elaborate transparent cover collector unit yielded a more feasible payback period of 4 yr compared to ca. 15 yr for a bare metal roof collector system. The principal difference was in collector efficiency, 58.3% for transparent cover design and 3.2% for the bare metal roof. Both fiberglass materials tested for transmissivity had a marked degradation over a 3-yr period. For regular fiberglass the decline was 29.0%, and for the UV-resistant fiberglass 18.4%; whereas, a glass control sample remained unchanged.

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EVALUATION OF A MULTI-VEGETABLE FREEZING FACILITY FOR THE NORTH FLORIDA REGION

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Abstract. **The study evaluated the feasibility of growing and freeze processing selected vegetable crops in Northwest Florida. Vegetable crops were selected on the basis of production efficiency, processing suitability, and product marketability. A large number of vegetable crops were initially considered for processing. Broccoli, cauliflower, lima beans, okra, and southern peas were selected for detailed evaluation. An equipment list and cost estimates were prepared for a dual line freezing facility with output capacities of 3,800 pounds per hour for lima beans and southern peas and 2,800 pounds per hour for broccoli, cauliflower and okra.**

Adverse economic conditions are causing farmers and others in the agribusiness sector to search for more profitable agricultural enterprises. There is considerable interest in growing vegetables for the processing market in many areas. This paper examines the economic feasibility of growing and freeze processing vegetables in north Florida.

Freezing was selected as the processing method because of the increasing popularity of frozen vegetables, largely at the expense of the canning industry. Annual per capita consumption of frozen vegetables has risen steadily for the past 3 decades, and in 1980-83 averaged 11.0 lbs., an increase of 11 percent over the 1970-74 period (2). In contrast, annual per capita consumption of canned vegetables declined by 30 percent during the same period (1). Canning of tomatoes and pickling of cucumbers were not considered in this study because previous research indicated that these enterprises would not be profitable because of Florida's relatively high growing costs (5, 4).

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Methods

A task force of researchers representing the Agricultural Engineering, Food Science, Vegetable Crops and Food and Resource Economics departments considered a large number of vegetable crops for the model freezing plant. Data required by this study were obtained from equipment manufacturers, trade associations, extension specialists and vegetable processors in other states, and published secondary sources.

Vegetable selection. Criteria included physical production constraints such as soil and climate, corroborated by production research in the north Florida and south Georgia growing region. Growing and harvesting costs for a number of vegetable crops were estimated and compared with those in other growing areas where possible. Marketing aspects were also analyzed, particularly trends in the quantities packed by the U.S. freezing industry, trends in per capita consumption and competing imports. Vegetables were also selected to maximize season length so that fixed costs could be allocated over greater product volume.

Physical characteristics of the vegetables were also considered, with preference given to those that did not require highly specialized processing line equipment. Also, a conscious effort was made to keep the total number of vegetable crops to a minimum to reduce changeover time.

After considering the foregoing factors, 5 vegetables were selected for more detailed evaluation, namely broccoli, cauliflower, baby lima beans, southern peas and okra.

Table 1. Initial investment and related annual costs.

Item	Initial cost	Depreciation	Tax, insurance maintenance, repair[z]	Interest (12%)	Annual cost
Land and site work (5 acres @ $8,000/acre)	$ 40,000	$ 0	$ 2,000	$ 4,800	$ 6,800
Plant building (30-yr.) (14,100 ft. @ $40)	564,000	18,800	28,200	67,680	114,680
Equipment (10-yr.)	1,130,000	113,000	56,500	135,600	305,100
Engineering (40% plant and equipment)	678,000	0	0	81,360	81,360
Operating capital	753,000	0	0	90,000	90,000
Total	$3,165,000	$131,800	$86,700	$379,440	$597,940

[z]Based upon 5% of plant and equipment.

In north Florida, broccoli and cauliflower can be harvested from mid-April through May and in October and November. Lima beans can be harvested from June through August, and southern peas from June through September. The harvest season for okra is July through October. These 5 vegetables result in a total processing season of 30 weeks or 1,440 hrs.

The model plant. The model plant was designed with dual preparation lines, feeding into one freezer which utilizes the individual quick freezing process (IQF). One line, designed for peas and beans, has an output capacity of 3,800 lb./hr. The second, for broccoli, cauliflower and okra, has a finished product capacity of 2,800 lb./hr. These capacities are for the smallest commercial freezing equipment currently available (Frigoscandia Contracting, Inc., Atlanta, and Key Technology, Inc., Milton-Freewater, Oregon, personal communications). Larger plants have been shown to be more efficient, but a small plant was selected as the model because of the lack of a processing industry in the study area (7). All products are to be packed in poly-lined bulk bins (1,000-lb. "tote bins" on pallets) prior to entering frozen storage.

Total equipment costs for the plant were estimated at $1,130,000. This includes $183,000 for a pea/bean harvester combine, $300,000 for the two processing lines, and $272,000 for the freezer and refrigeration plant. USDA research indicates that the plant requires a building of 14,100 ft². At $40/ft², the estimated cost is $564,000 (6).

Land and site work costs are estimated at approximately $40,000, and engineering services at about 40 percent of plant and equipment costs, or $678,000. The initial year's operating capital requirements (Table 2) would add another $753,000, resulting in a total initial investment of $3,165,000 (Table 1). Depreciation, taxes, insurance, maintenance, repair and interest on the initial investment result in annual overhead costs of $597,940 (Table 1).

Processing costs. Because of the differences in the lengths of growing seasons for the various crops, it was assumed that beans and peas would be processed on Line 1 for 16 weeks or a total of 768 hr and broccoli, cauliflower or okra would be processed on Line 2 for 14 weeks or 672 hr. Line 1 requires only half the labor of Line 2. Further, Line 1 has a greater production capacity, 3,800 lb./hr as compared with 2,800 lb. Thus, total direct costs are 8 cents/lb. of finished product for Line 1 and 13 cents for Line 2. When supervisory costs and other overhead costs are added, total processing costs are estimated at 20 cents/lb. for Line 1 and 30 cents/lb. for Line 2 (Table 3).

Raw product costs. Detailed estimates of production costs were developed for broccoli, cauliflower, lima beans, okra, and southern peas. Breakeven prices were calculated for average production levels in north Florida and also for a range of possible yields. The breakeven price per lb. at average yields, delivered to the processing plant, was 18.9 cents for broccoli, 13.2 cents for cauliflower, 22.3 cents for

Table 2. Operating capital for first season.

Item	Cost ($1000)
Direct labor[z]	211
Supervisory personnel (3 @ $15,000; 1 @ $30,000)	75
Energy and utilities ($71.50/hr x 1,440)	103
Taxes, insurance, maintenance and repair[y]	86
Interest on investment (12%)	277
Total	753

[z]Based upon $5.00 per man hour with 20 personnel on Line No. 1 and 40 on Line No. 2 for 768 and 672 hr, respectively.
[y]Based upon 5% of plant and equipment.

Table 3. Processing costs by operating line.

Cost Item	Line No. 1 Peas, beans (768 hr @ 3,800 lb./hr)		Line No. 2 Broccoli, cauliflower, okra (672 hr @ 2,800 lb./hr)	
	Cost basis	Unit cost	Cost basis	Unit cost
	Dollars/lb.			
Variable costs:				
Lab[z]	$100/hr	0.03	$200/hr	0.07
Utilities[y]	$72/hr	0.02	$72/hr	0.03
Packaging	$30/1,000 lb.	0.03	$30/1,000 lb	0.03
Total variable costs		0.08		0.13
Fixed costs:				
Supervisory personnel (@ $75,000/yr)	$52/hr	0.01	$52/hr	0.02
Overhead ($597,940) annual)	$415/hr	0.11	$415/hr	0.15
Total fixed costs		0.12		0.17
Total processing costs		0.20		0.30

[z]Based on $5.00 per man hour with 20 personnel on Line No. 1 and 40 on Line No. 2.
[y]Based on 620 kwh. electricity @ $0.08/kwh.

Table 4. Packout rates and current costs per pound of finished product, selected vegetables.

Item	Farm breakeven cost	Packout rate	Raw product price adjustment factor	Raw product cost	Total cost of processed product[z]
	Cents/lb.	%		Cents/lb.	
Broccoli	18.9	85	1.1765	22.2	52.2
Cauliflower	13.2	50	2.0000	26.4	56.4
Lima beans	22.3	95[y]	1.0526	23.5	43.5
Okra	13.2	83	1.2048	15.9	45.9
Southern peas	21.2	95[y]	1.0526	22.3	42.3

[z]Includes processing costs of 30 cents/lb. for broccoli, cauliflower, and okra and 20 cents/lb. for lima beans and southern peas.
[y]Based upon shelled farm weight.

lima beans, 13.2 cents for okra, and 21.2 cents for southern peas.

Breakeven prices at the farm level and packout rates of 85, 80, 95, 83, and 95% for broccoli, cauliflower, lima beans, okra and southern peas, respectively were used to determine the raw product cost per pound of finished product. Because of trim and cull losses in the processing plant, finished raw product costs range from about 5 to 25% greater than the farm-level breakeven prices (Table 4). When processing costs of 30 cents/lb. for broccoli, cauliflower and okra are added to the finished raw product cost, the total costs of the processed products were 52.2, 46.5 and 45.9 cents/lb., respectively. The total finished product costs for lima beans and southern peas were 43.5 and 42.3 cents/lb., respectively (Table 4).

Examination of wholesale prices for the 5 types of frozen vegetables revealed that most have gradually increased over the past 5 years, although there have been a few abberations, which probably resulted from fluctuations in supplies. Wholesale prices were compared with the estimated finished product costs shown in Table 4.

Published prices had to be adjusted for location and packaging to make them comparable. A New York destination was assumed for all finished bulk products. A west coast origin was assumed for broccoli, cauliflower, and lima beans and a southeastern origin, 1,000 miles from New York, assumed for okra and southern peas. Transportation costs were estimated to be $1.17 per mile. It was further assumed that all deliveries were made in 1,000-lb. tote bins at 36,000 lb. per trailer load. On this basis, Florida's transportation advantage was estimated to be about 6.5 cents/lb. of finished product.

Where wholesale prices were reported for 2.5-lb. foodservice packages, the wholesale prices were reduced by 6.3 cents/lb. for peas and beans and 6.9 cents/lb. for broccoli, cauliflower, and okra to reflect reduced costs associated with bulk packaging. Comparisons of estimated costs of Florida produced products with estimated wholesale prices from other areas indicate that Florida's production, processing and transportation costs for broccoli would be about 4 cents/lb. greater than the estimated delivered price in New York of product shipped from the west coast (Table 5). However, Florida's costs for cauliflower and lima beans appear to be 13 and 18 cents/lb. below the delivered wholesale price of these items shipped from California. Florida's respective costs for okra and southern peas are only 2 and 4 cents/lb. under the delivered wholesale price of product shipped from the southeast (Table 5).

Results

Based upon the differences between estimated costs of vegetables grown and processed in north Florida and estimated market prices, it appears that broccoli should not be grown for processing. However, frozen and fresh broccoli consumption has increased dramatically in the past decade and further increases in consumer demand are expected (9). If production does not keep pace with consumer demand, upward pressure on prices may eventually make broccoli an attractive crop for processing. It should be noted, however, that broccoli production has increased with the eastern and southern areas of the U.S. in recent years, and imports increased by 117% from 1979 to 1983 (2). The small price differential for cauliflower makes it a marginal crop at the present time. However, by processing a spring and a fall crop, a total of 672 hr. of plant time could be devoted to it, resulting in production of roughly 1.9 million lb. of finished product and net returns of $56,000 at 1984 prices (Table 6). All net returns are reported on a pretax basis. About 2.4 million lb. of farm-level cauliflower production would be needed. At average yields, this would require approximately 170 acres (Table 6). The market situation and outlook for cauliflower is very similar to that for broccoli. Consumer demand has been increasing rapidly and is likely to continue, but so has production. Yields in other growing areas have also been improving, and imports more than doubled from 1979 to

Table 5. Estimates of net returns of selected vegetables processed in north Florida.

Item	Estimated Florida costs, delivered to New York	Estimated market prices, delivered to New York[z]	Difference between estimated Florida costs and market prices
	Cents/lb.		
Broccoli	56	52	–4
Cauliflower	60	63	3
Lima beans	47	65	18
Okra	50	52	2
Southern peas	46	50	4

[z]Based upon 1984 wholesale prices as reported by the Food Institute. Assumes west coast origin for broccoli, cauliflower, and lima beans and southeastern origin for okra and southern peas. Assumes bulk delivery. F.O.B. west coast prices for spears, cut and chopped broccoli was weighted by 0.5, 0.3, and 0.2, respectively.

Table 6. Acreage requirements, net operating revenues, and other selected processing plant variables.

Product	Farm weight (1000 lb.)	Acreage required[z] (Acres)	Finished product (1000 lb.)	Percent of U.S. pack[y] (%)	Processing time (hr)	Net revenue at current prices ($1000)
Cauliflower	2,352	168	1,882	1.8	672	56
Lima beans	2,304	1,152	2,189	2.9	576	394
Southern peas	768	439	730	2.8	192	29
Total	—	1,759	4,801	—	1,440	479

[z]Acreage at average yields of 7 tons, and 0.875 ton for cauliflower, baby lima beans and southern peas, respectively.
[y]Percentage shown is based upon average annual U.S. pack for the 6-yr. period 1978-1983, except for lima beans and southern peas, which are based upon 1983 only.

1983 (2, 9). Another concern is the stability of the wholesale price level at current levels, particularly as affected by increased production in north Florida. Examination of industry data shows a total frozen pack in recent years of approximately 100 million lb./yr. (3). Florida's increased production would increase total supplies by about 1.8%. Precise estimates of the effects of additional quantities on wholesale prices are not available, but the effects would likely be small.

During the June-September period, there is a great deal of overlap in the growing seasons for lima beans, southern peas, and okra. Thus, the rational approach is to select those crops that will provide the maximum net revenue to the processing plant. Assuming that the basic wholesale price relationships will continue, lima beans should be the predominant crop. Because lima beans have the highest net return, the plant should process them exclusively during the June-August period and process southern peas only during September. In the June-August period, 576 hr of processing time would be devoted to lima beans, during which time approximately 2.9 million lb. would be processed. At present prices, net revenue would be $394,000.

Okra does not appear to be an attractive crop at present because of the relatively low profit margin. Although the industry pack of okra has been increasing in recent years, wholesale prices have remained virtually unchanged. This has probably been caused by the large increases in okra imports (2).

In September, the plant would operate 192 hrs. to produce 730,000 lb. of southern peas, and net returns would amount to $29,000. The production of lima beans and southern peas would amount to about 2.9 and 2.8% of the respective 1983 U.S. packs of these items (Table 6). Net revenue would be about $479,000 per year. This would yield a net return on the initial investment of about 15%. Assuming average yields, about 1,150 acres of lima beans and about 440 acres of southern peas would be required to operate at capacity for the June through September period. The combined acreage of cauliflower, lima beans and southern peas would be approximately 1,760 acres (Table 6).

Present market structure is another element to be considered which can affect the likely success of a processing plant. The number of plants with annual sales of $100,000 or more processing cauliflower was 20 in 1982, while 18 processed lima beans (2). Although the exact number processing southern peas was not reported, it is estimated at fewer than 10. Larger numbers of firms generally result in a more competitive business environment. If there are a very few but large plants processing southern peas, it may be difficult to compete with them.

Demand trends for lima beans and southern peas are another serious concern. Both products have been suffering long-term declines. Per capita consumption, which is reported only for lima beans, has decreased from 0.7 lb./yr in the 1960's and 1970's to only 0.3 lb. in 1983. This decline in popularity is also reflected in industry pack statistics (3, 8). The average annual pack of southern peas has declined by nearly 20% from the 1973-79 to the 1980-84 period. In a shrinking market environment, it could be more difficult to become established. This will be particularly true where existing firms have a lower cost structure. Competing firms' cost structures and pricing strategies can pose serious barriers to entry for a new firm.

Conclusions

Wholesale price trends and estimated processing costs for a new north Florida vegetable freezing plant indicate that cauliflower, lima beans and southern peas would have a modest profit potential at 1984 wholesale price levels. If these prices prevail, the estimated return on investment would be approximately 15%. It should be noted that this return assumes that all vegetables are obtained at breakeven prices. Thus, no profits accrue to producers. However, the breakeven producer prices do include interest on fixed assets used in production at 12% and interest on operating capital at 12%. An overhead and management charge is included, but costs include no land charges.

The stability of the wholesale prices is of primary concern. Existing processing firms may make entry into this market very difficult; at this point, it is virtually impossible to predict other firms' reaction and the resultant wholesale price levels for the three crops under consideration. One recommended couse of action is to explore the market for these vegetables with potential buyers and discuss possible contractual arrangements prior to investing in a processing facility. If satisfactory contracts can be arranged, a freezing plant may give north Florida an economically viable alternative.

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SUGAR LEVELS IN CANNED SINGLE STRENGTH GRAPEFRUIT JUICE FROM FLORIDA

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Abstract. **One hundred forty-nine samples of canned, single strength grapefruit juice from the 1979-80 season were analyzed for glucose, fructose and sucrose using high performance liquid chromatography (HPLC). One sample had additional sugar added and was properly labeled. Its sugar values differed from 4 to 7 standard deviations from respective mean values and was easily differentitated from the other 148 samples. Juices were supplied throughout the season on a regular basis from the 13 major processors of grapefruit juice in Florida. Average composition of the 148 samples in terms of fructose, glucose and sucrose was 2.39, 2.21 and 2.73 % (w/w) respectively. The average glucose/fructose ratio was 0.921 with a standard deviation of 0.0549. Sucrose concentrations were highly variable, ranging from 0.2 to 5.3% (w/w). The average percentage of sucrose compared to total sugars was 36.6%. This information can be used to help judge the authenticity of Florida grapefruit juice.**

The recent rise in the price of citrus juices has encouraged some out of state processors of juice to substitute cheaper materials in their product labeled 100% juice. In order to protect the consumer from this economic fraud an exact knowledge of the chemical composition of citrus juices is required. The natural range of each chemical component must be established for different cultivars, horticultural practices, climates and processing practices. The Europeans, particularly the French, Germans, and Dutch, have been very active in defining juices in terms of their detailed chemical composition. The juice definition program (1) initiated by the Florida Department of Citrus defined the chemical composition of Florida orange juice. However no similiar program has been initiated for Florida grapefruit juice. The Germans, French, and Dutch have recently established detailed chemical composition standards for grapefruit juice, GFJ. Unfortunately most, if not all, of this information is based on non-Florida juice.

Sugars are the major chemical component in both orange and grapefruit juices. Both the German "RSK Values" (2) and the Dutch "Authenticity Standards" (3) include detailed acceptable sugar values for grapefruit juice. Therefore it is the purpose of this paper to establish the normal distribution of individual sugars, total sugars and sugar ratios for Florida grapefruit juice over an entire season and to determine if they would meet European standards.

Materials and Methods

Reagents and standards. Baker Analyzed high performance liquid chromatography (HPLC) grade acetonitrile (J. T. Baker Chemical Co., Phillipsburg, PA.) was used to prepare the chromatographic mobile phase. Laboratory deionized water was further purified using a Milli-Q (Millipore, Milford, MA) water purification system. High grade sucrose, glucose and fructose were obtained as crystalline standards from the Sigma Chemical Co. (St. Louis, MO). Each sugar was dried for 2 hr at 60°C under vacuum (about 50-mm Hg or less) and cooled in a desiccator before weighing. Five grams of a standard consisting of 2% glucose, 2% fructose and 4% sucrose (w/w) was prepared fresh each week.

Equipment. The HPLC system consisted of a Waters (Milford, MA) model M-6000A pump, a model 710B WISP auto sampler and a R-401 differential refractive index detector. Chromatographic solvent was kept in the reference side of the detector. Chromatographic peaks were integrated using a Spectra—Physics (San Jose, CA) model 4000 recording integrator.

Chromatography. A DuPont (Wilmington, DE) Zorbax NH_2 column 25 cm. x 4.6 mm i.d. was used to separate the sugars. A 5-cm. NH_2 Brownlee (Santa Clara, CA) guard column was used at the head of the analytical column. The chromatographic solvent consisted of 75% CH_3CN and 25% H_2O (v/v). Flow rate was 1.0 ml/min. Solvents were degassed prior to use with vacuum in an ultrasonic bath. The column was thermally stabilized with 1/2-inch preformed foam rubber insulation to stabilize the baseline.

Sample preparation. Single strength grapefruit juice was centrifuged in a bench top centrifuge (International Clinical) for 5 minutes at the highest setting. Approximately 5-6 ml of the centrifuged juice was passed through a Waters C_{18} Sep Pak or Baker 10 SPE C_{18} (6 ml) cartridge that had been conditioned by rinsing with 5 ml of MeOH and then 10 ml of deionized water. The first 2 ml of juice through the cartridge were discarded. The final 3 ml were collected and filtered (Millipore 3μ filter with micron pre-