A Multiattribute Utility Analysis of Technological Choice in the California Wild Rice Industry

By

Jay E. Noel
James J. Ahern
Jess Errecarte
Kyle Schroeder

Presented at the American Agricultural Economics Association Annual Meeting
Long Beach, California
July 28-31, 2002

The first two authors are Professors in the Agribusiness Department at California Polytechnic State University. The next two are respectively, past undergraduate student and current graduate student of the California Polytechnic State University, Agribusiness Department.

Introduction

The California wild rice industry in 2001 is undergoing change. This change is being driven by increased wild rice production, changes in wild rice demand, and buyer concerns relative to product quality and food safety. These changes necessitate the need for the industry to evaluate its operational and marketing strategies. A major concern of the industry is how to meet the on-going changes while remaining profitable.

The major emphasis of this study to evaluate two of the technological choices that are available to meet those changes. The technologies are a traditional technology and newer experimental technology that has been conceptualized, but not as yet used by the industry. The traditional and experimental technologies use the same basic wild rice processing steps (Figure #1). The traditional technology requires that immediately after the curing stage that the wild rice be either parched or parboiled (see section on wild rice processing for definitions) to infuse the bran layer into the wild rice kernel and then further processed into black or scarified wild rice. The experimental technology allows the wild rice to be stored after the curing stage.

The technological choice begins with a multi-attribute analysis that compares the two technologies on the basis of certain selected characteristics. The technologies are compared on the basis of their internal rates of return under three differing product demand scenarios

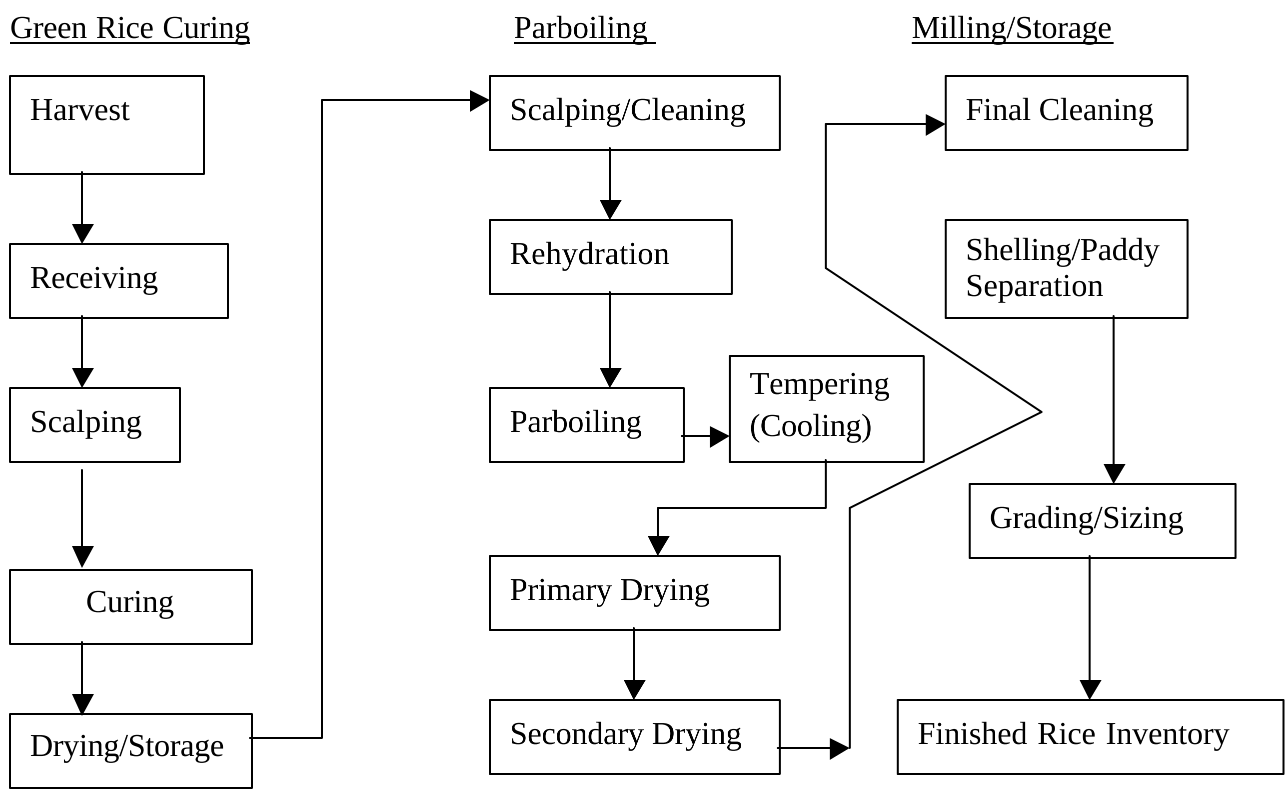
Wild Rice Processing and Technological Choice

Wild Rice Processing

Wild rice processing is composed of three main steps (Boedicker and Oelke). The initial step involves the handling of the fresh green rice. Once harvested, green wild rice is placed in long rows, ten inches deep, to allow the chlorophyll to dissipate from the plant. The rows are continuously turned to avoid heat damage. The wild rice is then transported to a processing facility. The wild rice is received into the facility where it is weighed and scalped. Scalping is the process of removing large foreign objects and field residues from the green wild rice. The wild rice is cured after the initial scalping process.

Curing allows for some fermentation of the green rice to take place. The wild rice then undergoes drying and short-term storage period in preparation for the parboiling process. Before the rice can be parboiled, it must again be scalped and cleaned.

Figure #1
Wild Rice Processing Flow Chart



Parboiling is a process of rehydrating the wild rice and heating it under pressure. In a pressure cooker, the wild rice is baked for forty-five minutes in order to caramelize the starches in the rice. This carmelization process facilitates the unique wild rice cooking attributes. The tempering stage is where the rice is allowed to cool before it is dried. The wild rice is dried after the parboiling/tempering process to moisture content of fourteen percent.

The last of the processing sequences is to mill the wild rice. The first substantial step is the shelling and paddy separation process. In this step, the hull is rubbed off of the kernel to expose the black wild rice kernel. A hull separator separates the hulls from the wild rice kernels. The output of this stage is black wild rice. A decision that can be made at this point is whether to scarify the black wild rice or leave the wild rice in the black form. Scarification is the process of scratching the black wild rice kernels with a stone or sandpaper substance in order to scar the surface. As discussed above this process allows for faster cooking times than wild rice in the black form.

Most wild rice is processed on either a green wild rice or finished wild rice basis by major processing facilities in Minnesota, California, and Southern Canada. Processing fees vary greatly as a result of the seasonal nature of wild rice processing, and as a result of the varying quantities of grain processed.

A processor using a green wild rice processing fee structure charges a set amount per pound of green wild rice processed by the plant. Wild rice processing fees based on a green rice system can be disadvantageous for the green rice producer since it gives the processor little incentive to maximize the quantity/quality of the finished wild rice. The result could be that processors are technically less efficient than they might be.

An alternative approach is for the processors to charge on a finished product basis. The processor is paid based on the end yield (quality and quantity) of finished wild rice. The processor can be disadvantaged by this fee structure. Finished product output can fluctuate greatly and if a lower output than expected occurs the processors will have reduced processing fees and suffer processing cost losses.

Economies of size also have a role in the fees charged by wild rice processors. Typically, plants that process in larger volumes are much more cost efficient than the smaller plants, some of which process as few as one hundred pounds (Oelke).
Current California wild rice processing costs can fluctuate from 16 to 21 cents per pound on a green wild rice basis, or between 32 and 42 cents per pound on a finished wild rice basis.

Wild rice is harvested in California during July, August, September and the first half of October. The California wild rice processing plants have historically processed all of the production in about a 105-day period. This requires that individual processors make decisions regarding the mix of black and scarified products that will be processed in the same 105-day period.

The end result is that while all processing efforts are completed in a 105-day period, the finished goods inventory must be maintained over the rest of the marketing year resulting in high finished goods inventory costs, product quality control problems, and there are limitations in the flexibility of adjusting the product mix for changing market conditions over the course of the marketing year. These issues have resulted in an effort to develop a wild rice processing technology that would allow for greater product mix flexibility, the ability to spread-out processing costs, to increase product quality control, and reduce finished goods inventory costs.

Technological Choice and Competitive Strategy

The choice of any given technology is strongly linked to the competitive strategy a firm is adopting. The idea of competitive strategy is perhaps most closely associated with Michael E. Porter (1980). Porter expresses this concept as follows: "Essentially, developing a competitive strategy is developing a broad formula for how a business is going to compete, what its goals should be, and what policies it needs to carry out those goals." Competitiveness is defined as the ability to get customers to choose your product or services over competing alternatives on a sustainable basis.

Sustainability is the key word here. For example, a firm may be able to gain a short-term advantage by using corporate assets to subsidize its prices. However, this is rarely a sustainable position and long term can lead to less than satisfactory firm performance. A sustainable advantage is one that allows for continual long-tem firm profitability.

Porter maintains that that there are three generic competitive strategies. They are: low-cost leadership, product differentiation, and focus. Focus is further divided into cost focus or product differentiation focus. Low-cost leadership corresponds to a potential low-price competitive advantage. Differentiation refers to uniqueness of product or service as perceived by the customer when comparing the alternatives. The focus strategy is one based on a specific geographical area, market, or product segment.

A basic assumption of research effort was that given the competitiveness of the wild rice processing sector and "commodity nature" of the product that a differentiation strategy was not realistic. That is, price is a primary determinate of the competitiveness of the individual firms in the industry. That is not to say that other factors are not important, rather at this time no basis of sustainable product differentiation exists.

The successful low cost competitor should not ignore the differentiating advantages in pursuit of its low costs. If quality, availability, customer service, or other factors valued by customers fall below a threshold level of acceptability held by customers, then a low-cost competitor may sink to a lower category of discount or low-quality competition. Therefore, it is necessary under a low-cost competitive strategy to ensure customer service parity if not greater than customer service parity with its competitors.

Technological choice is dependent on the choice of competitive strategy. Technology is defined as " a way to do something." There are almost always alternative technologies available to do something. There are new and old, labor-intensive and capital intensive, and unknown technologies yet to be developed. Technological choice must also be based on linkages in the firm's activities and recognition of the interactions among these activities. A further complication of technological choice is the recognition that new technologies may have the promise of enhancing firm performance by providing better products, better customer service then do existing technologies.

The following section of this paper explores technological choice in the California wild rice industry. Two basic assumptions are made: 1) that product demand cannot be perfectly forecast and that the best competitive strategy is one of low-cost leadership. Low-cost leadership refers to not just processing costs, but in all operations aspects of the firm including overhead costs, inventory costs, economies of scale, and learning curve efficiencies. As mentioned above, within the context of low-cost leadership is the ability to maintain at least service parity with competitors in maintaining existing differentiating factors.

Technological Choice Using Multiattribute Analysis

This section and the next develop a methodology for choosing between two wild rice processing technologies and explore the economic consequences of the processing technology that is chosen. Two technologies are compared: a traditional technology and an experimental technology.

Both technologies have the same basic processes as described above: green rice handling and curing, parboiling, and milling. The primary difference between the two occurs at the end of the green rice handling and curing process

The tradition technology allows for only short-term storage of green rice. The cured green rice is then taken out of storage, cleaned and rehydrated, parboiled, milled, left black or scarified, and stored in finished good inventory over an approximately 105-day period.

The experimental technology allows for the cured green rice to be stored and processed across the marketing year. This allows for parboiling and milling to be done throughout the marketing year. More importantly, it allows for just-in-time decision making as to whether to scarify the black product. Thus, the experimental technology allows for more flexibility in inventory control, product quality control, and market decision-making than does the traditional technology.

Although there are obvious benefits to this experimental technology there are risks inherent in the adoption of any new technology. For example, there is a least some probability that the technology simply will not work or will not perform at a level of technical and/or managerial efficiency sufficient to gain the cost, quality control, and product mix flexibility benefits.

The technological choice more appropriately needs to be done by precisely specifying the factors that affect the choice, by allowing trade-offs among the factors, and then choosing an alternative that offers the best balance. Technological choice is a strategic decision and like many strategic decisions of vertical integration, major capacity expansion, or entry into new businesses decision-makers should go beyond cost and investment analyses to consider broad strategic issues and perplexing administration problems that are very hard to quantify. Thus, technological choice needs to take into consideration a number of factors not simply the capital and operational costs of adopting a specific technology.

Multiattribute Utility Analysis (MUA)[2] is useful for any decision in which multiple factors are important, no alternative is clearly best on all factors, and some factors are difficult to quantify. There are two major components to this approach are the decision tree and the objective function. The decision tree presents the arrangement of

---

[2] A comprehensive treatment of the theory and applications of multiattribute utility analysis is provided by Ralph L. Keeney and Howard Raiffa in *Decisions with Multiple Objectives: Preferences and Value-Trade-Offs* [New York: Wiley, 1976]

choices that are controlled by the decision maker and those determined by chance. Often these are the subjective perceptions of the decision maker (Raiffa). The least restrictive objective function is the expectation of the multiattribute utility function:

(1) $$Eu(a_1, a_2, ..., a_n).$$

The a_i's are the attributes included in the decision makers' decision set. The attributes must be quantified and should be simple and meaningful to the decision maker. This is important because the decision maker(s) must provide a set of attributes that are independent of each other and provide weights for each of the attributes. MUA has been used widely to aid government decision makers to select military systems, set water supply policy, site nuclear facilities, and evaluate crime prevention programs (Ulvila and Brown). Two examples of the use of MUA in agricultural economic research are an analysis of Filipino rice policy (Rausser and Yassour) and agricultural lending (Stover, Teas, and Gardner).

The development of a MUA model requires the following: 1) define attributes of value for the technologies; 2) assess the performance of the technological choices on each attribute; 3) determining trade-offs across attributes, and 4) calculating overall values.

The attributes values need to comprehensive or broad enough to account for most of what is important in evaluating the technologies, to highlight the differences among the technologies, to reflect separate, non-overlapping values to avoid double counting, and to be independent of each other. The key attributes are arranged into a hierarchy showing their logical relationships. Each of the key attributes can be further subdivided into component attributes.

Assessment of each of the attributes requires that a ranking or rating scale be created. These scales can be either standard unit (*e.g.* dollars for costs) or relative such as the perceived degree of technological risk of adoption. These assessments are then transformed into 0-to-100 point scales for standardization. The determination of the trade-offs across attributes can be done by obtaining a set of weights that represent the decision-maker's judgment about the relative importance of the attributes. The last modeling activity is to calculate a weighted-average score for each candidate by working up the hierarchy.

A linear additive MUA model was constructed using input from the management group at SunWest Foods. SunWest is a rice and specialty food products company located in Davis, CA. The results[3] of that model are presented in Tables 1 and 2.

The six key attributes selected by the management group in term of their relative importance in making a wild rice processing technological choice were: product quality, demand flexibility, technological risk, inventory carrying cost, barriers-to-entry, and project costs.

Table 1
Multi-Attribute Analysis

Weights and Attributes Affecting Choice

.40 Product Quality	**.20 Demand Flexibility**	**.15 Technology Risk**	**.10 Inventory Carrying Costs**	**.10 Barrier-to-Entry**	**.05 Project Costs**
.40 Microbiological Safety .30 Uniformity .15 Post Harvest Handling .10 Appearance .05 Smell	No specific sub-elements were defined	.50 Rice Curing Process .20 Foreign Material Contamination .20 Product Quality Control .10 Capacity Bottlenecks	.50 Cured Paddy Inventory .50 Finished Product Inventory	.60 Working Capital .30 Market Barriers .10 Investment Barriers	.60 Operating Costs .30 Lead Time .10 Investment Cost

It is interesting to note the order of relative importance placed on each of the six attributes. Three of the six attributes (product quality, technological risk, and barriers-to-entry) do not lend themselves well to quantification yet make up 65% of the attribute value weights. Product quality aspects are deemed the greatest importance. Demand flexibility ranks second as an important choice attribute. This suggests that it and product quality are thought to be important differentiating factors for a low cost producer strategy.

[3] The input provided by the company's management should be viewed as general in nature and used to represent the useful of this type of modeling technique.

Project costs were assigned the lowest weight indicating that whatever cost differences may exist between technological choices they are deemed to be least important when compared to other decision attributes. The inventory cost attribute is weighted toward the cost of storing the green wild rice prior to parboiling. That green wild rice inventory cost has a higher weight than finished inventory value would indicate that there is more risk in storing green wild rice than the processed wild rice products. This risk would include product degradation and further moisture losses. The barrier-to-entry attribute has to do with the value a high capital cost technology has in potentially securing a strategic low cost producer sustainable competitive advantage. Table 2 shows the technology scoring values that were assigned to each attribute for the traditional and experimental technologies.

Table 2

Technology Scoring Values

Traditional Technology Scoring Values	
Product Quality	(.40) (0) + (.30)(0) + .15(0) + (.10)(0) + (.05)(0) = 0
Demand Flexibility	(100) (0) = 0
Technology Risk	(.50)(100) + (.20)(100) = 70
Inventory Carrying Costs	(.50)(100) = 50
Barriers-to-Entry	(.60)(50) = 30
Project Costs	(.30)(100) + (.10)(100) = 40
Overall Value	(.40)(0) + (.20)(0) + (.15)(70) + (.10)(50) + (.10)(40) + (.05)(40) = 21.5

Experimental Technology Scoring Values	
Product Quality	(.40) (100) + (.30)(100) + .15(100) + (.10)(100) + (.05)(100) = 100
Demand Flexibility	(1.00) (100) = 100
Technology Risk	(.20)(100) + (.10)(100) = 30
Inventory Carrying Costs	(.50)(100) = 50
Barriers-to-Entry	(.60)(50) + (.30)(100) + (.10)(100) = 70
Project Costs	(.60)(100) = 60
Overall Value	(.40)(100) + (.20)(100) + (.15)(30) + (.10)(50) + (.10)(70) + (.05)(60) = 79.5

The technological scoring values are computed by multiplying the sub-attribute weights shown in Table 1 by their assigned scale number (0-100). For example, the product quality score for the traditional technology is calculated by multiplying 0.40 (the sub-attribute weight for microbiological safety) times the scale number assigned to it by the management group. For this particular sub-attribute, the scale number is zero. This means that it was totally inferior to the experimental technology. Note that the same 0.40

is multiplied by 100 for the experimental technology. The rest of the calculations follow the above.

The overall scoring value for each technology is calculated by multiplying the attribute value by the respective sub-attribute score and summing across all attributes. The overall value for the traditional technology is 21.5. The technology with the highest ordinal score is deemed the dominant (choice) technology.

The dominant MUA choice is the experimental technology, which is not surprising given the weights placed on product quality and demand flexibility as differentiating factors and the relatively low weight placed on technological risk. This would indicate the management group thinks that the operational and management risks associated with the experimental technology are relatively low when compared to its cost and differentiation attribute values.

Economic Evaluations of the Technological Choice

Three economic evaluations of the technological choice are presented. The first evaluates economies-of-size between construction of an experimental technology 8MM lb. wild rice processing plant and a 10MM lb. plant. The second is temporal breakeven analysis. The third analysis is a set of three internal rates of returns calculations based on changing product demand assumptions.

Table 3 presents fixed and variable cost comparisons[4] between a 10MM lb. traditional technology plant, an 8MM lb. and 10MM lb. experimental technology plant. The 10MM lb. experimental technology plant has a slightly higher, $0.01, average total cost than the traditional technology. This is due to higher capital and depreciation costs than the traditional technology.

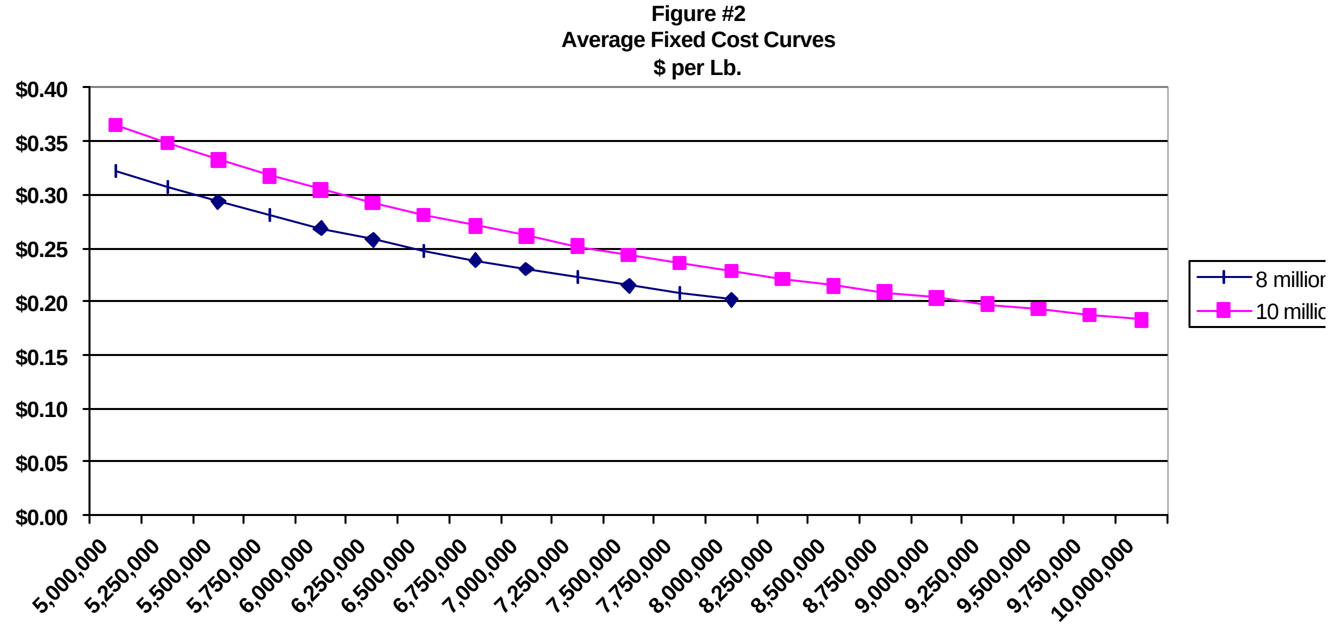
Figure 2 shows the average fixed cost curve associated with the 8MM lb. and 10MM lb. plants. The average fixed cost curve comparisons indicate that at every level of processing up to its capacity the 8MM lb. plant has lower average fixed cost of processing.

[4] The costs should be viewed as general estimates and not definitive numbers. The economic analysis that is based on these numbers must therefore be taken in the same light. The cost estimates are based on conversations with SunWest Foods staff. A more detailed breakdown of the fixed and variable costs developed for this study are contained in Appendix B to this report

The 10MM lb. plant would require a throughput of 9.25MM lb. of product or 92% of its capacity before achieving the same average fixed cost that the 8MM lb. plant would at full capacity. The average fixed cost of processing becomes lower for the 10MM lb. plant than that achievable by the 8MM lb. plant when more than 9.25MM lb. of green rice are processed. Thus, based on fixed costs and increased flexibility to meet increasing demand the 10MM lb. plant would be the preferable option given that the increased capital cost would not act as a constraint.

Table 3
Cost Comparison: Traditional Technology and Experimental Technology

	Plant Capacity (lbs)		
	Traditional Technology	Experimental Technology	
Capacity Cured Green Rice Throughput in pounds	10,000,000	8,000,000	10,000,000
1. Variable Costs			
Direct Labor	$402,000	$400,000	$402,000
Supplies	$1,500	$1,500	$1,500
Repairs	$30,000	$30,000	$30,000
Electrical Costs	$54,000	$45,000	$54,000
Total Variable Cost	$487,500	$476,500	$488,000
Average Variable Cost (lb.)	$0.05	$0.06	$0.05
2. Fixed Costs			
Operations Management	$237,000	$237,000	$237,000
General Management	$100,000	$100,000	$100,000
Taxes	$52,000	$41,300	$52,000
Capital Cost	$213,000	$188,000	$237,000
Miscellaneous Expenses	$50,000	$60,000	$60,000
Depreciation	$724,000	$648,000	$804,000
Total Fixed Cost	$1,376,000	$1,274,300	$1,490,000
Average Fixed Cost (lb.)	$0.14	$0.16	$0.15
Total Cost	$1,863,500	$1,750,800	$1,978,000
Average Total Cost	$0.19	$0.22	$0.20



The second analysis looks at the breakeven time associated with a 10MM lb. traditional plant and 10MM lb. experimental plant. The payback period is defined as the time when green rice procurement cost, curing cost and processing costs have been paid for by wild rice sales revenues.

The difference in the two technologies is that the tradition technology requires that all of the above costs be accrued in a 105-day period while the experimental technology accrues procurement and curing cost in a 105-period but processing costs are spreads across the marketing year. An advantage to this is lower overtime wages over the course of the marketing year. Procurement cost for both plants is based on a $0.45 per pound green rice cost. This results in a $4,500,000 total cost for procurement. Curing cost (including green rice handling costs) is based on a $0.03 cent per pound figure. This results in a $300,000 total curing cost. The processing cost for both technologies is approximately $0.17 per pound and results in $1,700,000 in total processing costs.

Thus, for the traditional technology $6,440,000 is expended in a 105-day period. The experimental technology requires expenditure of $4,800,000 in a 105-day period and allows for the $1,700,000 processing costs to be spread out over the marketing year.

Table 4 shows a “best guess” forecast of the demand for the finished wild rice products by month over the marketing year and the consequent gross revenues by month.

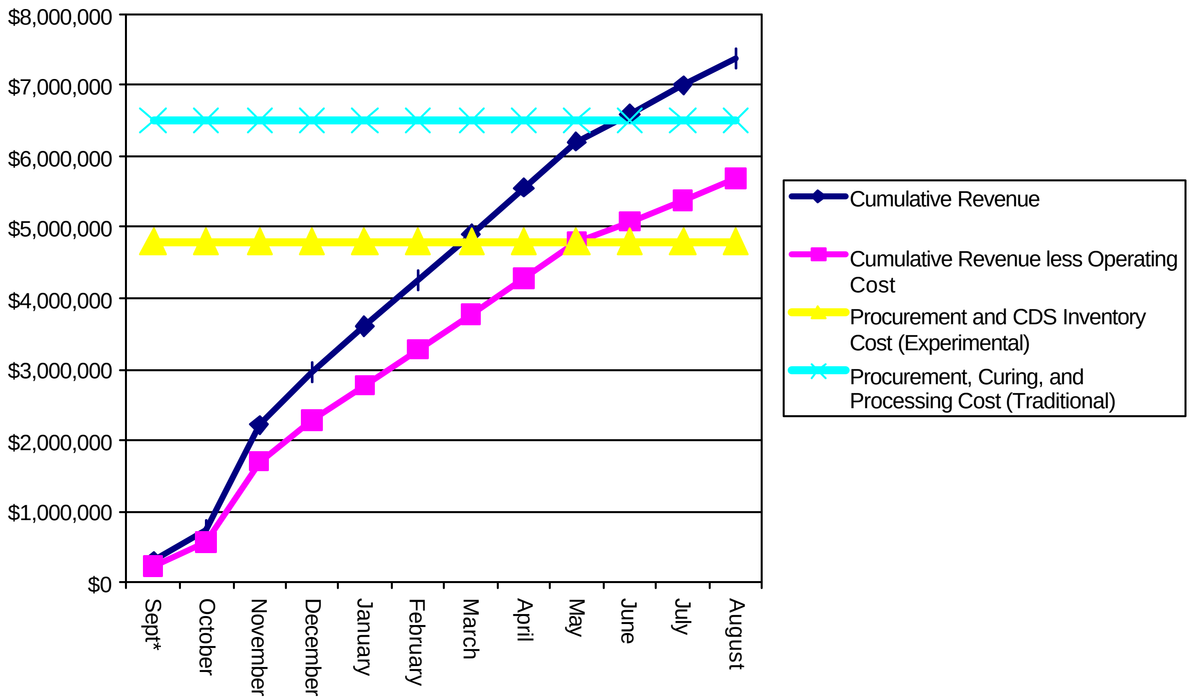
Table 4
Best-Guess Forecast (Pounds per Month)

			Monthly Demand and Revenue									
Month	Grade A Black	Grade A- Black	Grade A- Scarified	Grade B- Scarified	Grade B- Black	Grade C- Scarified	Large Brokens	Small Brokens	Total demand (final product)			
Sept	19,160	40,000	59,160	45,720	11,400	12,240	12,240	4,080	204,000			
October	28,740	60,000	88,740	68,580	17,100	18,360	18,360	6,120	306,000			
November	95,800	200,000	295,800	228,600	57,000	61,200	61,200	20,400	1,020,000			
December	47,900	100,000	147,900	114,300	28,500	30,600	30,600	10,200	510,000			
January	42,152	88,000	130,152	100,584	25,080	26,928	26,928	8,976	448,800			
February	42,152	88,000	130,152	100,584	25,080	26,928	26,928	8,976	448,800			
March	42,152	88,000	130,152	100,584	2,5080	26,928	26,928	8,976	448,800			
April	42,152	88,000	130,152	100,584	25,080	26,928	26,928	8,976	448,800			
May	42,152	88,000	130,152	100,584	25,080	26,928	26,928	8,976	448,800			
June	25,579	53,400	78,979	61,036	15,219	16,340	16,340	5,447	272,340			
July	25,531	53,300	78,831	60,922	15,191	16,310	16,310	5,437	271,830			
August	25,531	53,300	78,831	60,922	15,191	16,310	16,310	5,437	271830			
Total	479,000	1,000,000	1,479,000	1,143,000	285,000	306,000	306,000	102,000	5,100,000			
Price/Lb.	$1.50	$1.50	$1.50	$1.50	$1.50	$1.40	$1.00	$0.75				
Month	Sept	October	November	December	January	February	March	April	May	June	July	August
Gross Revenue	$295,596	$443,394	$1,477,980	$738,990	$650,311	$650,311	$650,311	$650,311	$650,311	$394,621	$393,882	$393,882
Total Gross Revenue =	$7,389,900											

Figure #3 is based on revenue data provided by Table 4. Figure 3 shows the approximate time when cumulative revenues will cover the costs. The gross revenue line for the traditional technology crosses the total procurement, curing and processing costs line in June of the marketing year while the cumulative revenue less operating cost line for the experimental technology cross the procurement and curing cost line in May. This suggests that the experimental technology will allow for net profitability to begin early for the experimental wild rice plant than it would for a traditional wild rice processing plant. The earlier profitability favors the experimental plant as the choice technology.

The third analysis focuses on the internal rate of return (IRR) of the technological choice under uncertain demand scenarios. The first IRR calculations are based on the "best-guess" product demand forecast provided in Table 4. Table 5 provides the information used to calculate the IRR on both technologies. The primary difference between the two technologies is the expenditure of processing costs in either a 105-day period or over the marketing year.

Figure 3
Marketing Year Breakeven Period for Traditional and Experimental Technologies



An additional cost is calculated. That cost is the cost of money for the processing plant operations. Both technologies incur upfront procurement and curing costs; however, the traditional plant incurs all processing costs in the initial 105-period of operations.

Let us assume that regardless of the plant's technology technologies operating capital and that capital is paid back out of the operating revenues over the course of the marketing year. The operating capital interest rate is assumed to be 8% on the unpaid portion of the operating capital. Conversely, if the plants have their operating capital supplied from firm retained earnings than the 8% is assumed to be the opportunity cost of that capital. The IRR's are calculated based on a 15-year investment period.

Table 5 suggests there is no significant difference between the internal rates of return on the two technologies. Two factors are affecting the slight 0.5% difference in the two IRR's. The first is the difference in the operating capital cost and the second is the difference in initial investment of the two technologies. If the investment cost of the two technologies were the same the IRR's would be 14.11% and 12.69% respectively.

Table 5
Traditional and Experimental Technology Investment Rates of Return: Best-Guess Demand

	Net Revenue	Gross Revenue	Procurement Cost	Curing Cost	Processing Cost	Operating Capital Cost (Opportunity Cost)	Technology Investment Cost
Before Tax: Experimental Technology	$759,700	$7,389,900	$4,500,000	$300,000	$1,700,000	$130,200	$4,733,000
Before Tax: Traditional Technology	$704,847	$7,389,900	$4,500,000	$300,000	$1,700,000	$185,053	$4,496,350
	IRR						
Experimental Technology	14.11%						
Traditional Technology	13.65%						

If the tradition technology were to have an investment cost that was 90% of the experimental technologies rather than the 95% shown above then the IRR's would be 14.11% and 14.7% respectively. Thus, based on previously stated assumptions and IRR calculations there is not a major financial advantage to either technology. This result would seem to be consistent with the results of the MUA. The investment cost weight was assigned a 10% value (the lowest) in the project cost value which itself received the lowest value weight of 5%.

Internal Rate of Return and Uncertain Demand

The next two tables show the impact of uncertain demand on the IRR for the technological choices. Uncertain demand means that there exists a certain probability that the best-guess forecast will be in error. It will be assumed that the error is 20% of the best guess forecast. That is, there will be 20% more Black A and Black B product demanded than processed. The demand estimate error must be on the black product since once wild rice is scarified it cannot be returned to the original black form. However, if the demand for scarified product were under estimated then the black product could be re-milled to the scarified form.

Table 6 is the result of the Type 1 uncertainty in demand error. The Type 1 uncertain demand error is the situation where the best-guess forecast is processed and then during the marketing year additional Black A and B product are demanded.

Table 6
Effect of Uncertain Demand on Internal Rate of Return: Type 1 Error

Products	Best-Guess Forecast	Actual Demand (20% Forecast Error)	Sales Based on Forecast Error	Market Price	Outside Purchase Price	Outside Purchase Cos	Lost Sal Reven
Grade A Black	479,000	574,800	479,000	$1.50	$1.75	$167,650	$143,7
Grade A Scarified	1,000,000	904,200	904,200	$1.50			
Grade A- Scarified	1,479,000	1,479,000	1,479,000	$1.50			
Grade B-Scarified	1,143,000	1,086,000	1,086,000	$1.50			
Grade B-Black	285,000	342,000	285,000	$1.50	$1.75	$99,750	$85,5
Grade C-Scarified	306,000	306,000	306,000	$1.40			
Large Brokens	306,000	306,000	306,000	$1.00			
Small Brokens	102,000	102,000	102,000	$0.75			
Total	5,100,000	5,100,000	4,947,200			$267,400	$229,2
Total Revenue =	$7,389,900	$7,389,900	$7,160,700				
Total Revenue Less Outside Purchase Cost =		$7,122,500	$0		IRR =	6%	
Total Procurement, Curing, and Processing Cost =		$6,685,000	$6,685,000				
Net Revenue Traditional Technology with Forecast Error =		$437,500	$475,700				

The firm has two options. The first is to not make the sale and the second is to purchase Black A and B wild rice from another firm for re-sale. If the sale is not made then lost revenues result and excess scarified product is placed into carry-over inventory.

The additional cost of purchasing outside wild rice is assumed to be $0.25 cents above the firm's sales price. Comparison of the two options suggests that the preferable economic option under the Type 1 uncertainty demand error is forego the sales. This results in a reduction of total revenues from $7,389,900 to $7,160,700. Subtracting out the total procurement, curing, and processing costs results in net revenue of $475,700. This net revenue based on a 15 year investment period results in a 6% IRR. This is a very conservative and somewhat improbable scenario. It is highly unlikely that the firm would not adjust future year's "best-guess" forecasts if the Type 1 error were being made. However, it does provide an IRR range from worst to best forecasts.

Thus, the traditional technology can have an IRR range of 13.65% to 6%, when there is a 20% probability that the best-guess forecast will be a Type 1 error. The experimental technology avoids this Type 1 uncertainty demand error since the processing is done just in time to meet the actual demand. The IRR advantage to the experimental technology increases substantially given the assumption of a Type 1 situation occurring.

Table 7 shows the results of the Type 2 uncertainty demand error. This error occurs when a firm recognizes that its best-guess forecast is likely in error. The firm attempts to allow for the error by processing more Black A and Black B product that it's best-guess forecast. The firm can then re-process the Black product to scarified product if it discovers that is best-guess forecast was more accurate than believed. This strategy is somewhat constrained in that, historically, out of every 100 pounds of green the finished product yield has been 29% A and 28% B.

There are two disadvantages to the strategy. The first is that re-milling black wild rice to scarified products is not a one-to-one process. A pound of re-milled black product on average will give an output of 0.9 pounds of scarified product and 0.1 pound broken products. Second, there is a cost to re-mill the product. This re-milling cost is approximated to be $0.10 per pound of black rice and 1/10 lb of product is discounted as brokens. It can be observed that a Type 2 uncertainty demand forecast error is preferable to a Type 1 uncertainty demand forecast error.

This analysis is based on re-milling enough black rice to return it to its best-guess forecast figure. This is a conservative view since it is possible that only a portion of the black product will actually be re-milled. That is, there will be something greater than a 0% forecast error, but something less than a 20% forecast error.

The costs of re-milling and purchasing outside rice to meet product demand are less costly under this option than processing wild rice to the best-guess forecast and purchasing outside rice to meet existing demand. Two IRRs for the Type 2 error are shown. The first is with outside rice purchases and the second is without outside purchases. The two IRR's are quite close. Both IRR's for this strategy are less than if the best-guess forecast been correct, but significantly less variable than the 6% to 13.6% range for the Type 1 error strategy.

Table 7
Effect of Uncertain Demand on Internal Rate of Return: Type 2 Error

Products	Best-Guess Forecast	20% Forecast Error	Product Availability after Re-Milling	Outside Scarified Rice Purchases	Outside Purchase Price (Net of Sales Price)	Market Price
Grade A Black	479,000	574,800	479,000			$1.50
Grade A Scarified	1,000,000	904,200	990,420	9,580	$1.75	$1.50
Grade A- Scarified	1,479,000	1,479,000	1,479,000			$1.50
Grade B-Scarified	1,143,000	1,086,000	1,137,300	5,700	$1.75	$1.50
Grade B-Black	285,000	342,000	285,000			$1.50
Grade C-Scarified	306,000	306,000	306,000			$1.40
Large Brokens	306,000	306,000	317,460			$1.00
Small Brokens	102,000	102,000	105,820			$0.75
Total	5,100,000	5,100,000	5,100,000	15,280		
Total Revenue =	$ 7,389,900		$ 7,404,225	$7,381,305.0		
Re-Milling Cost per lb =	$0.10		$15,280	$15,280		
Outside Rice Cost =			$26,740	$0		
Total Revenue less Re-Milling Cost and Outside Rice Purchases =			$7,362,205	$7,366,025		
Procurement, Curing, and Processing Costs =			$6,685,000	$6,685,000		
Net Revenue =			$677,205	$681,025		
IRR =			12.48%	12.59%		

Thus, it would appear that dominant marketing strategy would be to use a Type 2 error strategy if a traditional technology were to be the technological choice. A major advantage of the experimental technology is that its demand flexibility ability allows both Type 1 and Type 2 uncertain demand forecast errors to be avoided

Conclusions

This study has evaluated wild rice processing technological choice under demand uncertainty. The California wild rice industry is growing and the pressure to meet increasingly critical customer demands is increasing with that growth. The industry is under pressure to reduce costs and increase product quality.

Two technologies were studied to evaluate their potential for meeting those customer demands while providing a sustainable competitive advantage. A low cost strategy is chosen as the strategic choice since their exists a large degree of substitutability between individual firm's wild rice products and between wild rice and other types of specialty grain products. The strategic choice of low cost must be accompanied by differentiating factors, which must be comparable or greater than those supplied by competing firms.

The technological choice was first evaluated using a multiattribute utility analysis. The analysis indicates that for one of the firm's in the California wild rice industry that factors such as product quality, demand flexibility, technological risk, inventory carrying costs, barrier-to-entry considerations, and project costs are important choice variables. The first two factors, product quality and demand flexibility carry the majority of the value weight in the technological choice decision.

The MUA was followed by a financial analysis of the technology investment. IRR's were calculated for a best-guess demand forecast and two forecasts where the probability of forecast error was taken into account. Although the experimental technology has higher IRR's for all three analyses the only significant difference occurs under the Type 1 error where the firm processes to the best guess forecast and the meets changes in black wild rice demand by purchasing wild rice form competing wild rice processors.

The dominant processing strategy when using traditional technology to process wild rice would be a Type 2 strategy where the expected forecast error is included in the processing decisions. More black wild rice would be processed than indicated by the best-guess forecast and if needed it would be re-milled into scarified rice. This has the dual advantage of increasing the IRR over the Type 1 error and reducing the need to purchase wild rice from other processors. That reduction in outside purchases may also reduce the need to provide outside processors competitive knowledge.

The IRR results and the multiattribute utility analysis would appear to support the choice of the experimental technology. The avoidance of the Type 1 and Type 2 demand forecast errors would also strongly favor the experimental technology as the choice technology. Thus, in light of the MUA where the values on technological risk and projects costs were significantly less than those on product quality and demand flexibility it would appear that the experimental technology is the dominant technological choice.

References

Boedicker, J.J. and E.A. Oelke. "Wild Rice: Processing and Utilization". Handbook of Cereal Science and Technology. Chapter 10 pages 401-439.

Errecarte, James. President SunWest Foods, Davis California. Personal conversation

Hasbrook, John. Vice President SunWest Foods, Davis, California. Personal conversation.

Keeney, R L. and H. Raiffa. *Decisions with Multiple Objectives: Preferences and Value Trade-Offs*. 1976 New York: Wiley

Oelke, E.A. 1993. "Wild Rice: Domestication of American Wild Rice". New Crops. Pages 235-243

Raiffa, H. *Decision Analysis*, Reading, Mass.: Addison-Wesley Publishing Co. 1968

Rausser, G.C. and J. Yassour. "Multiattribute Utility Analysis: The Case of Filipino Rice Policy". American Journal of Agricultural Economics 1981 63(3) pg. 484-494

Simmons Market Research, 1994.

Stover, R.D., R. Kenneth Teas, and R.J. Gardner. "Agricultural Lending Decision: A Multattribute Analysis". American Journal of Agricultural Economics 1985 67(3) pg. 513-520.

Porter, Michael E. 1980. Competitive Strategy. [New York: The Free Press]

Ulvila, J.W. and R.V. Brown. "Decision Analysis Comes of Age" Harvard Business Review. September-October 1982. Pg. 131-141