest and also the fastest aseptic packager currently available.[68] Shrink wrapping and case packing equipment is also available from BOSCH. Acquisition costs are in the $1,000,000 neighborhood.[69]

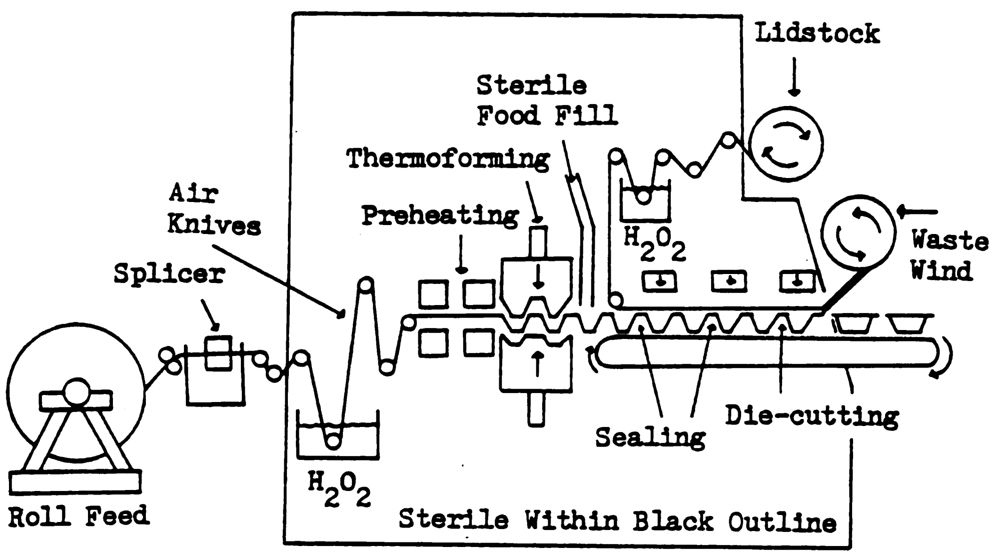

Figure 21. The SERVAC 78 AS and 78 AL/AS Process

68 BOSCH PACKAGING MACHINERY SERVAC 78 AS and 78 AL/AS specifications.

69 Private industry sources.

CONTINENTAL CAN CONOFFAST unit

CONTINENTAL CAN COMPANY U.S.A. introduced the French ERCA NEUTRAL ASEPTIC SYSTEM (NAS) in 1982 although a nearly identical system has packaged aseptically in Europe since 1965. NAS refers to sterilization without chemical sterilents. The CONOFFAST system receives a coextruded web from which a single layer, usually polypropylene (PP), is delaminated and wound up once entering the sterile environment. This exposes a sterile surface created during coextrusion by the extreme coextrusion temperatures. The other aseptic packaging system available in the U.S. that meets the FDA chemical residual regulation prior to sterilization is the LIQUI-PAK 820-A. FDA regulations limit residual H_2O_2 to 0.1 parts per million on the package material and to 1.0 parts per million in the surrounding work area atmosphere.[70, 71] Only plastic coextrusions can be packaged aseptically on the CONOFFAST system. Induction sealing is available via the aluminum foil/plastic laminate lids. Nitrogen flushing can also be accomplished. The CONOFFAST system possesses the high thermoforming rates and a wide range of package dimensional guidelines. Nonaseptic clean and normal packaging modes are available with little downtime on the CONOFFAST as

70 George Allan, "Aseptics: Sterile Packs with a Fertile Future," Packaging Digest 19 (September 1982):68.

71 V.R. Carlson, "METAL BOX FRESHFILL Aseptic Packaging System," paper presented at the National Food Processors Association meeting on February 7, 1983 in Los Angeles, CA., p. 5.

on most other aseptic units. Limited downtime is substantiated by performance in Europe. More than one flavor of product can be packaged at the same time, and die cutting the lidding material creates multiple packs. The CONOFFAST system is extremely complicated making proper mechanic and operator training a must. Figure 22 shows the CONOFFAST HTFS procedure. Acquisition costs are also in the $1,000,000 range.[72]

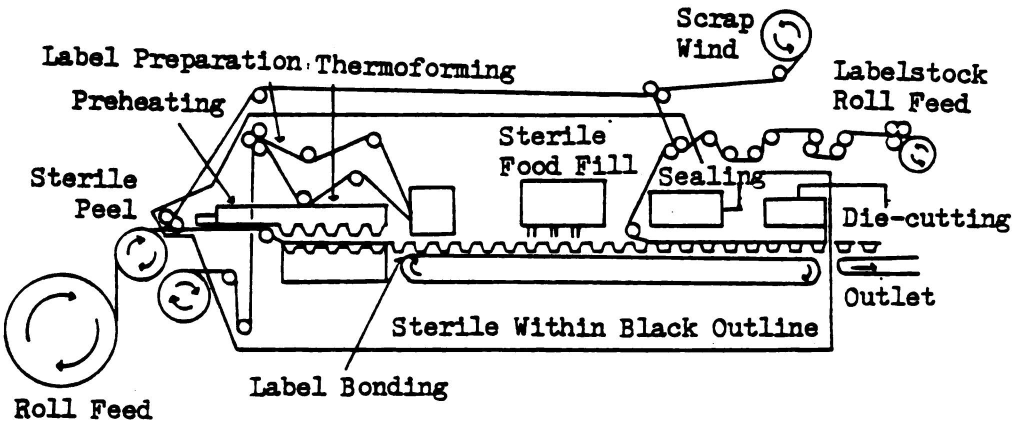

Figure 22. The CONOFFAST HTFS Procedure

BENCO ASEPACK Systems

BENCO U.S.A. markets two aseptic units, the ASEPACK 2 and the ASEPACK 24, for its parent company, BENCO of Italy. Mr. Scott Vivian is the U.S. BENCO representative. The ASEPACK went commercially aseptic in Europe in 1977 and has

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72 Private industry sources.

not yet sold a unit in the U.S. The ASEPACK model numbers refer to the package output per hour as multiples of 1000. The ASEPACK 2 is limited to low quantity production, most likely research and development. An ASEPACK 2 can be acquired for approximately $250,000 versus the one million dollar investment required for the ASEPACK 24.[73] Any roll fed thermoformable plastic sheet can be used. The lid and cup materials are sterilized in a 35% H_2O_2 75°C water bath with hot sterile air creating a H_2O_2 vapor which sterilizes inner machine surfaces. The cups are sealed with heat and pressure after nitrogen flushing the headspace. BENCO guarantees high outputs, 24,000 units per hour, as a term of sale and slightly reduced factory space is also an ASEPACK forte. Automatic case packers, straw and spoon applicators are available. Figure 23 outlines the ASEPACK 24 packaging system.

ASTEC METAL BOX FRESHFILL

ASEPTIC TECHNOLOGY ENGINEERING COMPANY, ASTEC, of Cedar Rapids, Iowa, markets the METAL BOX FRESHFILL System developed by METAL BOX P.L.C. of the United Kingdom. The packager utilizes any preformed coextruded or single component plastic or aluminum cups with membrane lids. Because of operational simplicity and lower cost, this deposit-fill-seal system will likely be implemented before the previously

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73 Scott Vivian, "Aseptics: Sterile Packs with a Fertile Future-Part 2," Packaging Digest (October 1982):123.

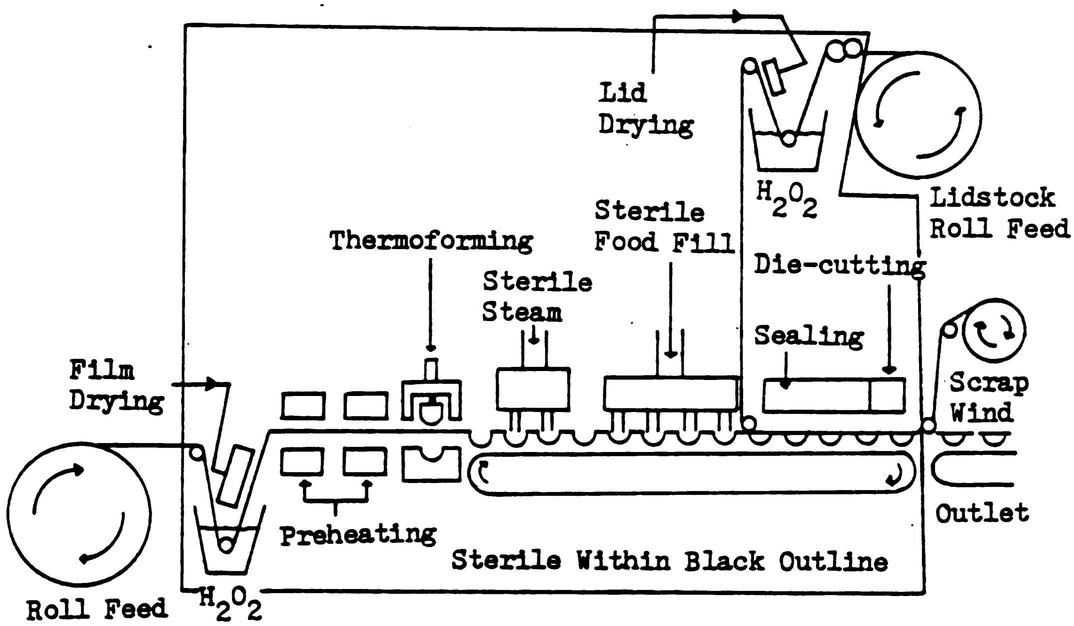

Figure 23. The BENCO ASEPACK 24 Unit

discussed plastic thermoform-fill-seal (TFS) units. Thirty-five percent (35%) H_2O_2 and hot air dryers achieve commercial sterility of the cup body, lidding and internal equipment surfaces. The system has been tested since 1972 to reach the ultimate metal canning failure rate of one in 10,000 units. Most of the other aseptic systems on today's market only one to three failures in 1000 units.[74] The sealing process utilizes a plastic bead which when debossed during heat sealing greatly increases the lid to cup seal strength. Impulse heat sealing debosses the bead from the lidding material and requires polymer to polymer contact. Sterile steam flush and air filtration systems are available too. Single to multiple lane versions, 1, 4 and 6 lanes, are

74 ASTEC INCORPORATED, METAL BOX FRESHFILL Aseptic System Specifications (in-house publication), 1983.

available. Moderate operating rates and quick changeovers are its strengths.[75] Cup and membrane responsibilities are shifted to the supplier. A unique particulate food product actuated filler developed along with Raque, Inc. allows packaging viscous particulate-matter food up to 5/8 inch cubes on the FRESHFILL system. The METAL BOX FRESHFILL horizontal deposit-fill-seal system appears in Figure 24.

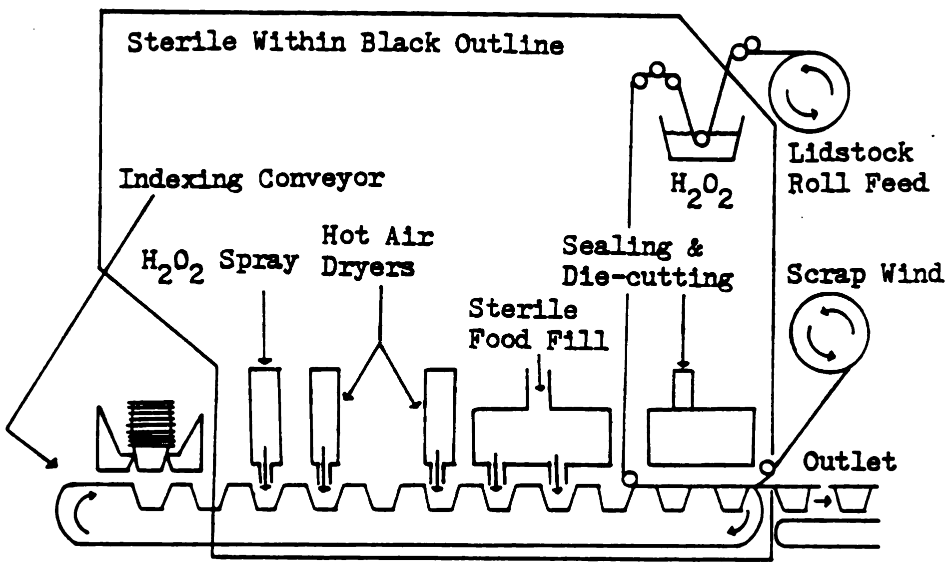

Figure 24. The METAL BOX FRESHFILL HDFS System

Miscellaneous aseptic packaging systems

Aseptic bulk methods are available from Scholle Corporation. Bulk packaging systems receive previously formed, sealed and sterilized plastic bags which are then opened,

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[75] V.R. Carlson, "Aseptic Processing and Packaging, A Short Course," International Food Technologist Presentation University of Florida, Gainesville, 14-16 September, 1982, pp. 1-2.

filled and resealed in a sterile atmosphere. Typically bag-in-box product/package systems are economical only for bulk sizes. Aseptic pouch and composite can systems are also entering the market, however, these lack the necessary operational experience. Pouch and bag-in-box systems are not applicable to this research, so further discussion is not warranted. The DOLE aseptic packaging system operates at such high temperatures that only metal cans can be utilized. The metal can's heavy weight and high material cost detract from distribution savings, so the DOLE system is not viable for this COJ application. The DOLE/BOISE CASCADE aseptic composite can system is an innovative and very compatible method which may be implemented for ACOJ packaging once operational modifications can tightly control residual headspace oxygen levels. However, the aluminum foil layer containing composite can material cost presently makes this system too costly versus the previous paperboard aseptic packaging units.

ACOJ Package System Selection

The viable domestically available aseptic packaging systems have now been investigated. An optimum method can be ascertained from the ten choices upon consideration of ACOJ requirements. The number one objective is a sterile final product/package unit. Only systems with extensive operational experience and intimate processing knowledge of ACOJ can ensure maximum continuous manufacturing. Secondly, it has been shown that little or no oxygen in the headspace can be tolerated by the ACOJ nutritional, flavor or odor characteristics.[76] Thirdly, residual H_2O_2 levels must be held to extremely small margins to meet legal regulations and to preserve vitamin C and color content. Fourthly, the system must have published operating and acquisitional expense data that is available for reference. Currently ACOJ is being aseptically packaged in one liter BRIK PAKS on an AB-3 by JOHANNA FARMS for institutional sale and by BROOKS PRODUCTS SUN GLO POP COMPANY for retail sale.[77] On the basis of this fact and the previous objectives, the BRIK PAK AB-8 and AB-9 packaging systems are the logical choice.

The ACOJ BRIK PAK Line

The selected BRIK PAK system is now developed in detail for ACOJ packaging. The models utilized are two AB-8s and one AB-9. Since the study's proposal is a new product introduction, the product mix should be limited. The presently available U.S. BRIK PAK sizes are 236.5ml., 250ml., 940ml. and one liter. However, by early 1984, the identical 6, 12, 16, and 32-ounce sizes seen in the FCOJ market will be available from the Denton, Texas facility.[78] Thus the same portions and production size mix as those in FCOJ

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[76] Kanner et al., p. 429.

[77] Personal communication with Rita Simpson of BRIK PAK INC. on March 15, 1983.

[78] Personal communication with Mr. Ron Miller of BRIK PAK INC.

processing and packaging are available for ACOJ packaging. From Hooks and Kilmer, the COJ production size mix is 21.6% for six ounce, 52.9% for 12 ounce and 25.5% for 16 ounce.[79] As mentioned earlier, 32-ounce FCOJ production cost data was not available, so it is not assessed in the study's model. Further product introductions are beyond the scope of this thesis, so only portion variations are considered.

Production output is limited by the BRIK PAK fillers (6000 units per hour), so more than one aseptic filler is required. Aseptic surge tanks provide a buffer, so that some deviation in ACOJ processing and packaging is tolerable. Previously the ACOJ sterilizer, the CHERRY BURRELL NO BAC 600, was matched to the estimated TASTE concentration output, 2,666 gallons per hour for ten hours per day. The extra daily production time left is another buffer for this highly seasonal industry. Utilizing the aforementioned production size mix, Table 18 delineates the number of aseptic packaging units necessary. The four-hour excess

Table 18. Number of Brik Pak Packaging Systems

Portion	Production Size Mix	Required Output (gal/day)	Required Output (units/day)	6000 Unit/ Hr Production Hours	Adjusted Hours of Production /PKGG Unit
6 oz.	21.6%	5,753	122,731	20.45	21.0
12 oz.	52 9%	14,090	150,293	25.0	21.0
16 oz.	25.5%	6,792	54,336	9.0	14.0

79 Dr. Kilmer and Dr. Hooks, pp. 4-6.

requirement on the 12-ounce AB-8 system is handled on the remaining capacity on the 16-ounce AB-8 unit. Two AB-8s and one AB-9 are needed to package the NO BAC 600's daily output. However, two 6,000 gallon aseptic surge tanks allow this matching.

Secondary packaging systems employed are traywrapping, shrinkwrapping, automatic palletizers and forklift handling. The traywrappingg and shrinkwrapping systems utilized are produced by A-B-C Packaging Machine Corporation. Multipack shrinkwrapping is not utilized, since many people will not wish to purchase ACOJ in multiples of three. Each AB packager requires a traywrapper. Their ten tray per minute capacity is adequate. Since the 16-ounce AB-8 line is off-line on third shift, the best operation is to have a separate line for it from this point on. The other two lines converge through a single shrinkwrapper, a shrink tunnel, an autopalletizer and a forklift takeaway. The single ACOJ BRIK PAKs are checkweighed on RAYMOND AUTOMATION checkweighers prior to tray and shrinkwrapping. Figure 25 illustrates the entire packaging line layout.

The trays are shrinkwrapped in one mil low density polyethylene (LDPE) film. Two B-flute corrugated partitions are inserted prior to tray shrinking to increase tray strength. The B-flute trays are stacked ten layers high. Six-ounce BRIK PAKs result in a pallet load of 150 trays. Twelve and sixteen-ounce BRIK PAKs equal pallets of 120 and 80 trays, respectively. Warehoused 40 inch x 48 inch

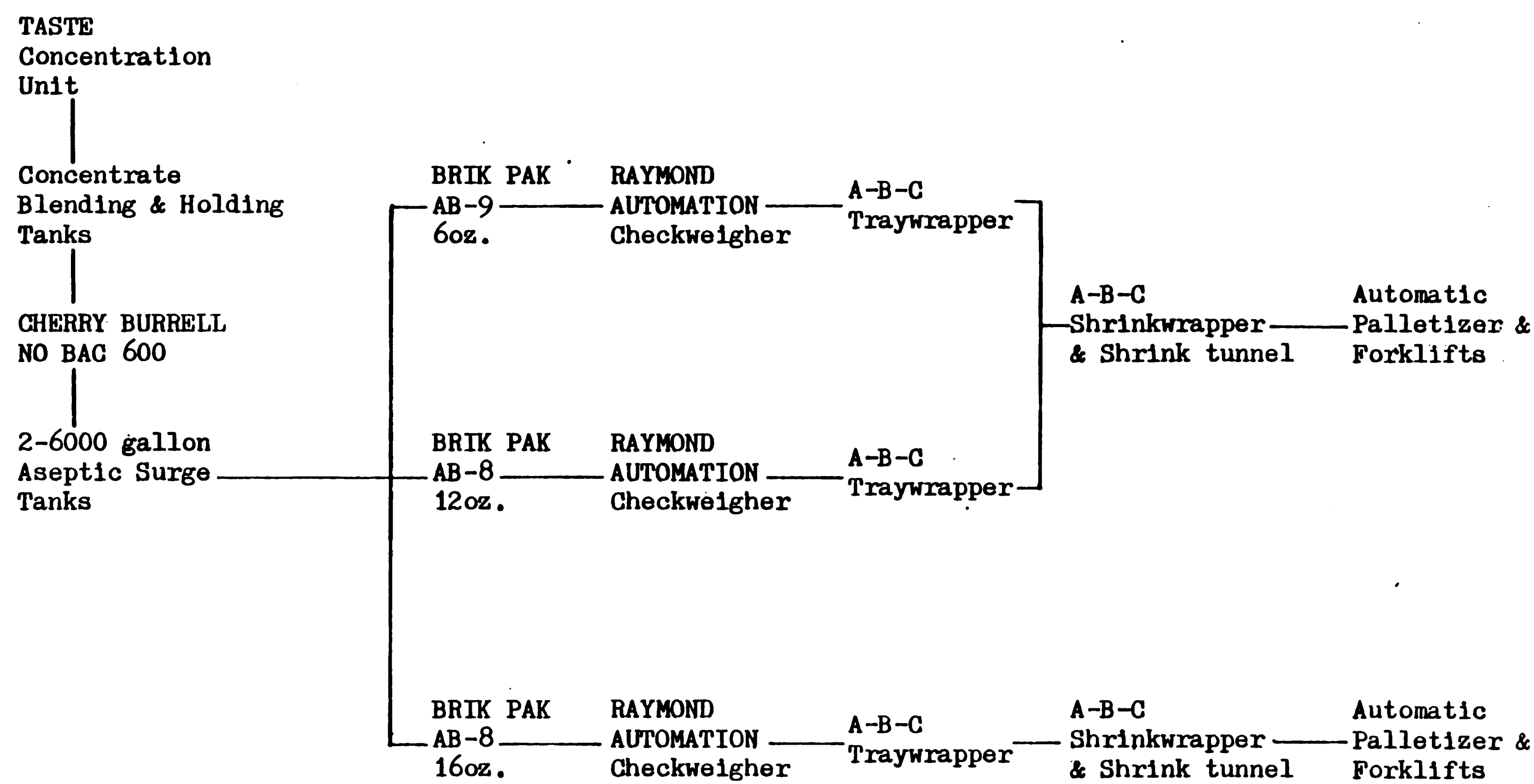

Figure 25: ACOJ Packaging Line Layout

pallets are stored two high. Intransit pallets are not stacked since load weigh out occurs before the floor area is covered. Twenty six-ounce, 13 12-ounce and 14 16-ounce pallets can be shipped in a 40,000 pound tare weight common carrier.

The corrugated trays support the BRIK PAK sidewalls enchancing stacking heights and lowering overall brik fragility. Plastic banding around traylayers of the pallets increases load stability further. Shrink film and the partitions prevent inter-BRIK PAK abrasion from vibration. BRIK PAK's surprising shock strength arises from the zero headspace created at sealing. Since package failure via shock or vibration input requires an increase in package volume, which is available only when a headspace exists, the headspace-free BRIK PAK cannot be readily expanded by shock or vibration inputs.

Further recommendations for retailing the ACOJ BRIK PAKs are possible. The BRIK PAKs utilize rotogravure printing and a special point-of-purchase display to stimulate sales. The display is situated as near as possible to the ready-to-serve SSOJ refrigerators with the actual ACOJ placed next to the SSOJ in the refrigerators. The display, television and womens' magazine advertising should educate the consumer on the new product and package. How to open the package, mix the product and nutritional statements should be stressed. The above system is partially adapted from the present distribution environment of the HI-C BRIK PAK.[80] Appendices 4 and 5 demonstrates the quantification of pallet load and shipping weights for the ACOJ and FCOJ operations.

Having developed the current optimum aseptic processing/packaging system for ACOJ and investigated current FCOJ processing and packaging methods, ACOJ's economic advantages are calculated versus the predominant FCOJ system in July 1983 dollar terms in Section 4.

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[80] Personal communication with Mr. Bob Halladay of ASSOCIATED GROCERS in Holt, MI., on March 29, 1983.

Section 4:

Frozen and Aseptic

Concentrate Orange Juice

Total System Cost Comparison

Actual cost implications are now investigated over a single year at July 1983 prices. These calculations are based on the previously determined production parameters in Section 1. Total system costs are the sum of investment and operating expense throughout production and distribution activities. Table 19 reviews the main production parameters.

Table 19. ACOJ and FCOJ Productions Parameters

ACOJ	Parameter	FCOJ
26,634 gal/day	Output/Day	26,634 gal/day
Three	Shifts/Day	Two
7 of 8 hours	Actual Output Time/Shift	7 of 8 hours
170 days	Production Year	170 days
4,527,915 gal	Output/Year	4,527,915 gal

Source Justification

Two key publications are utilized along with assorted industry sources to produce meaningful cost figures. Wood's study, a cost estimation for selected model fluid UHT milk plants, contained many figures helpful to this research.[81] NO BAC 600 operating, aseptic surge tank, corrugated tray, shrink wrap and building costs are developed from Thomas Wood. The validity of these values are sound, since identical output rates and balancing differences exist between the two systems. A less severe processing temperature is required by the concentrate orange juice's pH (approximately 210°F for 30 seconds) thereby ensuring a cost estimate on the conservative side.[82] These Wood study January 1981 costs are brought up to July 1983 values by appropriate 1981-1982 and 1982-1983 producer price index rates.

The second main expense source dealt with FCOJ processing, selling and warehousing (inbound only) costs. Kilmer and Hooks published the 1979-1980 season costs which are acceptable, since it was the last undisturbed orange crop from freezes. This weather votality is dissipating with the importation of Brazilian FCOJ. 1983 costs are reached by applying a trend analysis on 48 6-ounce cases of FCOJ over the 1978-1979 and 1979-1980 seasons.[83] Each cost area variation is summed and divided by two producing an average

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[81] Thomas Michael Wood, "Estimated Costs for Selected Model Ultra-High-Temperature Fluid Milk Processing Plants," M.Sc. thesis, North Carolina State University at Raleigh, 1981.

[82] Robert Ellis, "Ocean Spray Pioneers in Aseptic Packing of Juices," Food Processing, 43 (January 1982): 104.

[83] Dr. Kilmer and Dr. Hooks, p. 16.

cost area increase per year. Each 3 year inflation adjustment value is multiplied by its corresponding 1979-1980 value resulting in a July 1983 figure (Appendices 5 and 6).

FCOJ costs were reported in Kilmer and Hooks in dollar per case expense area figures. Fortunately the production volumes indicated the production size mix among portions to be: 980,906 gallons for 6 ounces, 2,393,734 gallons for 12 ounces, and 1,153,275 gallons for 16 ounces annually of 45° Brix retail packs. Assuming this mix is relatively unchanged, the portional breakdown provided a method to calculate a total dollar cost for every functional area. Appendix 10 analyzes both FCOJ and ACOJ production lines verifying each daily production time requirement.

The study makes the assumption that an immediate 100 percent conversion to aseptic production is under consideration. In this manner, the entire effect of its introduction is quantified. As developed in Section 1, the actual shelf life of the FCOJ and ACOJ is likely to be identical on a yearly average during introduction. Consumer buyer behavior is never altered easily, and so retail customers would probably purchase only enough ACOJ to last until the next shopping trip. Since this final consumption point drives the distribution channel, no increased savings accrue from an available extended shelf life. Having addressed these factors, the thesis turns to the bottom line or actual cost elements under consideration.

Capital Investment

Land and building

Capital investment subsists of acquiring and installing new land, building and equipment. For this analysis, the acquisition and development of new land is deemed unnecessary because of the little extra space needed. Aseptic building space modifications are calculated in Wood.[84] Wood also reported these construction costs as $38/square foot.[85] By adjusting for inflation, 1983 costs are estimated at $44.3/square foot.[86] Table 20 enumerates the construction outlays.

Table 20. Building Modification Costs

Functional Area	Space Modified or New (ft^2)
Processing	1129.
Filling	2010.
Clean-In-Place Room	288.
Total	3427. ft^2 x $44.3/$ft^2$ = $151,800.

Equipment

The majority of investment and installation arises from new equipment expenditures. A summary of equipment costs appears in Table 21 along with their various sources. Used

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84 Thomas Wood, p. 69.

85 Ibid., p. 68.

86 Econom.c Report of the President to Congress, by Martin Feldstein, Chairman of the President's Council of Economic Advisors, Washington, DC, U.S. Government Printing Office, February 1983, p. 232.

Table 21. Total Aseptic Equipment Cost

Aseptic Equipment Needs	Dollar Value
No Bac 600-UHTST Spiratherm[87]	$ 250,000
2-6,000 gal Aseptic Surge Tanks[88]	330,000
Filling and Tray Line[89]	1,069,000
Aseptic Total less installation	1,649,000
Installation at 25 percent	412,200
Aseptic Total with installation	2,061,200
Less Excess FCOJ Equipment	
2-Used 61-H Seamers[90]	(47,700)
1-Used Composite Can Unscrambler/ Cleaner[91]	(20,000)
2-Used CA-109 Case Packers[92]	(22,500)
1-Used FCOJ Piston Filler[93]	(15,000)
Total Aseptic Equipment Cost	1,956,000

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87 Private industry sources.

88 Thomas Wood, p. 71.

89 Private industry sources.

90 Personal communication with Mr. Harry Nelson of ANGELUS SANITARY SEAMER in Los Angeles, CA.

91 Personal communication with Mr. Joe Miller of NEW ENGLAND MACHINERY, INCORPORATED.

92 Personal communication with Sue Neets of INTERNATIONAL PAPER COMPANY of Miami, FL.

93 Personal communication with Mr. Bill Ellison of PACKWEST MACHINERY COMPANY.

FCOJ seamers and case packers are shown because they are subtracted from the new aseptic machinery cost to arrive at total equipment cost. Twenty-five percent of 1983 prices are utilized for the good condition used machinery.[94] Installation costs are assumed to be 25 percent of entire new equipment cost.[95] Aseptic surge tank cost is inflation adjusted by values from the president's economic report.[96]

Capital investment costs must be transformed into equivalent uniform annual costs to allow inclusion in yearly operating expenditures. A capital recovery formula utilized by Wood accomplishes this.[97] The study's interest rate is

$$A = P\frac{(i(1 + i^{n})}{((1 + i)^{n} - 1)}$$

Where: A = Equivalent Uniform Annual Cost (EUAC)
P = Total Investment Cost
i = Interest Rate
n = Economic Life of the Asset

estimated as 13 percent, which is a few points above the current rate. Building and equipment generally have a useful economic life of 20 years.[98] To best determine profitability, the 20-year period is utilized.[99] Table 22

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94 Private industry sources.

95 Thomas Wood, p. 71.

96 Council of Economic Advisors, p. 232.

97 Ibid., p. 33.

98 Ibid., p. 33.

99 Ibid., p. 34.

outlines the total aseptic investment cost and reports the equivalent uniform annual cost (EUAC) of the aseptic conversion.

Table 22. Total Aseptic Capital Investment and EUAC

Land	---
Building	$ 151,800
Equipment	1,956,000
Total Capital Outlay	2,107,800
EUAC	$ 300,100

Operating Costs

Operating costs include all costs (excluding investment) incurred in getting a finished good out of raw material and to the point of sale. These values tend to vary with output, but our sample compares on an equivalent yearly output rate. This allows valid yearly cost comparisons. All costs are collected for comparison on a dollar per gallon and a dollar basis. Orange costs are not included in the analysis because of wide price fluctuations and commonality to both compared systems.

Labor

FCOJ labor figures are readily available.[100] The FCOJ 16 packaging line operators are freed to be applied to the aseptic processing and packaging line. The FCOJ operation only operates two shifts per day, eight hours per shift on a yearly average. ACOJ labor requirements are 17 workers for two shifts and eight on a third shift. Both lines are

[100] Dr. Kilmer and Dr. Hooks, pp. 4-6.

assumed to operate six days per week on the average. Table 23 shows direct labor hour (DLH) per week estimates for the NO BAC 600.[101] Table 24 describes the ACOJ labor cost addition to existing FCOJ labor developed in Table 25. An

Table 23. NO BAC 600 Labor Requirements

Functional Area	DLH/Week	
Clean up	20	
Sterilizing	252	
Relief	40	
Overtime (5%)	15	
Total	307	at 6 days/week at 16 hours/day = approximately 3 persons/hour.

Table 24. Aseptic Labor Cost Addition

Number of Extra Workers		DLH/Year
1 for 2 shifts = 1 * 16 * 6 * 170	=	16,320
8 for 1 shift = 8 * 8 * 6 * 170	=	65,280
Aseptic Addition Total DLH		81,600
Wage and Benefit Rate ($12/Hour)		979,200
Cost per COJ gallon		$ 0.2162

hourly wage rate of $12/hour (including benefits) is utilized for estimating ACOJ sterilizer and packaging operator wage rates.[102] Table 25 compares ACOJ and FCOJ labor needs across operational layouts. Each system utilizes two roving quality control inspectors. No difference exists in the amount of labor required for all COJ processing activity up

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[101] Thomas Wood, p. 73.

[102] Private industry estimates.

Table 25: FCOJ & ACOJ Production Line Labor Needs

FCOJ-16 total for 2 shifts per day

Concentrate Blending & Holding Tanks → NEW ENGLAND MACHINERY Unscrambler & Cleaner (2) → PACK WEST MACHINERY Piston Filler (2) →

- ANGELUS SANITARY 61-H Seamer (2) → INTERNATIONAL PAPER CA-109 Case Erector/Packer/Sealer (1) → Automatic Palletizer & Forklift (1)
  - RAYMOND AUTOMATION Checkweigher (1)
- ANGELUS SANITARY 61-H Seamer (2) → INTERNATIONAL PAPER CA-109 Case Erector/Packer/Sealer (1) → Automatic Palletizer & Forklift (1)
  - RAYMOND AUTOMATION Checkweigher (1)

+ 2 roving quality control inspectors.

ACOJ-17 for 2 shifts & 8 on 3rd. shift

Concentrate Blending & Holding Tanks → CHERRY BURRELL NO BAC 600 (2) → 2-6000 gallon Aseptic Surge Tanks (1) →

- BRIK PAK AB-9 (VFFS) 6oz. (1) → RAYMOND AUTOMATION Checkweigher (1) → A-B-C Traywrapper (1) → A-B-C Shrinkwrapper & Shrink tunnel (.5) → Automatic Palletizer & Forklift (1)
- BRIK PAK AB-8 (VFFS) 12oz. (1) → RAYMOND AUTOMATION Checkweigher (1) → A-B-C Traywrapper (1) → (same A-B-C Shrinkwrapper & Shrink tunnel (.5) → Automatic Palletizer & Forklift (1))
- BRIK PAK AB-8 (VFFS) 16oz. (1) → RAYMOND AUTOMATION Checkweigher (1) → A-B-C Traywrapper (1) → A-B-C Shrinkwrapper & Shrink tunnel (.5) → Automatic Palletizer & Forklift (1)

to steps following the concentrate blending and holding tanks, so these laborers are ignored. Table 26 indicates FCOJ labor costs as reported by Kilmer and Hooks.[103] No additional indirect or payroll taxes and insurance is assessed. The weighted average cost is determined via the 1979-1980 production mix mentioned earlier.

Table 26. FCOJ Labor Costs

	Portion	$/gallon	Gallons/Year	Yearly $
A. Direct Labor				
	6 oz.	0.1278	980,906	125,360
	12 oz.	0.1279	2,393,734	306,158
	16 oz.	0.1281	1,153,275	147,734
	Direct Labor Total			579,300
B. Indirect Labor				
	6 oz.	0.0615	980,906	60,326
	12 oz.	0.0617	2,393,734	147,693
	16 oz.	0.0629	1,153,275	72,541
	Indirect Labor Total			280,600
C. Payroll Taxes and Insurance				
	6 oz.	0.0324	980,906	31,781
	12 oz.	0.0326	2,393,734	78,036
	16 oz.	0.0329	1,153,275	37,943
	Payroll Taxes and Insurance Total			147,800

D. Total FCOJ Labor Cost = $1,007,700/year
Total FCOJ Labor $/gal = 0.2226/year

Material

Materials mainly consist of packaging material and other miscellaneous items. FCOJ pa·kaging requires premade composite cans, corrugated cases, pallets, strapping material and glue. ACOJ packaging necessitates roll-fed BRIK PAK

103 Dr. Kilmer and Dr. Hooks, pp. 4-6.

material, tape, H_2O_2, and corrugated trays with partitions, low density polyethylene (LDPE) shrink wrap, pallets and glue. Table 27 estimates ACOJ material costs.[104, 105] Appendix 7 itemizes ACOJ packaging material costs on a daily basis.

Table 27. ACOJ Material Costs

Material		Yearly Cost ($)
BRIK PAKs (4¢/Brik)		$ 2,227,400
Corrugated Trays (24.4¢/tray)		479,500
Shrinkwrap (1.6¢/tray)		31,200
Wasted BRIK PAKs		5,100
Other Waste and H_2O_2		7,600
Total ACOJ Material Cost	=	2,750,800
Total ACOJ Material Cost $/gal	=	0.6075/ year

Table 28 describes current FCOJ material costs.[106] Each unit cost is multiplied by its portion's yearly volume to develop a total yearly FCOJ material cost.

Table 28. FCOJ Material Costs

	Composite Cans		Shipping Cartons		Other	
Portion	$/gal	$/year	$/gal	$/year	$/gal	$/year
6 oz.	0.7943	779,100	0.0632	62,000	0.0044	4,300
12 oz.	0.5431	1,300,000	0.0605	144,800	0.0035	8,400
16 oz.	0.5201	599,800	0.0529	72,500	0.0039	4,500
Subtotals		2,678,900		279,300		17,200

Total FCOJ Material Cost = $ 2,975,400/year
Total FCOJ Material Cost $/gal = 0.6571/year

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104 Thomas Wood, p. 76.

105 Private industry estimates.

106 Dr. Kilmer and Dr. Hooks, pp. 4-6

Other Processing Costs

In addition to labor and material, other processing inputs consist of the following items: utilities, maintenance and repairs, depreciation and rent, machine royalties, taxes and insurance, and miscellaneous costs. In order to ascertain actual ACOJ other processing costs, overlapping outlays between the ACOJ and FCOJ systems must be subtracted out of each effected FCOJ other processing value. Then total additional ACOJ expenses can be added to the uncommon FCOJ category cost (which is the ACOJ cost base) producing total ACOJ costs.

Utilities

Utilities include electricity, water compressed air, and natural gas produced steam. Cost values are \$.06/KWH and \$.02/m^3 of compressed air.[107] Water expense is set at \$1.00 per 1000 gallons and natural gas (for steam production and plant heating) at \$2.7464 per million cubic feet (MCF).[108] Eliminated cooling costs arise from the NO BAC 600 accepting 70°F. COJ versus the previous -5°F. FCOJ filling temperature. Aseptic production still requires cooling from 70°F. to 40°F. after packaging. Mr. Carlson provides the cooling costs in Table 29.[109] From Appendices 2 and 3, 45° Brix COJ is known to weigh 0.0752 lb/fluid ounce.

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[107] Private industry estimates.

[108] Thomas Wood, p. 78.

[109] V.R. Carlson, "Aseptic Processing and Packaging, a Short Course," p.2.

Table 29. Production Cooling Costs

A. Cooling Cost from 70°F. to 40°F.

Portion	Ounces COJ/yr	COJ wt (lbs)/yr	Cost Factor	Yearly Cost ($)
6 oz.	1.2556×10^8	9.442×10^6	$0.0056/lb	52,876
12 oz.	3.0640×10^8	2.3041×10^7	0.0056/lb	129,031
16 oz.	1.4762×10^8	1.1101×10^7	0.0056/lb	62,166
ACOJ Cooling Cost Total		=		244,000

B. Cooling Cost from 70°F. to -5°F.

6 oz.	1.2556×10^8	9.442×10^6	$0.0112/lb	105,752
12 oz.	3.0640×10^8	2.3041×10^7	0.0112/lb	258,080
16 oz.	1.4762×10^8	1.1101×10^7	0.0112/lb	124,331
FCOJ Cooling Cost Total		=		488,200
Final ACOJ Cooling Savings		=		244,200

Table 30 illustrates ACOJ and eliminated FCOJ utility expenses.

Table 30. Additional ACOJ and Eliminated FCOJ Utility Costs

ACOJ Utilities	Yearly Cost ($)	$/gal/yr
Electricity	65,100	0.144
Water	13,800	0.0030
Compressed Air	7,500	0.0016
Steam (natural gas)	91,800	0.0203
Nitrogen Gas	91,800	0.0203
Subtotal Additional ACOJ Utilities	211,200	0.0466
Overlapping FCOJ Utilities		
Electricity	8,800	0.0019
Compressed Air	14,800	0.0033
FCOJ Cooling Eliminated	244,200	0.0539
Common FCOJ Utilities	267,800	0.0591
Total Additional ACOJ Utilites	<56,600>	<0.0125>

FCOJ utilities published by Kilmer and Hooks and adjusted to 1983 values appear in Table 31.[110] FCOJ utility costs uncommon to the aseptic production line are also shown, which are added to total additional ACOJ utilities in Table 30 to collect total ACOJ utility expenses. Appendix 4 itemizes the additional ACOJ utility requirements on a daily basis. FCOJ utilities are on for 13 hours per day.

Table 31. FCOJ & ACOJ Total Utility Costs

Portion	Yearly Cost ($)	$/gal/yr
6 oz.	83,400	0.0850
12 oz.	207,100	0.0865
16 oz.	101,400	0.0879
Total FCOJ Utilities	391,900	0.0866
Plus Total Additional ACOJ Utilities	< 56,600>	<0.0125>
Total ACOJ Utilities	335,300	0.0741

Maintenance and repairs

Maintenance and repairs consist of supplies, mechanics, service contracts, emergencies, and parts for production machinery. These estimates arose from Kilmer and Hooks, A-B-C PACKAGING MACHINERY, INTERNATIONAL PAPER COMPANY, ANGELUS SANITARY SEAMER, PACKWEST MACHINERY, NEW ENGLAND MACHINERY, RAYMOND AUTOMATION, and private industry

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110 Dr. Kilmer and Dr. Hooks, pp. 4-6.

sources.[111-117] Table 32 describes additional ACOJ maintenance and repair costs. Appendix 8 itemizes additional ACOJ maintenance and repair costs on a daily basis.

Table 32. Additional ACOJ and Eliminated FCOJ Maintenance and Repair Costs

ACOJ Maintenance and Repair	Yearly Cost ($)	$/gal/year
Supplies	36,900	0.0081
Mechanics	12,200	0.0027
Service Contracts	6,300	0.0014
Emergencies	3,000	0.0007
Parts	13,500	0.0030
Subtotal Additional ACOJ Maintenance and Repair	71,900	0.0159
Eliminated FCOJ Maintenance and Repair		
61-H Parts	16,000	0.0035
CA-109 Parts	8,000	0.0018
Eliminated FCOJ Maintenance and Repair	24,000	0.0053
Total Additional ACOJ Maintenance and Repair	47,900	0.106

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111 Dr. Kilmer and Dr. Hooks, pp. 4-6.

112 Personal communication with Mr. Michael McKee of A-B-C PACKAGING MACHINERY, INC.

113 Personal communication with Sue Neets of INTERNATIONAL PAPER COMPANY, INC.

114 Personal communication with Mr. Harry Nelson of ANGELUS SANITARY SEAMER, INC.

115 Private industry estimates.

116 Personal communication with Mr. Bill Ellison of PACKWEST MACHINERY, INC.

117 Personal communication with Mr. Joe Miller of NEW ENGLAND MACHINERY, INC.

FCOJ maintenance and repair costs along with uncommon maintenance and repair are listed in Table 33. Again, the total additional ACOJ maintenance and repair costs from Table 32 are added to the total FCOJ maintenance and repair costs developed in Table 33.

Table 33. FCOJ and ACOJ Total Maintenance and Repair Costs

Portion	Yearly Cost ($)	$/gal/yr
6 oz.	75,000	0.0765
12 oz.	179,300	0.0749
16 oz.	83,000	0.0720
Total FCOJ Maintenance and Repair	337,300	0.0745
Plus Total Additional ACOJ Maintenance and Repair	47,900	0.0106
Total ACOJ Maintenance and Repair	385,200	0.0851

Remaining processing costs

Remaining processing costs are a summation of depreciation and rent, machinery or production royalties, taxes and insurance, and miscellaneous items. BRIK PAK U.S.A., INC. charges a variable production rental of two percent upon the material cost of every BRIK PAK filled creating a $44,600. increase in machine and product royalties. No other appreciable differences were identified in these areas. Thus other processing costs, less utilities and maintenance and repairs and the BRIK PAK royalty are depicted in Table 34.[118]

118 Dr. Kilmer and Dr. Hooks, pp. 4-6.

Table 34. ACOJ and FCOJ Remaining Processing Costs

Depreciation and Rent		Machine Royalties		Taxes and Insurance		Miscellaneous	
$/gal /yr	$/yr	$/gal /yr	$/yr	$/gal /yr	$/yr	$/gal /yr	$/yr
6 oz. Portion							
0.0507	49,700	0.0345	33,800	0.0146	14,300	0.0514	50,400
12 oz. Portion							
0.0511	122,300	0.0347	83,100	0.0136	32,600	0.0526	125,900
16 oz. Portion							
0.0506	58,400	0.0348	40,100	0.0144	16,600	0.0504	58,100
Sub Totals	230,400		157,000		63,500		234,400

Yearly Total Cost = $685,300
Yearly Total Cost $/gal = 0.1514

Transportation costs

Transportation costs seen here are outbound freight charges on finished goods. Inbound charges are contained in on-site warehousing expense. A geographic breakdown of the national FCOJ market published in Simmons 1979 Consumer Market Surveys is utilized to direct the processor's shipments to consumer markets. The market mix shown in Table 35 is assumed to have not changed significantly since 1979.[119]

Table 35. Transport Parameters

USA Region	Sales Distribution	Centrally Located City	Distance From Tampa, FL (miles)	Intraregional Travel (miles)
Northeast	23.8%	Albany, NY	1242	200
East Central	15.2%	Chicago, IL	1118	300
West Central	18.8%	Omaha, NE	1411	400
South	23.6%	Jackson, MS	968	300
Pacific	18.6%	Reno, NV	2717	300

119 Simmons Consumer Market Surveys, Simmons Market Research Bureau, Inc., 1979, FCOJ Section, p. 390.

The representative city areas are picked to allow mileage estimation. Intraregional transport distances provide for deviations in destinations within a single region and vary according to regional size. Our product requires refrigeration in the ACOJ case, and frozen conditions under the present system. Thus, only refrigerated and frozen transport costs are collected. Data from the truck weight analysis (Appendices 2 and 3) provides the estimated number of shipments per year based on the quantity of units per 40,000 pound truckload. Transportation truckload rates are supplied by RYDER RANGER TRUCKS for July 1, 1983. Yearly cost variance is assumed to vary equally for frozen and refrigerated shipments. RYDER RANGER TRUCKS is a major hauler of FCOJ and refrigerated products making them a fine cost source. Tables 36 and 37 display FCOJ and refrigerated ACOJ transportation figures respectively.[120]

Table 36. FCOJ Transporation Costs

Tampa to	Total Distance	# Shipments per Year	$ Rate/ TLL mile	Yearly Cost ($)
Albany, NY	1442 miles	301	1.15	499,148
Chicago, IL	1418 miles	192	1.15	313,094
Omaha, NE	1811 miles	238	1.20	517,222
Jackson, MS	968 miles	298	1.15	331,734
Reno, NV	3017 miles	235	1.20	850,794

Total FCOJ Transportation Cost = $2,512,000
Total FCOJ Transportation Cost $/gal = 0.5548/yr

[120] Personal communication with RYDER RANGER TRUCKS in Jacksonville, FL.

Table 37. ACOJ Transportation Costs

Tampa to	Total Distance	# Shipments per Year	$ Rate/ TLL mile	Yearly Cost ($)
Albany, NY	1442 miles	274	1.00	395,108
Chicago, IL	1418 miles	175	1.00	248,150
Omaha, NE	1811 miles	216	1.05	410,735
Jackson, MS	968 miles	272	1.00	263,296
Reno, NV	3017 miles	214	1.05	677,920
Total ACOJ Transportation Cost				= $ 1,995,200
Total ACOJ Transportation Cost $/gal				= 0.4406/yr

Warehouse expense

Warehouse expense includes raw material transport-in, storage, handling, labor, taxes and material handling equipment. These values are reported by Kilmer and Hooks. Warehouse expense must also address finished goods storage and handling throughout distribution channels. CHERRY CENTRAL COOPERATIVE in Traverse City, Michigan supplied refrigerated and frozen storage and handling estimates that they see in public warehouses on a yearly average nationwide. Storage costs at wholesalers and retailers is assumed to be relatively the same.

To quantify outgoing warehouse costs, FCOJ and ACOJ shelf life data from Section 1 is applied. These figures provide each truckload's duration at each storage stage. To simplify cost estimation, truckload's are assumed intact to the retai'er. Since this is done for both systems, acceptable error is introduced by the method. Storage and handling cost estimates are attained in dollars per hundred weight for the first month. A fractional rate is applied for additional duration over a month's time at a channel level. Data from the truckload analysis is also utilized. Tables 38 and 39 report the storage parameters for FCOJ and ACOJ respectively.[121]

Table 38. FCOJ Warehouse Parameters

Portion	Pallets Truckload	Shipments /Year	Pallet Wt (lbs)	$/100 wt 1st Month	$/100 wt 2nd Month
6 oz.	29	278	1366	1.38	0.70
12 oz.	22	670	1763	1.14	0.56
16 oz.	17	314	2319	0.84	0.40

Table 39. ACOJ Warehouse Parameters

Portion	Pallets Truckload	Shipments /Year	Pallet Wt (lbs)	$/100 wt 1st Month	$/100 wt 2nd Month
6 oz.	20	254	1964	0.75	0.32
12 oz.	13	604	3076	0.51	0.26
16 oz.	14	291	2746	0.51	0.26

30.4167 days per month is employed (365/12). The fraction of this month in a storage stage sets the cost. Plant shelf life originates from the yearly average developed in Appendix 1. Wholesaler and retail fractions arise from current FCOJ inventory turnover data from ASSOCIATED GROCERS.[122]

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[121] Personal communication with Mr. Steve Eisler of CHERRY CENTRAL COOPERATIVE, INC. in Traverse City, MI.

[122] Personal communication with Mr. Bob Halladay of ASSOCIATED GROCERS of Holt, MI.

Tables 40 and 41 depict the estimated warehouse costs for FCOJ and ACOJ respectively.

Table 40. FCOJ Finished Goods Warehouse Costs

	Plant 35 Days		Wholesaler 14 Days		Retail 7 Days	
Portion	$/gal/yr	$yr	$/gal/yr	$yr	$/gal/yr	$yr
6 oz.	0.1668	163,591	0.0713	69,950	0.0356	34,975
12 oz.	0.1329	318,176	0.0570	136,355	0.0285	68,178
16 oz.	0.0099	111,443	0.0415	47,860	0.0208	23,930

FCOJ Total Finished Goods Warehousing Costs = $ 974,500

Table 41. ACOJ Finished Goods Warehouse Costs

	Plant 35 Days		Wholesaler 14 Days		Retail 7 Days	
Portion	$/gal/yr	$yr	$/gal/yr	$yr	$/gal/yr	$yr
6 oz.	0.0812	79,639	0.0351	34,441	0.0176	17,221
12 oz.	0.0554	132,642	0.0237	59,696	0.0118	28,348
16 oz.	0.0533	61,438	0.0228	26,261	0.0114	13,130

ACOJ Total Finished Goods Warehousing Costs = $ 449,800

The addition of each frozen and refrigerated finished goods warehousing cost to incoming and processing warehouse expense seen in Table 42 describes total warehouse outlays.[123]

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123 Dr. Hooks and Dr. Kilmer, pp. 4-6.

Table 42. Additional and Total Warehouse Expenses

A. Raw Material and Work-In Process Warehousing

Portion	Warehousing, Shipping, Labor and Taxes $/gal/yr	$/yr	Other Warehousing $/gal/yr	$/yr
6 oz.	0.0372	36,500	0.0691	67,800
12 oz.	0.0349	83,500	0.0669	160,100
16 oz.	0.0331	38,200	0.0627	72,300
Subtotal Warehousing		158,200		300,200

Total Section A = $ 458,400/yr

B. FCOJ Total Warehousing Cost

Finished Goods Total = 974,500
Base Warehouse Total = 458,400
Total Warehousing = $ 1,432,900 /yr or $0.3165/gal/yr

C. ACOJ Total Warehousing Cost

Finished goods Total = 449,800
Base Warehouse Total = 458,400
Total Warehousing = $ 908,200 /yr or $0.2006/gal/yr

Remaining operating expense

Remaining operating expense consists of administrative, selling and miscellaneous costs. These values are assumed the same for the two systems under comparison. Kilmer and Hooks report the unit costs which have been adjusted for inflation to mid-1983 figures.[124] As before, the unit costs are multiplied by each portion's yearly gallon output producing dollar per year figures. Table 43 outlines the final operating expenses.

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124 Ibid., pp. 4-6.

Table 43. Remaining Operating Expenses

A. Administrative

	6 ounce		12 ounce		16 ounce	
	$/gal/yr	$/yr	$/gal/yr	$/yr	$/gal/yr	$/yr
Administrative	0.0747	13,300	0.0747	178,800	0.0708	81,700
Subtotal =	$ 333,800/yr or $ 0.0737/gal/yr					

B. Selling

Brokerage Fees	0.0600	58,900	0.0584	139,800	0.0554	63,900
Other Selling Expense	0.0405	39,700	0.0430	102,900	0.0422	48,700
Subtotal =	$ 453,900/yr or $ 0.1002/gal/yr					

C. Other Expense

Advertising, Tax and Quality Control	0.1003	98,400	0.1001	239,600	0.1001	115,400
Miscellaneous Deductions	0.0721	70,700	0.0677	162,100	0.0705	81,300
Subtotal =	$ 767,500/yr or $ 0.1695/gal/yr					

D. Total Remaining Operating Expenses

A + B + C = $ 1,555,200/yr or $ 0.3435/gal/yr

Total System Costs Compared

Having estimated all relative operating costs for each alternative, the overall cost effects of switching to ACOJ from FCOJ is addressed in Table 44. Table 44 sums all the previous cost elements and determines the less expensive choice.

Table 44. ACOJ and FCOJ Total System Costs

Cost Center	ACOJ ($/yr.)	% of Total ACOJ Dollars	FCOJ ($/yr.)	% of Total FCOJ Dollars
Capital Investment	300,100	2.7	---	0.0
Labor	1,986,900	18.2	1,007,700	9.2
Material	2,750,800	25.1	2,975,400	27.3
Other Processing				
- Utilities	335,300	3.1	391,900	3.6
- Maintenance & Repairs	385,200	3.5	337,300	3.1
- Depreciation & Rent	230,400	2.1	230,400	2.1
- Machine Royalties	201,600	1.9	157,000	1.5
- Taxes & Insurance	63,500	0.6	63,500	0.6
- Miscel-laneous	234,400	2.2	234,400	2.2
Transporta-tion	1,995,200	18.2	2,512,000	23.0
Warehouse	908,200	8.3	1,432,900	13.1
Remaining Operating				
- Administra-tive	333,800	3.0	333,800	3.1
- Selling	453,900	4.1	453,900	4.2
- Miscel-laneous	767,500	7.0	767,500	7.0
Total System Costs =	$10,946,800	100.0	$10,897,700	100.0

Aseptic Expense = $49,100/yr. or a 0.04% increase in Total System Costs

The aseptic conversion produces a 0.04 percent total system cost increase equivalent to a 1.1 cent rise in cost per gallon of concentrated orange juice (COJ). The ACOJ operation has substantial increases in labor, capital investment and machine/production royalties, while decreasing material, transportation and warehouse expenses. Cost portion shifts of 1.0 percent or greater are deemed significant in this study. Although not considered as significant, a $47,900 rise in maintenance and repairs and a $56,600 decrease in utilities occur. A $44,600 increase in machine/production royalties is created by the BRIK PAK variable production rental charges. Thus, a $49,100 increase in yearly total system costs is estimated for the conversion to aseptic processing and packaging of concentrated orange juice (COJ).

The effect of the aseptic COJ production conversion upon the per gallon and per unit costs by portional volume appears in Table 45. The production size mix of 21.6% 6-ounce, 52.9% 12-ounce, and 25.5% 16-ounce is again utilized to assign the total system costs by portion. Table 45 illustrates the 1.16¢ per 6-ounce portion total system cost increase upon conversion to aseptic COJ production. A 0.18¢ per gallon 12-ounce portion decrease is estimated for ACOJ production. A 1.64¢ per 16-ounce portion total system cost decrease occurs in aseptically packaged COJ. Thus, the estimated costs for the two compared systems have been calculated for analysis and recommendation in Section 5.

Table 45: Total System Cost Comparison Separated By Package Volume

$/year	ACOJ			FCOJ		
Cost Center	6oz.	12oz.	16oz.	6oz.	12oz.	16oz.
Capital Investment	64,821.	158,753.	76,526.	----	----	----
Labor	429,170.	1,051,070.	506,660.	217,663.	533,073.	256,964.
Material	1,033,720.	1,261,306.	455,772.	845,400.	1,453,200.	676,800.
Utilities	72,425.	177,374.	85,501.	85,521.	206,998.	99,781.
Maintenance & Repairs	83,203.	203,771.	98,226.	72,857.	178,432.	86,011.
Depreciation & Rent	49,766.	121,882.	58,752.	49,766.	121,882.	58,752.
Machine Royalties	43,546.	106,646.	51,408.	33,912.	83,053.	40,035.
Taxes & Insurance	13,716.	33,592.	16,192.	13,716.	33,592.	16,192.
Miscellaneous Processing	50,630.	123,998.	59,772.	50,630.	123,998.	50,630.
Transportation	430,963.	1,055,461.	508,776.	542,592.	1,328,848.	640,560.
Warehousing	196,171.	480,438.	231,591.	309,506.	758,004.	365,390.
Adminstrative	72,101.	176,580.	85,119.	72,101.	176,580.	85,119.
Selling	98,042.	240,113.	115,745.	98,042.	240,113.	115,745.
Other	165,780.	406,008.	195,712.	165,780.	406,008.	195,712.
Portional Totals	2,804,054.	5,596,992.	2,545,752.	2,558,486.	5,643,781.	2,696,833.
Portional Gallons Per Year	980,906.	2,393,734.	1,153,275.	980,906.	2,393,734.	1,153,275.
Portional Cost $/gal./yr.	2.8586	2.3381	2.2074	2.6083	2.3577	2.3384
Portional Units Per Year	20,925,995.	25,533,163.	9,226,200.	20,925,995.	25,533,163.	9,226,200.
Portional Cost $/gal./yr.	0.1339	0.2192	0.2759	0.1223	0.2210	0.2923

Section 5:

Discussion of Results, Recommendations and Conclusions

The study's estimated slight 0.04% total system cost increase for an aseptic concentrated orange juice (ACOJ) changeover form the model Florida frozen concentrated orange juice (FCOJ) processor indicates the importance of aseptic processing and packaging developments to FCOJ processors. An explanation of the estimated cost shifts for ACOJ production, of this study's shortcomings, and of further recommended areas of research can best exemplify aseptic technology's cruciality to FCOJ processors.

Cost Shift Explanation

The cost element increases and decreases arise from specific factors. The capital investment increase emanates from aseptic building and equipment acquisition. The rise in labor expenditures occurs because the aseptic packaging units cannot keep pace with the higher output composite can fillers and seamers. Thus, more aseptic packaging systems are necess.tated each with its corresponding auxiliary equipment requiring more operators. The reduced material outlays arise from the basic BRIK PAK's 4¢/unit cost versus the composite cans 3.7¢, 5.1¢ and 6.5¢ unit cost for the 6, 12 and 16-ounce composite cans, respectively. These primary package cost differences between the BRIK PAKs and composite cans are the major determinant creating ACOJ's portionally allocated cost reductions in the 12 and 16-ounce portions, while causing ACOJ's portionally allocated cost increase versus the FCOJ six-ounce package. Increased machine royalties are the result of BRIK PAK's terms equipment use. The decreased transportation and warehousing charges occur because of the refrigerated storage temperature and the BRIK PAK's lighter weight.

Probable future developments could very well negate this study's current slight increase in total system costs upon conversion to ACOJ production. Since a need for higher output aseptic packaging systems which can effectively control headspace oxygen content to a minimal concentration exists, such a system will be developed to fill the market demand for it. This type of aseptic packager able to equal or even surpass present FCOJ filling lines could greatly reduce aseptic labor requirements. Secondly, the current process differential between aseptic packages and composite cans could expand further. Thirdly, the newly developed aseptic packaging systems mentioned above may have reduced or no production royalties, since many currently do not require royalty payments. Increased ACOJ savings could occur from the frozen versus refrigerated temperature distribution cost difference increasing. This is likely to happen via rising energy costs.

Model Limitations

Further cost reducing factors could arise which were not accounted for by this research. The study assumed a one step entire conversion into ACOJ production. Even though this is extremely unlikely, it provided an immediate indication of the maximum savings condition versus the current FCOJ production methods once the total conversion was completed. A more gradual conversion might identify unknown cost saving opportunities available from fine tuning the aseptic changeover to better fulfill market needs. Another factor that could not readily be addressed by this study is that aseptically packaged COJ will likely have a reduced spoilage and damage rate versus the current FCOJ system. Less spoilage arises, because the ACOJ is sterilized and refrigerated. Therefore, the concentrate will not fail as often via microbes, color or flavor degradation. The BRIK PAKS do not see quite as severe a handling and warehousing environment as do FCOJ composite cans. The composite cans are stacked much higher and handled on the production line much rougher. Also the zero headspace makes the BRIK PAKS surprisingly strong. Thus the previous factors will tend to expand the slight total system cost reduction indicated by this study for conversion to ACOJ production.

Recommendations and Conclusions

A further decrease in total system cost may be achieved by decentralizing the aseptic production facility from the nationwide Florida FCOJ processor. Five or six regional aseptic production facilities, owned or subcontracted, could each receive FCOJ in bulk via tanker trucks from the Florida processor to be distributed within every plant's region. Lowering storage, handling and transportation costs would probably result from this modification. By developing a direct COJ importation routing by passing Florida processors and mixing its own juice and concentrate blends, the regional ACOJ processor could reduce COJ product costs and obtain a direct control over the level of juice or concentrate quality packaged. Also the shelf life requirement may be reduced below two months so that ambient temperature storage transportation and warehousing can be utilized. The ambient temperature distribution capability alone could make this recommendation very cost efficient.

An ongoing research and development program including participation by aseptic production equipment manufacturers is recommended to direct future aseptic equipment developments. An intimate research and development program can keep a FCOJ processor one step ahead of other FCOJ processors when eventual ACOJ production implementation occurs. Also by communicating interest in future aseptic production equipment development towards ACOJ applications, Florida FCOJ processors can hasten these developments.

From these arguments, this study concludes that even though current costs calculated in this model indicate a slight 0.04% total system cost increase upon converting to aseptic production of COJ, typical future developments could easily reverse the cost increase and expand the cost savings greatly towards aseptic processing and packaging of retail portion COJ. Thus, at this time an actual conversion to this study's ACOJ production model is not recommended, since expected near-future developments may provide increased cost reduction incentives for conversion to ACOJ production for Florida FCOJ processors. In order to capitalize on future aseptic technological improvements as they occur, FCOJ processors must initiate and continue to monitor and test aseptic processing and packaging equipment developments for possible application to retail portion ACOJ production. Therefore, current and probable aseptic processing and packaging developments are extremely critical to the highly price competitive retail portion frozen concentrate orange juice industry.

APPENDICES

Appendix 1: COJ Shelf Life Quantification

1. COJ is processed from oranges only 7/12 months of the year.
2. On a yearly basis the average shelf life is the seven months production spread over twelve months plus each system's distribution time table.

Months/Year	Storage Time Prior To Shipment
1	0.
2	0.
3	0.
4	0.
5	0.
6	0.
7	0.
8	1.0
9	2.0
10	3.0
11	4.0
12	5.0
12 months = 1 Year	15.0 months/Year

Primary On-site Shelf Life = $\frac{15.0}{12.0}$ = 1.25 months = 35 days

3. Considering the remaining FCOJ distribution system:
   a. Common carrier transport, 1-3 days/shipment.
   b. Warehousing at regional wholesalers & major retailers nationwide, 14 days/shipment.
   c. Retailer transport, 1 day/shipment.
   d. Retailer shelf and warehouse storage, 7 days/shipment.
   e. Home storage, resupply once a week, 7 days/unit.
   f. Secondary distribution shelf life sum = 32 days.

   FCOJ Total Shelf Life = 32 days + 35 days = 67 days.
4. Considering the remaining refrigerated ACOJ distribution system:
   a. Common carrier transport, 1-3 days/shipment.
   b. Warehousing at regional wholesalers & major retailers nationwide, 14 days/shipment.
   c. Retailer transport, 1 day/shipment.
   d. Retailer shelf and warehouse storage, 7 days/shipment.
   e. Home storage, resupply once a week, 7 days/unit.
   f. Secondary distribution shelf life sum = 32 days.

   ACOJ Total 40°F. Shelf Life = 32 days + 35 days = 67 days.
5. Considering the remaining ambient ACOJ distribution system:
   a. Common carrier transport, 1-3 days.
   b. Warehousing at regional wholesalers & major retailers nationwide, 14 days/shipment.
   c. Retailer transport, 1 day/shipment.
   d. Retailer shelf and warehouse storage, 10 days.
   e. Home storage, resupply once a week, 7 days/unit.
   f. Secondary distribution shelf life sum = 42 days.

   ACOJ Total Ambient Shelf Life = 42 days + 35 days = 77 days.

Note: a). One month = 30.4167 days (365/12).
b). COJ inventory turnover rates estimated by ASSOCIATED GROCERS.

Appendix 2: Truck Weight Analysis-BRIK PAK ACOJ

1. General
   a. All weighing by a top-loading METTLER balance on a marble isolation table.
   b. BRIK PAK dimensional data based on BRIK PAK specifications.

2. Primary Package Weight
   a. One 250ml. BRIK PAK = 12.37g. and has $67.125in^2$ material surface area (surface areas were figured on a flattened BRIK PAK with seal area included).
   b. Aseptic BRIK PAK material = $0.184g/in^2$.
   c. 12 ounces of MINUTE MAID 45^o Brix FCOJ = 409.9g.
   d. FCOJ = ACOJ = 34.2g/ounce = 0.0752lb./ounce.
   e. 6, 12, and 16 ounce BRIK PAK surface dimensions are extrapolated from BRIK PAK specifications.

Portion	Package Dimensions (lxhxd)	BRIK PAK Material Surface Area
6oz.(178ml.)	2.5x3.0x1.6"	$56.in^2$
12oz.(355ml.)	2.5x4.3x1.85"	$72.in^2$
16oz.(473ml.)	3.75x3.45x2.5"	$105.in^2$

Portion	BRIK PAK Material Weight	ACOJ Weight	Filled BRIK PAK Weight
6oz.	10.3g.	205.2g.	215.g.
12oz.	13.2g.	410.4g.	424.g.
16oz.	19.4g.	547.2g.	567.g.

3. Shrink Film Weight
   a. HI-C BRIK PAK shrink film is identified through infra-red spectrophotometry as heat shrinkable low density polyethylene (LDPE).
   b. Automatic micrometer identifies thickness as 1.0mil.
   c. Store bought HI-C BRIK PAKs in a 3x1 matrix come shrink wrapped in LDPE.
   d. This LDPE weighs 2.86g.; has a shrunk surface area (SA) = $96.675in^2$.
   e. Assuming a shrinkage factor of 20%, preshrink area (PSA) = $116.in^2$.
   f. Thus, this LDPE weighs $0.02465g/in^2$.
   g. Nine rows of the 3x1 matrix are shipped in a wraparound tray shrinkwrapped in this LDPE.

Portion	Tray SA (in^2)	Shrinkage Factor	Tray PSA (in^2)	Tray LDPE Weight
6oz.	68.	1.2	81.6	13.g.
12oz.	97.	1.2	116.9	15.5g.
16oz.	134.	1.2	160.6	24.3g.

Appendix 2: Truck Weight Analysis-BRIK PAK ACOJ

4. Wraparound Corrugated Tray Weight
   a. Tray measurements are extrapolated from the current 250ml. B-flute BRIK PAK tray.
   b. 250ml. tray SA = 355.3125in^2 and weighs 143.7g.
   c. Thus, the corrugated tray board = 0.4044g/in^2.

Portion	2-partition SA (in^2)	Base Blank SA (in^2)	4-side SA (in^2)
6oz.	47.9375	139.5	113.75
12oz.	67.555	158.875	183.2
16oz.	80.475	298.125	196.1

Portion	Total Tray SA (in^2)	Tray Weight
6oz.	301.2	122.g.
12oz.	410.	166.g.
16oz.	575.	232.g.

5. Truck Weight Calculations
   a. Assuming the common 40 x 48" pallet and HI-C's current 10 layers per pallet of BRIK PAKs, weigh out occurs before cube out.
   b. These results are then compared versus the FCOJ composite can system.

Portion	Weight/ Filled Tray	Tray Dimensions (lxhxd)	Trays/ Pallet Layer	Layers/ Pallet
6oz.	13.093lbs.	15.5x3.375x7.75"	15	10
12oz.	25.634lbs.	17.17x4.71x7.75"	12	10
16oz.	34.321lbs.	23.6x3.825x11.25"	8	10

Portion	Pallet Weight	Truck Tare Weight (lbs.)	Pallets/Truck (weigh out)	Total PKG Weight/ Palletload(lbs.&%)
6oz.	1964.lbs.	40,000.	20.	136.61/1964=6.95%
12oz.	3076.lbs.	40,000.	13.	142.31/3076=4.62%
16oz.	2746.lbs.	40,000.	14.	125.94/2746=4.59%

   c. TLL = truckload limit.

Portion	ACOJ Wt./ TLL (lbs.)	ACOJ Volume/ TLL (oz.)	Units/ TLL	% Increase in Units/ TLL-BRIK PAK vs. the Composite Can
6oz.	37,268.	495,578.	82,596.	9.6%
12oz.	38,150.	507,306.	42,275.	10.9%
16oz.	38,237.	508,463.	31,778.	7.9%

Portion	Gallons/Year	Units/Year	Units/TLL	Shipments/Year
6oz.	980,906.	20,925,995.	82,596.	254.
12oz.	2,393,734.	25,533,163.	42,275.	604.
16oz.	1,153,275.	9,226,200.	31,778.	291.
Total ACOJ Shipments in a Year =				1149.

Appendix 3: Truck Weight Analysis-FCOJ Composite Can

1. General
   a. All weighings by a top-loading METTLER balance on a marble isolation table.
   b. Composite can dimensions come from current MINUTE MAID FCOJ.
   c. Layers/pallet, case counts, and other data are those seen by ASSOCIATED GROCERS for MINUTE MAID.
   d. Corrugated container dimensions are calculated from a summation of the primary package dimensions.

Portion	FCOJ Weight	Composite Can Weight	Composite Can Dimensions (hxd)	Composite Can Filled Weight
6oz.	205.2g.	22.5g.	4 x 2.25"	227.7g.
12oz.	410.4g.	33.75g.	5 x 2.75"	444.1g.
16oz.	547.2g.	41.6g.	6.5 x 2.75"	588.8g.

2. Corrugated Case Weight
   a. Assume same board weight as the BRIK PAK tray = 0.4044g/in^2.
   b. Assume the use of a Center Special Slotted Container (CSSC).

Portion	Primary PKG Matrix	Carton Dimensions (lxhxd)	Carton SA (in^2)	CSSC Weight
6oz.	6 x 8	18.5 x 4.5 x 14."	1355.	548.g.
12oz.	6 x 4	17.0 x 5.5 x 11.5"	1100.	445.g.
16oz.	6 x 4	17.0 x 7.0 x 11.5"	1180.	477.g.

3. Truck Weight Calculations
   a. Assume a 40 x 48 inch pallet and 9 layers/pallet.

Portion	Cartons/ Pallet Layer	Layers/ Pallet	Pallet Weight	Truck Tare Weight (lbs.)	Pallets/ TLL
6oz.	6.	9.	1366.	40,000.	29.
12oz.	8.	9.	1763.	40,000.	22.
16oz.	8.	9.	2319.	40,000.	17.

Portion	Total PKG Wt./ Palletload (lbs.&%)	FCOJ Weight TLL (lbs.)	FCOJ Volume/ TLL (oz.)	Units/ TLL
6oz.	194/1366 = 14.2%	34,005.	452,194.	75,365.
12oz.	199/1763 = 11.3%	34,396.	457,394.	38,116.
16oz.	234/2319 = 10.5%	35,438.	471,250.	29,453.

Portion	Gallons/Year	Units/Year	Units/TLL	Shipments/Year
6oz.	980,906.	20,925,995.	75,365.	278.
12oz.	2,393,734.	25,533,163.	38,116.	670.
16oz.	1,153,275.	9,226,200.	29,453.	314.
Total FCOJ Shipments in a Year =				1262.

Appendix 4: Itemized ACOJ Utility Requirements

Additional Daily ACOJ Utilities

	Electrical Consumption(KWH)	Compressed Air(m^3)	Water (gal.)	Natural Gas (Steam)(MCF)
NO BAC 600 & 2-Aseptic Surge Tanks	800.	----	68,000.	195.
3-BRIK PAK AB Fillers	1,152.	1,957.	13,440.	1.5
3-A-B-C Traywrappers	256.	131.	----	----
2-A-B-C Shrinkwrapper/Tunnels	3,696.	57.	----	----
1-RAYMOND AUTOMATION Checkweigher	225.	35.	----	----
New Lighting(3W/ft.^{2})	247.	----	----	----
Subtotals	6,376.	2,180.	81,440.	196.5
Dollar Subtotals	$383.	$44.	$81.	$540.
Nitrogen Gas for Flushing A. Surge Tanks	$192.			

Eliminated FCOJ Daily Utilities

	Electrical Consumption(KWH)	Compressed Air(m^3)	Water (gal.)	Natural Gas (Steam)(MCF)
1-NEW ENGLAND Comp. Can Unscrambler/Cleaner	234.	1,149.	----	----
1-PACK WEST Comp. Can Piston Filler	273.	2,673.	----	----
2-61-H Model Comp. Can Seamers	231.	340.	----	----
2-CA-109 Case Erector/Packer/Sealers	130.	177.	----	----
Cooling	----	----	1,436,470.	----
Subtotals	868.	4,339.	1,436,470.	----
Dollar Subtotals	$52.	$87.	$1,436.	

Final Totaling

Total Additional Daily ACOJ Utilities = ($335.)

Total Daily FCOJ Utility Cost = $2,305.

Final Total Daily ACOJ Utility Cost = $1,970.

Appendix 5: Itemized Total System Cost Inflation Adjustment Values

FCOJ System Cost Adjustments

1. Most FCOJ cost areas utilize cost adjustment values from Kilmer & Hooks, p. 16.
2. Each 1979-80 season cost area must be brought forward three years to July 1983 (end of the 1982-83 season) dollars.
3. The 1978-79 and 1979-80 trend for each cost area is summed together. This two year increase is divided by two and then multiplied by three to calculate the below adjustment values.

Cost Area	Two year 1978-80 % Cost Increase	Calculated July 1983 Cost Adjustment Value
Packaging Materials	7.6	11.4
Labor	2.9	4.35
Other Processing	0.8	1.2
Warehousing	2.4	3.6
Administrative	7.4	11.1
Selling	0.5	0.75
Other Fixed	0.5	0.75

ACOJ System Cost Adjustments

1. Aseptic Surge Tanks-utilize the inflation adjustment value for capital equipment in "The Economic Report of the President to Congress," February 1983, p.232.
   a. Capital equipment averaged an 8.0% increase across the entire 1981 and 1982 period.
   b. The January 1981 aseptic surge tank cost needs to be brought forward two and one half years to mid 1983 dollars.
   c. Therefore, the aseptic surge tank cost adjuster equals:

   $$8.0\% \times \frac{1}{2 \text{ years}} \times 2.5 \text{ years} = 10.\% \text{ rise to July 1983 dollars.}$$

2. Corrugated Trays & Plastic Shrinkwrap-utilize the inflation adjustment value for paper and plastic products in the "Statistical Abstract of the U.S. 1981," p.464.
   a. Paper and plastic products averaged a 13.0% increase across the entire 1981 and estimated 1982 period.
   b. The January 1981 corrugated tray and plastic shrinkwrap costs need to be brought forward two and one half years to July 1983 dollars.
   c. Therefore, the corrugated tray and plastic shrinkwrap cost adjuster equals:

   $$13.0\% \times \frac{1}{2 \text{ years}} \times 2.5 \text{ years} = 16.25\% \text{ rise to July 1983 dollars.}$$

Appendix 5: Itemized Total System Cost Inflation Adjustment Values

3. Aseptic Equipment Supplies-utilize the inflation adjustment value for maintenance supplies in "The Economic Report of the President to Congress," February 1983, p.229.
   a. Maintenance supplies averaged a 10.65% increase across the entire 1981 and 1982 period.
   b. The January 1982 aseptic equipment supplies cost needs to be brought forward two and one half years to July 1983 dollars.
   c. Therefore, the equipment supplies cost adjuster equals:

$$10.65\% \times \frac{1}{2 \text{ years}} \times 2.5 \text{ years} = 21.3\% \text{ rise to July 1983 dollars.}$$

Appendix 6: FCOJ Cost Conversions

	6oz. July 1983		12oz. July 1983		16oz. July 1983	
Packaging Materials	$/case	$/gal.	$/case	$/gal.	$/case	$/gal.
Composite Cans	1.7872	.7943	1.2220	.5431	1.5604	.5201
Corrugated Cases	.1446	.0623	.1361	.0605	.1704	.0568
Other	.0099	.0044	.0079	.0035	.0117	.0039
Total FCOJ Materials	1.9417	.8610	1.3660	.6071	1.7425	.5808
Processing Labor						
Direct	.2875	.1278	.2878	.1279	.3842	.1281
Indirect	.1384	.0615	.1389	.0617	.1888	.0629
Payroll taxes & insur.	.0728	.0324	.0734	.0326	.0988	.0329
Total FCOJ Labor	.4987	.2217	.5001	.2222	.6718	.2239
Other Processing Expense						
Electric, Water, Compressed Air, Nat. Gas	.1912	.0850	.1946	.0865	.2638	.0879
Maintenance & Repairs	.1722	.0765	.1685	.0749	.2161	.0720
Depreciation & Rent	.1140	.0507	.1149	.0511	.1517	.0506
Machinery Royalties	.0777	.0345	.0780	.0347	.1044	.0348
Taxes & Insurance	.0329	.0146	.0306	.0136	.0432	.0144
Miscellaneous	.1157	.0514	.1184	.0526	.1513	.0504
Total FCOJ Other Proc.	.7037	.3127	.7050	.3134	.9305	.3101
Warehouse Expense (raw mtls)						
Whsing, Shipping In, Labor, & Taxes	.0838	.0372	.0785	.0349	.0993	.0331
Other Whsing Expense	.1555	.0691	.1505	.0669	.1881	.0627
Subtotal FCOJ Whsing.	.2393	.1063	.2290	.1018	.2874	.0958
Remaining Operating Expense						
Administrative Expense	.1680	.0747	.1681	.0747	.2123	.0708
Brokerage Fees	.1350	.0600	.1315	.0584	.1661	.0554
Other Selling Expense	.0912	.0405	.0967	.0430	.1267	.0422
Advertising, Taxes, & Quality Control	.2257	.1003	.2253	.1001	.3003	.1001
Miscellaneous Deduction	.1622	.0721	.1523	.0677	.2115	.0705
Total Remaining Operat.	.7821	.3476	.7739	.3439	1.0169	.3390

Note: $/case to $/gal. conversion
6oz. = divide by 288oz./case and multiply by 128oz./gal.
12oz. = divide by 288oz./case and multiply by 128oz./gal.
16oz. = divide by 384oz./case and multiply by 128oz./gal.

Appendix 7: Aseptic Packaging Material Cost Calculations

Lump Sum Packaging Material Costs	Dollars Per Year
1. BRIK PAKs (4¢/BRIK) 55,685,000 BRIKs/yr.	2,227,400.
2. Corrugated Trays (Wood thesis) 20¢/tray x 16.25% = 23.25¢/tray x 2,062,419. trays/yr. =	479,500.
3. LDPE Shrinkwrap (Wood thesis) 1.3¢/tray x 16.25% = 1.511¢/tray x 2,062,419 trays/yr. =	31,200.
4. BRIK PAK Waste	
a. Splicing @ 4 BRIKs/splice, 1 splice/18,000 BRIKs	
Daily-1st.9hrs. = 9 splices	
2nd.½hr. = 2 splices	
3rd.5hrs. = 4 splices	
4th.6½hrs. = 7 splices	
Total of 22 splices per day	600.
b. Problems @ 2 problems/shift, 30 BRIKs/problem 8 shifts/day =	3,300.
c. Starts @ 6 starts/day, 30 BRIKs/start =	1,200.
5. Other Waste of Corrugated Trays & LDPE Shrinkwrap	
a. Corrugated Trays @ 20 trays/shift =	6,300.
b. LDPE Shrinkwrap @ 40 trays/shift =	800.
6. Hydrogen Peroxide is recycled into the 35% H_2O_2 hot water bath, so less than $1.00/day/BRIK PAK System =	500.
Lump Sum Yearly ACOJ Packaging Material Costs =	$2,750,800.

Yearly ACOJ Packaging Material Costs Allocated By Portion

Material	6oz. 775,037.trays/yr. 20,925,995.BRIKs/yr.	12oz. 945,673.trays/yr. 25,533,163.BRIKs/yr.	16oz. 34,171.trays/yr. 9,226,200.BRIKs/yr.
BRIK PAKs	$837,040.	$1,021,327.	$369,033.
Corrugated Trays	$180,196.	$219,867.	$79,435.
LDPE Shrinkwrap	$11,711.	$14,289.	$5,200.
#'s 4-6 Allocated By Volume	$4,773.	$5,823.	$2,104.
Allocated Totals	$1,033,720.	$1,261,306.	$455,772.

Appendix 8: Itemized ACOJ Maintenance & Repair Costs

Additional ACOJ Maintenance & Repair Costs	Dollars Per Day
1. Supplies (Wood) $891. x 21.3% = $1080.78/5 day work week divided by 5 =	217.
2. Mechanics @ $18./day x 4 hours/day =	72.
3. Service Contracts @ $2100./yr x 3 contracts divided by 170 days per year =	37.
4. Evergencies @ $1,000./filler x 3 fillers divided by 170 days per year =	18.
5. Parts @ $4,500./yr. x 3 fillers divided by 170 days per year =	79.
Subtotal Additional Daily ACOJ M & R Costs =	$423.
Eliminated Daily FCOJ Maintenance & Repair Costs	
1. 61-H Composite Can Seamer Parts @ $16,000./yr. divided by 170 days per year =	(94.)
2. CA-109 Case Erector/Packer/Sealer Parts @ $8,000./yr. divided by 170 days per year =	(47.)
Total Eliminated Daily FCOJ M & R Costs	($141.)
Total Additional Daily ACOJ Maintenance & Repair Costs	$282.
Total Daily FCOJ Maintenance & Repair Costs	$1,984.
Total Daily ACOJ Maintenance & Repair Costs	$2,266.

Appendix 9: Itemized ACOJ Equipment Costs

Additional ACOJ Equipment Needs		Dollar Value
1. NO BAC 600 U-H-T-S-T Sterilization System		250,000.
2. 2-6,000gal. Aseptic Surge Tanks with nitrogen flushing (Wood) 1-5,000gal.= $125,000. = $25,000./1,000gal. , thus 2 x 6 x $25,000. = $300,000. x 10% =		330,000.
3. 3- BRIK PAK AB Systems @ $281,000. x 3 =		843,000.
4. 3-A-B-C Traywrappers @ $50,000. x 3 =		150,000.
5. 2- A-B-C Shrinkwrapper/Tunnels @ $27,000. x 2 =		54,000.
6. 1-RAYMOND AUTOMATION Checkweigher @ $22,000. x 1 =		22,000.
7. Installation @ 25% of this total =		412,200.
Subtotal Additional ACOJ Equipment Costs		$2,061,200.
Less Eliminated FCOJ Equipment		
1. 1-Used NEW ENGLAND MACHINERY Composite Can Unscrambler/Cleaner @ $20,000 x 1 =	(20,000.)	
2. 1-Used PACK WEST Piston Filler @ $15,000. x 1 =	(15,000.)	
3. 2-Used 61-H ANGELUS SANITARY Composite Can Seamers @ $23,850. x 2 =	(47,700.)	
4. 2-Used CA-109 Case Erector/Packer/Sealers @ $11,250 x 2 =	(22,500.)	
Total Eliminated FCOJ Equipment Value	($105,200.)	
Total Additional ACOJ Equipment Cost		$1,956,000.
Plus Total ACOJ Building Cost		151,800.
Total ACOJ Capital Investment		$2,107,800.
Total ACOJ Capital Investment as an Equivalent Uniform Annualized Cost (EUAC) =		$300,100.

Appendix 10: FCOJ & ACOJ Production Line Analysis

FCOJ*		ACOJ**	
Unscrambler/Cleaner	600 units.min.	NO BAC 600 @ 2,666 gal./hr.	= TASTE concentration
Piston Filler	600 units/min.	Each Checkweigher	100-350 units/min.
Checkweighers	700 units/min.	Each Traywrapper	12-15 trays/min.
Casers	1000 units/min.	Each Shrinkwrapper/Tunnel	12-30 trays/min.
Autopalletizers	1.7-2.5min./pallet	Each Autopalletizer	5.3-10 minutes/pallet

Composite Can Seamers are the slowest operation, so they set the line speed at 500 units/min.

Each BRIK PAK is the slowest operation, setting the line speed at 100 units per minute.

FCOJ 6oz.	FCOJ 12oz.	FCOJ 16oz.		ACOJ 6oz.	ACOJ 12oz.	ACOJ 16oz.
20,925,995.	25,533,163.	9,226,200.	Units/yr.	20,925,995.	25,533,163.	9,226,200.
123,094.	150,195.	54,272.	Units/day	123,094.	150,195.	54,272.
4.1hrs.	5.0hrs.	1.8hrs.	Time to Produce Daily Rqmts.	20.5hrs.	25.0hrs.	9.0hrs.
			Adjusted Time	21.0hrs.	21.0hrs.	13.0hrs.
2.0 hrs. total			Down Time	3.0hrs.	3.0hrs.	3.0hrs.
13.0 hrs. total			Total Daily Production Time	24.0hrs.	24.0hrs.	16.0hrs.

Note: *The FCOJ production line operates on one size portion of FCOJ at a time, and it is switched over to the next size when the previous size portion'sdaily production requirement has been fulfilled.

**The ACOJ production line operates on every size portion of ACOJ simultaneously until each size portion's daily production requirement has been fulfilled.

Appendix 11: Aseptic Surge Tank Volume Requirements

1. Two smaller aseptic surge tanks are desired over one large aseptic surge to provide operational flexibility.

2. TASTE concentration & NO BAC 600 concentrated orange juice (COJ) sterilization operates for ten hours per day at 2,666 gallons per hour.

3. Calculate the required sterile COJ accumulation necessary for the BRIK PAK AB aseptic packagers.
   a. For the first nine hours of production, all three BRIK PAK fillers each operate at 6,000. units per hour.

      6,000.-6oz.units = 281.25-6oz. gallons
      6,000.-12oz.units= 562.5-12oz. gallons
      6,000.-16oz.units= 750.0-16oz. gallons
      Subtotal volume = 1,593.75 gallons per hour
      First 9hr. Total= 14,343.75 gallons

      Thus as BRIK PAK's package 1,593.75 gal./hr., 1,072.25 gal/hr. accumulate (2,666. - 1,593.75). After nine hours, 9,650.25 gallons collect.
   b. For the next half hour of production only the 6 and 12 ounce BRIK PAK packagers are on-line, while the previous 16 ounce unit is converted and resterilized for 12 ounce packaging.

      3,000.-6oz.units = 140.625-6oz. gallons
      3,000.-12oz.units= 281.25-12oz. gallons
      Subtotal Volume = 421.875 gallons per one half hour

      Thus as BRIK PAK's package 421.875 gal./½hr., 911.25 gallons accumulate (1,333. - 421.875).
   c. For the final one half hour of NO BAC 600 production, all three BRIK PAK packagers operate at 6,000 units per hour producing 6 and 12 ounce ACOJ portions.

      3,000.-6oz.units = 140.625-6oz. gallons
      3,000.-12oz.units= 281.25-12oz. gallons
      3,000.-16oz.units= 281.25-12oz. gallons
      Subtotal Volume = 703.125 gallons per one half hour

      Thus as BRIK PAK's package 703.125 gal./½hr., 629.875 gallons accumulate (1,333 - 703.125).
   d. Since the TASTE orange juice concentrator and the NO BAC 600 U-H-T-S-T sterilizer now shut down for the day, this total is the bare minimum COJ accumulation required.

      9,650.25 + 911.25 + 629.875 = 11,191.25 gallons.
   e. By raising the required tank volume to 12,000 gallons, a 7.2% safety margin is available. The 808.75 gallon safety margin corresponds to anywhere from 26 to 45 minutes of BRIK PAK packaging down time.

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