An Economic Analysis of Dryland Fruit Production of *Opuntia ficus indica* in Santiago del Estero, Argentina

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Received April 2001

ABSTRACT

An economic analysis was conducted for nonirrigated cactus-fruit production in Santiago del Estero, Argentina, using three market price/volume options: 1) low price (US$120 per ton) high volume for juice production, 2) intermediate price (US$2000 per ton) for the domestic fresh fruit market, and 3) a high-price (US$4000 per ton) low-volume scenario for the international fresh-fruit market. The economic analyses were made in Excel and included the flexibility to assume various labor rates, hours of operation, and percentage sales of fruits for the three price/volume market options. The operation included prices for herbicides, fertilizers, insecticides for control of cactoblastis, cleaning and packaging, refrigeration, and freight to the national or international markets. Yield data from 8-year-old existing plantations was used to establish a goal of 23.4 kg of fruit per plant (156 fruits) which, at a 2-m by 5-m spacing, would yield 23,400 kg ha^{-1}. At full production in year 8 the production costs for the fruit were estimated to be US$0.08, 0.95, and 2.25 kg^{-1} for fresh fruits destined for the juice industry, domestic and international market, respectively. The internal rate of return assuming 100% of the fruits went to the juice market (which did not require refrigeration) was estimated to be 20%. In order to recoup the costs for refrigeration, at least 20% of the fruit would have to be sold to the national or domestic market to achieve an IRR of 20%. However, when 90% of the market was sold to the domestic or international market, an IRR of 50% was achieved. Because great quantities of cactus fruits are produced in a short time of 6 to 8 weeks and the postharvest shelf life is only about 4 weeks, it is critical to develop alternative markets for the fresh fruits to ensure a market for all the fruits. The best scenario would seem to be to fully develop the market for the juice industry and at the same time seek opportunities to sell significant quantities on the national or international market, which would result in large increases in the IRR.

Keywords: Internal rate of return, net present value, cactus pears, export, cactus juice

INTRODUCTION

This work presents an economic analysis of the growing cactus fruit industry in Argentina. Our previous works have examined the economic feasibility of marketing cactus fruit in the Mendoza market and the possibilities of marketing Argentine fruit in the international market due to off season production in Europe and North America (Guevara and Pizzi, 1998) and the economic feasibility of cactus for forage production (Guevara et al., 1999 a,b).

Our goals in this economic analysis are threefold. First, this economic analysis will assist the potential investor in deciding whether there is sufficient return on the investment to justify entering into cactus fruit production. A second objective is to assist the investor who has decided to engage in cactus production to plan amounts of capital required at different times in the life of this perennial crop. Our third objective is to develop a long-term management plan that includes specific production goals at various stages in the life of this perennial crop to ensure the enterprise is on track financially.

To maximize the financial returns it is also necessary to optimize the array of cactus fruit products. In this regard, there are three contrasting volume/price possibilities. The greatest price/lowest volume potential is for fresh fruit for the international market. An intermediate price/volume relationship is for the domestic fresh fruit market. Within the domestic market there are also two major subclasses: 1) the sale of bulk fruit close to the site of production at roadside fruit stands and in farmers markets and 2) the sale of individually wrapped, sized fruits in major supermarket chains. The last major market is only beginning, but is the sale of fruit for the processed juice industry

METHODS

This analyses used standard economic methods for calculating the net present value and the internal rate of return for a nonirrigated planting in Santiago del Estero, Argentina. All of the costs and times for individual operations were entered into an Excel spreadsheet to allow the user to insert his/her own values. Cactus plantations are obviously in their infancy and much information is not as accurate as is desirable. Our assumptions for each of the major operations are listed in modules i.e. for yield, insect control, etc. As more information becomes available, any or all of these individual modules will be updated to provide better economic estimates.

Plantation Layout Module

The basic analysis of operations, i.e., number of hours for bedding the field, plantation planning, planting, replanting, pruning and harvesting were taken from the Chilean guide to cactus fruit production (SAG, 1976). As more recent information from our Argentine field research on weed and insect control, fertilization, and yield became available, we updated the Chilean model. The labor cost assumed a charge of US\$2.00 hour^{-1}.

Data Analysis Module

The economic analysis was conducted using an Excel spreadsheet. To make the analysis more flexible, the number of hours per operation and the hourly wage can be changed from the Argentine default values. Of particular interest is the ability to assign percentages of fruit destined for export, the domestic market and for juice. The period of analysis for computing the net present value (NPV) and the internal rate of return (IRR) was 20 years. Land charges were not assessed as we assumed that land was already available to potential Argentine producers. An output of the spreadsheet using the most typical values for Argentine conditions is presented in Table 1. To allow the reader to examine various fruit prices, labor rates, etc., not described in this paper, the Excel spreadsheet with its embedded formulas is available for downloading at the end of this paper.

Yield Module

While the production of fruits at different ages is unknown, Felker et al. (2000) recently reported the frequency distribution of fruit size, and number of fruits per plant in an 8-year-old unmanaged farmer's plantation near Santiago del Estero. They reported that on a 4 by 4 m spacing, the means for the various variables were: height, 2.89 m; largest canopy diameter, 3.2 m; number of cladodes with fruit, 43; total cladodes, 216; fruits per plant, 197; pH of fruit, 5.91; pulp/entire fruit, 46%; pulp firmness, 1.3 kg/cm^2; Brix, 14.6; and yield, 18.5 ton ha^{-1}. The mean fruit weight of the 150 fruits that were sampled was 151 g.

As a significant number of plants had 250 fruits and as the origin of the cladodes of this unmanaged plantation was completely unselected native stock, a reasonable management objective with improved genetic stock would be to obtain 250 fruits per plant of 150 grams each. At the spacing of this farmer's field of 4 m by 4 m, there would be 625 plants per hectare for a yield of 23,400 kg ha^{-1}.

While a 4-m by 4-m spacing is a good arrangement for farmers without mechanization, this spacing is too narrow to pass tractors or trucks between the rows to provide cultural operations (control of cactoblastis, mechanical weed control or applications of preemergence herbicides, and harvesting). With pruning, a minimum row spacing of 5 m would permit mechanical operations. A within-row spacing of 2 m would not permit mechanical cultivation perpendicular to the main row direction but would provide a high planting density. Thus the minimum plant density that would permit mechanical operations would be a 2-m by 5-m spacing (1000 plants ha^{-1}). At this increased plant density, it is unlikely that the same fruit load per plant could be achieved as on the 4-m by 4-m spacing. However, the same yield per ha of 23,400 kg ha^{-1} should be a reasonable management objective for an individual plant yield of 23.4 kg $plant^{-1}$ or 156 fruits per plant.

From the measured yield of 23,400 kg ha^{-1} at year 8, we have extrapolated to obtain production for earlier years. We assumed no production in years one and two and 1000 kg ha^{-1} in the third year and thereafter a linear annual increase of 4,500 kg ha^{-1} to arrive at the production of 23,400 in year 8. To provide a conservative economic analysis, no further increase in yield was predicted after year 8 although yield increases beyond year 8 are highly probable.

Despining, Packaging And Freight Costs

The despining costs for all fruit uses assumed a machine with a capital cost of 10000 that could process 500 kg of fruit hr^{-1} with 2 laborers for a total hourly charge of US$20, i.e. US$0.04 kg^{-1}. The freight costs assumed international airfreight charges of US$1.8 kg^{-1} for commercial-size shipments greater than 1000 kg. Customs and brokering costs were not included, as they are minimal per kg on large commercial orders. The freight costs for domestic shipments assumed a charge of US$0.50 kg^{-1} for a refrigerated truck having a capacity of 6000 kg and a 1000 km haul. The freight costs for juice industry assumed a charge of US$0.005 kg^{-1}. Packaging costs assumed 6 to 8 fruit (depending on size) totaling 1 kg in a small cardboard box and placement of four of these 1 kg boxes into a larger box with printed labeling totaling 4 kg. As the price for these 5 boxes was US$1, the packaging cost was US$0.25 kg^{-1}.

Refrigeration Investment And Costs

The refrigeration investment per ha, based on 10-ha fruit production requirements, was US$12,000 (shed and cooler) and US$2500 (forklift with 5000 kg capacity. The estimates for the refrigeration costs were supplied by Ing. Osvaldo Roby of Frigoricos Aconcagua de Mendoza and assumed that the peak storage capacity requirement was 6 tons per week (with a floor surface area of 30 m^2) when the ambient temperature was 38ºC and the storage temperature was 10ºC. The total amount of investment was charged in year 2. The refrigeration cost (US$ kg^{-1}) decreased as fruit production increases: 0.31 for a yield of 1000 kg ha^{-1}, 0.148 for 5500 kg, 0.13 for 10000 kg, 0.125 for 14500 kg, 0.121 for 19000 kg and 0.119 for 23,400 kg ha^{-1}. Due to the high summer temperatures in Santiago del Estero(35ºC to 40ºC) when the fruit is ripe, and the long distances to national and export markets, cooling to 10ºC was deemed essential to maintain fruit quality.

Weed Control Module

Weed control in university field plots has used the low cost, long residual preemergence herbicide diuron in two applications of 2 kg ha^{-1} per year for general weed control. This is applied between the rows with a boom sprayer in 280 liters water ha^{-1} and also in a 1-m-wide band on each side of the rows with a directed spray using only one nozzle. The weeds that emerge despite use of diuron are controlled between the rows with disking at a cost of US$30 ha^{-1} and in the row with a directed spray of a 1.75% solution of glyphosate. Glyphosate causes no damage to mature cladodes that occur at the base of the plant.

Insecticide Module

The only significant insect problem in Argentina is that of cactoblastis. This insect lays eggs on the outside of the cladode. After the eggs hatch they burrow into the cladodes and develop into orange and black striped larvae that consume enormous amounts of tissue, causing great damage. Our field trials have confirmed that cactoblastis is very sensitive to the insecticide carbaryl (Sevin). When the egg deposition is very noticed on the plants, an application of carbaryl is made at the rate of 1 liter of carbaryl (480 g active l^{-1}) ha^{-1} in 1000 liters of water. The high volume of water is required due to the great surface area of cactus. For moderate to severe cactoblastis pressure, three applications per year are required. We use the custom rate of US$8 ha^{-1} for the application and US$8 $liter^{-1}$ for the carbaryl. Recently, we have noticed that 10 days after these carbaryl applications, mature larvae inside the cladodes are also killed.

Fertilizer Module

A definitive fertilizer regime is not available for dryland fruit production from *Opuntia ficus-indica*. Chilean agronomists (SAG, 1976) suggest 7.4 ton ha^{-1} of organic matter the first year of planting and 0.13 kg $plant^{-1}$ of ammonium sulfate and superphosphate every third year. Most fertilizer recommendations include a high application rate of nitrogen (100 kg ha^{-1}) to stimulate off-season production (Nerd et al., 1989, 1993) but there is little information in the literature to suggest rates for the other 2 major macronutrients, P and K. Thus, we have used the empirical rates developed by Potgieter (1996, pers. comm.) in South Africa for dryland fruit production as outlined below.

Table 1. Fertilizer Application Rates (Potgieter, 1996 pers. comm.)

Fertilizer	Year 1	Year 2	Year 3	From Year 4 Onward
$(NH_4)SO_4$ per plant (g)	100	300	450	600
10.5% Superphosphate per plant (g)	40	120	160	200
50% K per plant (g)	40	120	160	200

For a 2-m by 5-m spacing, this is 10 sq. m $plant^{-1}$ or 1000 plants ha^{-1}. Thus, 0.1 kg $plant^{-1}$ @ 1000 plants ha^{-1}=100 kg ha^{-1}.

Price Module

Three different marketing strategies were employed that resulted in different prices. The most expensive price was assumed for the export market (US$4.00 kg^{-1}), but this also entailed greater shipping and packaging costs. The medium price was assumed for the domestic market (US$2.00 kg^{-1}). The lowest price (and lowest packaging costs) was assumed to be for fruits that were destined for processing (US$0.12 kg^{-1}) and was assumed to be similar to the price of Argentine lemons destined for juice. These prices were used to calculate the NPV and the IRR.

RESULTS AND DISCUSSION

Total cost schedule is presented in Table 1 when 100% of fruits are produced for juice, domestic and international market, respectively. Total cost (US$ kg^{-1}) when full production capacity is reached (year 8) is 0.08, 0.95, and 2.25 for fresh fruits destined for juice industry, domestic and international market, respectively. If fresh fruits were destined for Santiago del Estero market, total cost would be US$0.36 kg^{-1} (as US$0.50 kg^{-1} for refrigerated freight to distant national markets would not be encurred) and was comparable to that estimated for fruits destined for Mendoza market (Guevara and Pizzi, 1998). The income schedule for these three scenarios is also shown in Table 1.

The net present value would be positive if all fruit production were destined for the juice industry, regardless the discount rate considered (Figure 1). With one exception, due to the added cost of the refrigeration and packing facilities, that are not required for the domestic juice industry, at least 20% and 10% of the fruit production would have to go for the domestic and international market, respectively (ratios of 0.8 and 0.9), to reach a positive NPV. The exception was as follows, using an 8% discount rate the NPV would be positive if 10% of the fruit production is directed to the domestic market (Figure 1a).

The sensitivity analyses of NPV as a function of fruit selling price (Figure 2) indicate that fruit production would be profitable when fruit selling prices (US\$ kg^{-1}) destined for juice industry, domestic and international market were higher than 0.104, 1.13, and 2.43 at a 12% discount rate. The same values for a 10% discount rate were 0.101, 1.10, and 2.40 and for an 8% discount rate were 0.098, 1.08, and 2.38.

The internal rates of return for the different juice/domestic or international market ratios are shown in Figure 3. The dip in the IRR going from the 100% juice market to 95% juice market was attributable to the fact that refrigeration and packing facilities were required for the domestic and international markets that were not required for the juice market.

This analysis indicates great sensitivity in economic feasibility to the percentages of fruit that are sold for high value export and domestic fruits vs. fruits sold only for juice. However, even if all fruits are sold for juice, after year 4 the operation has a net annual positive cash flow and after year 8 the initial investment is recovered (at a 10% discount rate) and an annual net profit (nondiscount value) of about US\$890 ha^{-1} is achieved.

Thus the most reasonable strategy seems to be to fully develop the market for juices at the lowest price, as this would provide the greatest potential demand and ensure a market for all of the fruit. However at the same time, if a small percentage of the fruit can be sold in attractively packaged containers in the domestic or international markets, very great increases in profit can be achieved.

The experience with small- to medium-size cactus farmers in Argentina (1-10 ha) is that the long distances (ca 1000 km) to major metropolitan markets, the lack of refrigerated trucks willing to transport less than full loads, and the perishability of the fruits during frequent summer temperatures of 40ºC makes the fresh-fruit market for small and medium growers difficult. As great quantities of cactus fruits are produced in a very short time of 6 to 8 weeks and as the postharvest shelf life is only about 4 weeks, there is often a surplus in the major domestic markets leading to depressed prices.

It is our opinion that the most important result of this work is the possibility of obtaining an attractive internal rate of return (about 20%) when growing cactus for a market that can produce cactus-pear juice competitively with other fruit juices. Our contacts with domestic and international buyers for juice to be used in products such as ice cream or the retail beverage market indicate the price must be about US\$1500 ton^{-1} to be competitive with the prices of other juices and frozen concentrates that are purchased in quantities of hundreds of tons per year. Juice prices of US\$2000 to US\$3000 per ton would place cactus juice outside the mainstream juice market and would result in applications only for small volumes or artesanal applications. With a fruit price of US\$120 ton^{-1} the price of the juice is estimated to be about US\$1400 ton^{-1} (private industry confidential sources). Our experience with cactus R&D in weed control, genetics, fertilization, etc. from 1983 to 2000 suggests the major limitation to development of the cactus industry is lack of a market that can consume the large quantities of cactus-pear fruits that are produced over relatively short periods of time (about 8 weeks). Thus, future R&D efforts should focus on developing technology and markets for high-volume fruit-juice markets for cactus pears.

ACKNOWLEGEMENT

The authors thank Oscar R. Estevez for his capable technical assistance in the development of the spreadsheet.

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Table 1. Summary of Costs, Incomes and Profits (US\$ ha^{-1}) Until Full Production Year According to Fruit Use

	Year 1	Year 2	Year 3	Year 4
Total fruit production			1000	5500
Establishment, maintenance and harvesting costs				
Initial soil preparation. Disk and prepare seed bed	29.6			
Bed the soil	24.7			
Plan spacing of plants (19.7 hours ha^{-1})	39.5			
Initial planting stock (1000 plants ha^{-1} @US\$ 0.35 each)	350.0			
Planting/replanting	79.0	17.4		
Pruning		54.4	74.2	81.6
Weeding				
Roundup @ US\$13.70 materials and US\$15 per applic.	114.8	114.8	114.8	114.8
Diuron @ 4 kg ha^{-1} and US\$8.75 kg^{-1}	35.0	35.0	35.0	35.0
Disking	90.0	90.0	90.0	90.0
Fertlilization				
Am. sulf. @ US\$220 ton^{-1}	22.0	66.0	99.0	132.0
Superphosphate @ US\$220 ton^{-1}	8.8	26.4	35.2	44.0
Potasium @ US\$200 ton^{-1}	8.0	24.0	32.0	40.0
Insecticide				
Carbaryl @ US\$8 material and US\$8 per applic.	48.0	48.0	48.0	48.0
Harvesting			39.6	71.6
Total establishment, maintenance and harvesting cost	849.4	476.0	567.8	657.0
Juice industry 100%				
Despine cost (US\$0.04 kg^{-1})			40.0	220.0
Freight cost (US\$0.005 kg^{-1})			5.0	27.5
Total cost	**849.4**	**476.0**	**612.8**	**904.5**
Income (0.12 US\$ kg^{-1})			**120.0**	**660.0**
Annual profit (loss)	**-849.0**	**-476.0**	**-492.8**	**-244.5**
Domestic market 100%				
Despine cost (US\$0.04 kg^{-1})			40.0	220.0
Packaging cost (US\$0.25 kg^{-1})			250.0	1375.0
Freight cost (US\$0.5 kg^{-1})			500.0	2750.0
Refrigeration cost			310.0	814.0
Total cost	**849.4**	**476.0**	**1667.8**	**5816.0**
Income (US\$2.00 kg^{-1})			**2000.0**	**11000.0**
Annual profit (loss)	**-849.4**	**-476.0**	**332.2**	**5184.0**
International market 100%				
Despine cost (US\$0.04 kg^{-1})			40.0	220.0
Packaging cost (US\$0.25 kg^{-1})			250.0	1375.0
Freight cost (US\$1.80 kg^{-1})			1800.0	9900.0
Refrigeration cost			310.0	814.0
Total cost	**849.4**	**476.0**	**2967.8**	**12966.0**
Income (US\$4.00 kg^{-1})			**4000.0**	**22000.0**
Annual profit (loss)	**-849.4**	**-476.0**	**1032.2**	**9034.0**

Table 1. Summary of Costs, Incomes and Profits (US\$ ha^{-1}) Until Full Production Year According to Fruit Use (continued)

	Year 5	Year 6	Year 7	Year 8
Total fruit production	10000	14500	19000	23400
Establishment, maintenance and harvesting costs				
Initial soil preparation. Disk and prepare seed bed				
Bed the soil				
Plan spacing of plants (19.7 hours ha^{-1})				
Initial planting stock (1000 plants ha^{-1} @US\$ 0.35 each)				
Planting/replanting				
Pruning	89.0	111.2	133.4	155.6
Weeding				
Roundup @ US\$13.70 materials and US\$15 per applic.	114.8	114.8	114.8	114.8
Diuron @ 4 kg ha^{-1} and US\$8.75 kg^{-1}	35.0	35.0	35.0	35.0
Disking	90.0	90.0	90.0	90.0
Fertlilization				
Am. sulf. @ US\$220 ton^{-1}	132.0	132.0	132.0	132.0
Superphosphate @ US\$220 ton^{-1}	44.0	44.0	44.0	44.0
Potasium @ US\$200 ton^{-1}	40.0	40.0	40.0	40.0
Insecticide				
Carbaryl @ US\$8 material and US\$8 per applic.	48.0	48.0	48.0	48.0
Harvesting	125.8	148.2	177.8	207.4
Total establishment, maintenance and harvesting cost	718.6	763.2	815.0	866.8
Juice industry 100%				
Despine cost (US\$0.04 kg^{-1})	400.0	580.0	760.0	936.0
Freight cost (US\$0.005 kg^{-1})	50.0	72.5	95.0	117.0
Total cost	**1168.6**	**1415.7**	**1670.0**	**1919.8**
Income (0.12 US\$ kg^{-1})	**1200.0**	**1740.0**	**2280.0**	**2808.0**
Annual profit (loss)	**31.4**	**324.3**	**610.0**	**888.2**
Domestic market 100%				
Despine cost (US\$0.04 kg^{-1})	400.0	580.0	760.0	936.0
Packaging cost (US\$0.25 kg^{-1})	2500.0	3625.0	4750.0	5850.0
Freight cost (US\$0.5 kg^{-1})	5000.0	7250.0	9500.0	11700.0
Refrigeration cost	1300.0	1812.5	2299.0	2784.6
Total cost	**9918.6**	**14030.7**	**18124.0**	**22137.4**
Income (US\$2.00 kg^{-1})	**20000.0**	**29000.0**	**38000.0**	**46800.0**
Annual profit (loss)	**10081.4**	**14969.3**	**19876.0**	**24662.6**
International market 100%				
Despine cost (US\$0.04 kg^{-1})	400.0	580.0	760.0	936.0
Packaging cost (US\$0.25 kg^{-1})	2500.0	3625.0	4750.0	5850.0
Freight cost (US\$1.80 kg^{-1})	18000.0	26100.0	34200.0	42120.0
Refrigeration cost	1300.0	1812.5	2299.0	2784.6
Total cost	**22918.6**	**32880.7**	**42824.0**	**52557.4**
Income (US\$4.00 kg^{-1})	**40000.0**	**58000.0**	**76000.0**	**93600.0**
Annual profit (loss)	**17081.4**	**25119.3**	**33176.0**	**41042.6**

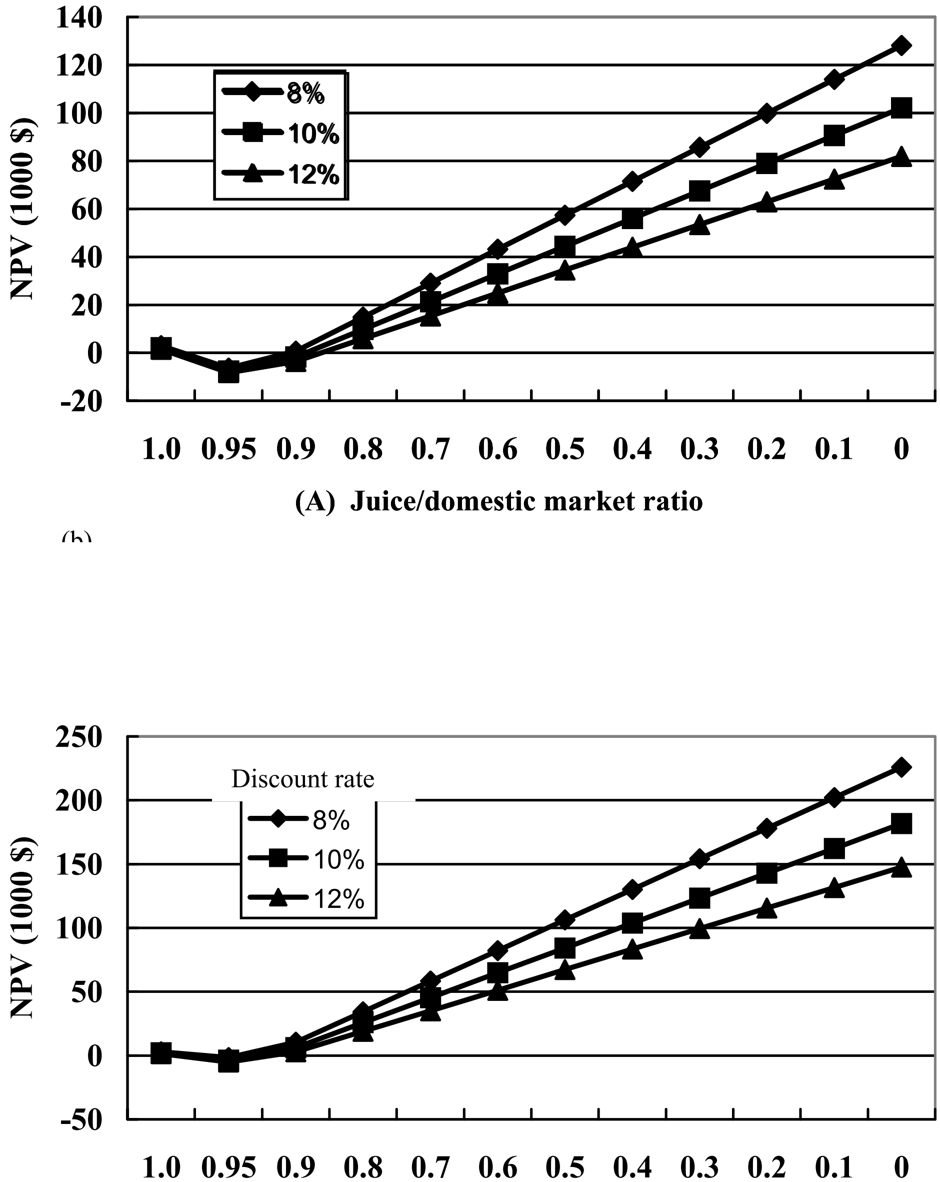

Figure 1. Net Present Value for Different Juice Domestic or International Market Ratios at Three Discount Rates for Fruit Prices of US\$0.12, US\$2.0, and US\$4.0 Kg^{-1}, Respectively

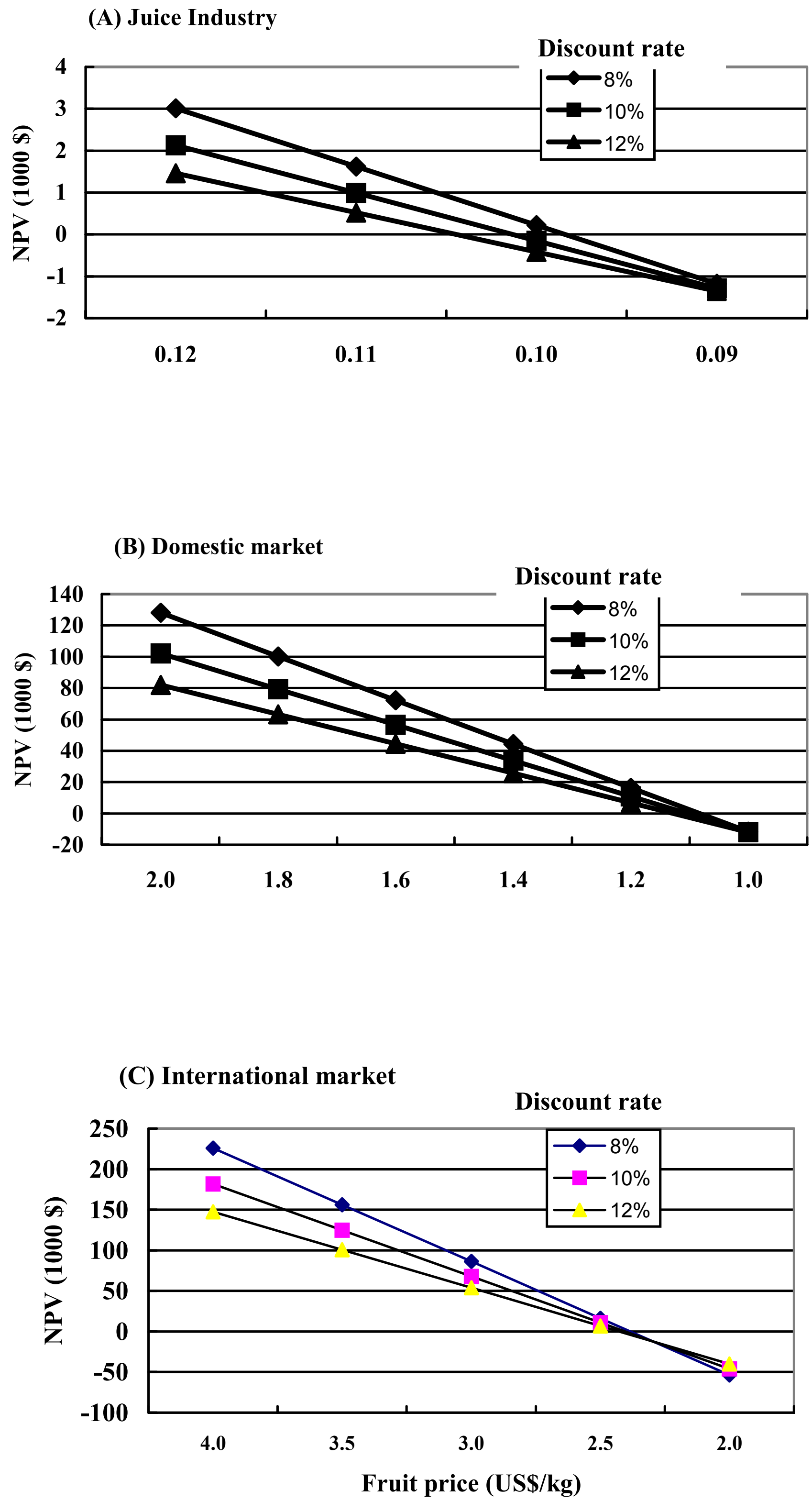

Figure 2. Effect of Fruit Price on the Net Present Value (NPV) for Different Discount Rates

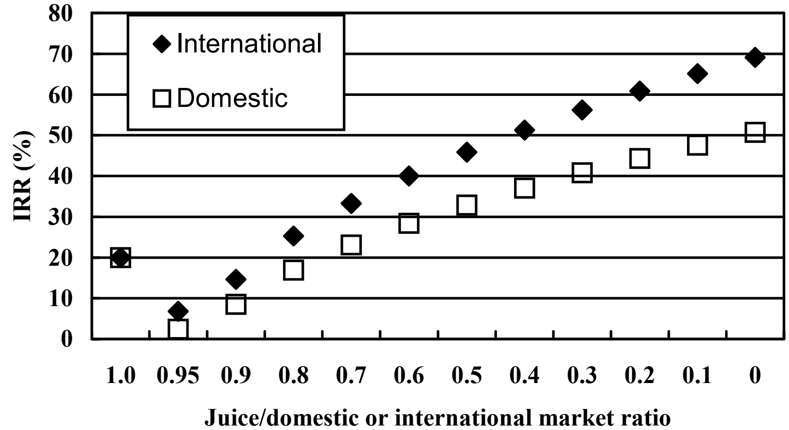

Figure 3. Internal Rate of Return for Different Juice Domestic or International Market Ratios for Fruit Prices of US$0.12, US$2.0, and US$4.0 kg^{-1}, Respectively