Minimal processing of fish and pork in Quebec: A financial feasibility study

K. GUNJAL[1], M. OWUSU-MANU[1], H.S. RAMASWAMY[2] and F. AMANKWAH[1]

[1]Department of Agricultural Economics and [2]Department of Food Science & Agricultural Chemistry, McGill University, Macdonald Campus, 21111 Lakeshore, Ste. Anne de Bellevue, QC, Canada H9X 3V9. *Received 13 October 1998; accepted 18 October 1999.*

Gunjal, K., Owusu-Manu, M., Ramaswamy, H.S. and Amankwah, F, 1999. **Minimal processing of fish and pork in Quebec: A financial feasibility study**. Can Agric. Eng. **41**:247-251. Three food processing projects, cryogenic freezing of pork loin and of fish as well as Modified Atmosphere Packaging (MAP) of pork loin, were evaluated. By adopting a similar plant layout and production plan, it was shown that construction and operation of a processing plant in Quebec for each of the three processes was financially profitable. Further sensitivity analysis was also carried out. The calculated IRR compared favorably with the return rates on the Toronto Stock Exchange and on capital for some food and beverage industries. The results also showed that the MAP technology of processing pork was much more profitable than the other alternatives.

Dans cette étude, trois procédés de conservation d'aliments ont été évalués : la congélation de filets de porc, la congelation de poissons et l'Emballage à l'Atmosphère Modifiée (EAM) de filets de porc. En adoptant un plan de production, il a été demontré que la contruction et la mis en service d'une usine de transformation de Quebec est financièrement profitable pour chacun des trois procédé. De plus, des scenarios de sensibilités ont été établis. Le Taux de Rendement Interne (TRI) calculé se compare favorablement aux taux de rendement moyen de l'indice de bourse de Toronto (TSE) du taux de rendement sur le capital pour quelques firmes d'aliments et boisons.Les resultants ont egalement demontré que la technologie de l'emballage à l'Atmosphère Modifiée (EAM) de filets de porc, est bien plus finacièrement profitable que les autres alternatives.

INTRODUCTION

Minimal processing involves procedures that change little the inherent fresh quality attributes of a food product but at the same time endow the product with a shelf life sufficient for its transportation from the processing plant to the consumers (Ohlsson 1994). Traditionally, minimally processed foods are attractive to both consumers and producers because they maintain the best opportunity for retaining fresh food quality without incurring excessive costs of processing.

Various minimal processing techniques are available for a wide range of food products. For example, controlled atmosphere storage has been widely used to control spoilage in fruits and vegetables (Kader 1992). Similarly, non-thermal processing methods such as gamma irradiation (Morrison et al. 1992) and ultra high pressure (Hoover 1993) have been used in the processing of many products. A more common approach in packaging technology using modified atmospheres has proven useful in shelf life extension of raw meat and fish products (Carlin et al. 1990). The use of conventional freezing methods to store muscle foods is widely known (Poulsen 1989). However the economic feasibility of storage at alternative freezing temperatures as a minimal processing technique has not been fully explored. Additionally, the economics of modified atmosphere packaging (MAP) as a viable alternative to freezing storage in meat and meat products needed to be verified quantitatively.

This study, therefore, dealt with the economics of fish and pork processing in particular regards to the situation in Quebec. Specifically, it analyzed three processing projects: conventional cryogenic freezing of both fish and pork at freezing temperatures of −18, -12, and −7°C; and pre-treated pork loin stored under MAP. The MAP storage conditions involved packaging of pork (pre-treated with chitosan), using a combination of nitrogen and carbon dioxide gases and its subsequent storage at 5, 10, and 15°C (Morris 1995). The main objective of this study was to evaluate the relative profitability of these projects by using the appropriate financial criteria.

METHODOLOGY

The main steps followed in this study were:

1. Estimating the material, equipment, labor and other costs at the commercial plant level based on the underlying technologies developed by the food scientists.
2. Determining the plant construction costs by using the appropriate plant design and layout and establishing the costs of industrial equipment.
3. Estimating the expected prices of the product, annual output of processing plant and expected revenues for each of the three selected processes, and finally
4. Applying the financial evaluation criteria to each of these three alternative projects.

Data sources

The primary data used for the study was obtained from earlier work carried out by the Department of Food Science and Agricultural Chemistry, McGill University. In addition, other information was obtained through government agencies, utility companies and from published sources as described below. Further details are provided in Owusu-Manu (1997).

Plant requirements and costs The proposed plant equipped with a cryogenic freezing system was one designed by Dr. Juan Silva of Mississippi State University (Silva 1986). The same plant design and layout were assumed for a plant location near Montreal, QC. The processing capacity of the plant was set at 3000 kg/h running a single shift of 8 hours per day for a total of

2000 hours per annum (excluding the weekends and public holidays). The average yield of the final product was assumed to be 80% of raw material. From this figure an annual plant output capacity of 4.8 x 10^6 kg was estimated from an equivalent of 6.0 x 10^6 kg of raw material. It was assumed that plant installation was completed in year zero and full scale operation commenced in year one for a 20-year project life span. The capital costs mentioned in the plant design were converted from US dollars to constant Canadian dollars (1995) using the average 1986 rate of exchange. The figures were then adjusted to 1995 levels using industry indices. The average exchange rate and the industry indices were obtained from Statistics Canada (1996).

Cost model The variable costs associated with the production process were those that involved the purchase of raw materials and packaging material, and the cost of utilities and labor. Estimates for raw material and supply costs were obtained from Agriculture and Agri-Food Canada as well as from selected seafood distributors in the area. For example, the 1995 Montreal wholesale price for pork loin from the slaughterhouse to processing was $4.00 per kilogram (Reynolds Packing House, Montreal, PQ), whereas for fresh fish the expected price was $4.25 per kilogram. Both pork plants were assumed to obtain raw materials from the same slaughterhouses and therefore had similar cost structures. The data for estimating fixed costs of processing required further manipulation. The required plant investment spread over outlays on industrial land, buildings, refrigeration and cold storage facilities calculated to include the equipment price, installation charges, freight and handling, and insurance. The size and processing capacity of the selected items were determined by the expected annual output of the plant as a whole. The amortized value was estimated and used to determine the annual value of fixed costs of processing for the purpose of comparison of the three selected processes.

The amortized value of fixed assets was obtained from:

$$PMT = I_0\left(\frac{1}{1-(1+i)^{-n}}\right) - PVSv\left(\frac{1}{1-(1+i)^{-n}}\right)$$

$$= (I_0 - PVSv)\left(\frac{1}{1-(1+i)^{-n}}\right)$$

$$= \left(I_0 - \frac{0.15 I_0}{(1+i)^n}\right)\left(\frac{1}{1-(1+i)^{-n}}\right) \quad (1)$$

where:

PMT = annualized uniform cost,
I_0 = purchase value of capital goods in present period,
PVSv = present value of the salvage value of capital asset,
i = real discount rate of 8% based on long term Canadian Bond of 9.37% minus a 3.36% inflation rate (Price 1993) plus a risk premium of 2%, and
n = expected life of asset.

All items with the same service life are summed up and a total amortized value estimated for that service group (Owusu-Manu 1997). The total annual value was the summation for all amortized values for all items i.e. total PMT. The annualized uniform costs were added to annual operating costs to derive the total annual costs of owning and operating a plant. These were compared among the projects to find the least cost process/technology.

Benefit analysis

In the financial analysis only those benefits considered to be quantifiable were included. The benefits were therefore reduced to the expected sales revenue and salvage value of capital goods. The expected product price was estimated from the retail sale price.

The value of the sales revenue at the processors level was estimated by computing: 1) expected wholesaler's price (P_p,) i.e. the price processing plant expects to receive from a wholesaler, and 2) expected sales revenue (R); thus:

$$P_p = P_r(1-m_r)(1-m_w) \quad (2)$$

where:

P_r = average retail price (price that consumers would pay in the market),
m_r = retailer's percentage mark-up,
m_w = wholesaler's percentage mark-up,

and

$$R = P_p Q \quad (3)$$

R = expected revenue for the processing plant, and
Q = quantity to be sold by the processing plant.

For lack of sufficient data the expected prices were assumed to be equal to the average observed prices during 1995. The details of the actual prices and mark-ups used in this study are given in Owusu-Manu (1997). Additional revenues expected to accrue from resale of capital items (the residual of all equipment and buildings) were assumed to be 15% of the initial market value. The value of land used for plant construction was assumed to remain constant in nominal terms.

Evaluating alternatives

There are several methods identified in the literature for evaluating costs and benefits aimed at the recovery of cost of capital and profitability of investments. Two approaches were used in evaluating the projects. The first approach involved generating and evaluating annual equivalent costs of each of the three processes. This cost analysis is useful when the benefits from the alternative projects are either similar or unknown. The second approach involved combining the present values of benefits and costs and evaluating the overall profitability of each of the three projects over their expected life span. These criteria included the net present value (NPV), benefit-cost ratio (BCR) and the internal rate of return (IRR). Gittinger (1982), Hacking (1986), Edgar (1986), and Horton (1994) have discussed the use of discounted cash flow method in project feasibility studies.

The NPV represents the difference between the present value of benefits and present value of costs at a given discount rate. Thus:

$$NPV = PVB - PVC$$

or

Table I. Initial investment to set-up food processing plants in Quebec (in dollars).

Item	Pork processing plants	Fish processing plant
Land and buildings, sub-total	**$ 1,204,000**	**$ 1,204,000**
Land	26,000	26,000
Buildings	1,178,000	1,178,000
Machinery and equipment, sub-total	**1,285,000**	**1,267,000**
Other, sub-total:	**1,111,000**	**1,110,500**
Equipment installation	496,500	496,500
Process equipment layout	168,000	168,000
Waste treatment	168,300	168,300
Freight	8,400	8,400
Piping installation	33,700	33,700
Electrical power and control wiring	50,500	50,500
Engineering	50,500	50,500
Start-up and operator training	67,300	67,300
Civil engineering work	16,800	16,800
Construction management	16,800	16,800
Project management	33,700	33,700
20% contingency on total investment	720,000	716,300
Total initial investment	**4,320,000**	**4,297,800**
Annuity equivalent investment cost	**281,670**	**279,680**

$$NPV = \sum \frac{B_t}{(1+i)^t} - \sum \frac{C_t}{((1+i)^t} \quad (4)$$

where:

NPV = net present value,
PVB = present value of benefits,
B_t = quantifiable benefits in period t,
PVC = present value of costs,
C_t = project costs in period t,
i = the discount rate as discussed under equation 1,
t = time period (years in this study going from 0 to n), and
n = expected project life.

A project is considered feasible if the NPV is positive.

The second criterion, BCR, was obtained by formulating the ratio of the two present values. Thus:

$$BCR = PVB / PBC \quad (5)$$

When the BCR is greater than one, the proposed project is considered financially feasible.

Both the NPV and the BCR criteria are useful only in selecting between financially feasible and infeasible projects. They are not useful to rank a set of feasible projects especially of different sizes (Gittinger 1982). Within a group of projects, all of which are feasible, the IRR is the criterion of selection. The IRR also reflects the efficiency with which investment in a project generates funds over the life of the project (Price 1993). IRR is that discount rate which equates the present value of benefits to the present value of costs (i.e. where the NPV is set equal to zero). Here, the IRR was obtained by an iterative process using the Microsoft Excel spreadsheet. When determined, the rate is compared with the required rate of return, which includes premium for risk. If the estimated IRR is greater than this rate, then the investment is feasible. Gariepy et al. (1984) have used the IRR criterion to study the feasibility of off-season cabbage storage.

Sensitivity analysis

Sensitivity analyses looked at what might happen if certain changes in the variables of interest were to take place. For instance, how will the results change if the operating hours or expected prices changed? Two scenarios were examined:

1. Changing annual working hours from a single shift to a double shift (change from 2000 to 4000 hours per annum), and
2. Product prices and the raw material prices change.

The results obtained would give an indication of the relative resilience of the project to unexpected exogenous shocks. Since economic assumptions upon which the analysis was based were not expected to stay the same, the sensitivity analysis gave an indication of the degree to which the results of the feasibility tests would be valid.

RESULTS and DISCUSSION

Financial feasibility

Table I shows a summary of the total investment in (i) land and buildings, (ii) machinery and equipment, and (iii) other items required to set up a food processing plant near Montreal, QC in 1995. The total investment for each of the three specified alternative processes was estimated at about $4.3M or approximately $280,000 annually over a life span of 20 years. The fish processing plant cost was slightly lower mainly due to the lower equipment costs. Machinery and equipment represented the major part of these investments.

Table II shows the operating cost structure. The annual operating costs were estimated at $25.17M, $26.59M and $25.20M for the given size plants for frozen pork, frozen fish, and MAP pork, respectively. The raw material represented approximately 95% of all operating costs for the frozen pork and MAP pork plants and 96% for the frozen fish plant. As can be seen from the two tables, the annual equivalent investment costs of about $280,000 were very small compared to the total operating costs. The frozen fish plant had the highest operating costs due mainly to the higher costs of raw material. The difference was also as a result of the different processing procedures.

Quantifiable benefits were derived mainly from the sale of the product. In summary, the total annual sales revenue were estimated at $25.92M, $27.22M and $26.02M for the frozen pork, frozen fish and MAP pork processing plants, respectively. This was estimated at their respective prices of $5.40, $5.67, and $5.42 per kg of the product and an annual output of 4.8×10^6 kg in all cases. In addition, revenues from the salvage value (15% of the initial price) of $32,950 at the end of tenth year and $192,760 at the end of 20^{th} year for all equipment and $176,700

Table II. Annual operating costs (in dollars).

Item	Frozen pork processing plant	Frozen fish processing plant	MAP pork processing plant
Raw material*	**$24,000,000**	**$25,500,000**	**$24,000,000**
Processing material, sub-total	**504,000**	**504,000**	**537,400**
Liquid carbon dioxide	504,000	504,000	4,200
Nitrogen	–	–	1,000
Chitosan (0.2%, pH 6.5)	–	–	528,000
Oxygen absorbent (ageless FX)	–	–	4,200
Other costs, sub-total	**664,400**	**586,000**	**666,400**
Fuel and electricity	167,000	89,000	169,000
Water	33,600	33,600	33,600
Cryovac bags	60,000	60,000	60,000
Cardboard boxes	24,000	24,000	24,000
Labour	344,800	344,800	344,800
Spare parts	15,000	15,000	15,000
Miscellaneous	20,000	20,000	20,000
Total (direct operating costs)	**25,168,400**	**26,590,400**	**25,203,800**

* Raw material represents fresh pork loins in cases of pork processing plants and ocean perch in case of fish processing plant.

at the end of twentieth year for all buildings were assumed. The value of land used for construction of the plant was assumed to remain constant at $26,000.

The base run results of the study show that the NPV for each of the three projects was positive (Table III). Consequently, the BCR was greater than one. This suggests that under the assumptions of the model and the cost of capital of 8% or lower, all three projects were financially feasible. Based on the average 1995 Montreal prices of pork and fish, the IRR results indicate that annual rates of return ranged from 13% to 18% over the 20 year period with the MAP pork project having the highest IRR (Table III). It is observed that by using the internal rate of return criterion and given market and technical conditions, pork processing (frozen and MAP) can be more profitable than processing of fish.

The IRR values were found higher than the average return on other investment alternatives in the study period. For example, long term Canadian Bonds averaged 9.37%, return on equity averaged 7.94% whereas return on capital averaged 6.41% (Statistics Canada 1996). The return on capital for some food and beverage establishments was estimated at 8.8% (Moody's Investors Service 1996). The IRR values also compare favorably with the average 1995 rate of return for the Toronto Stock Exchange (TSE) for all investments, which stood at 9.5%. Thus return on investment in comparable alternatives ranged from 6.4% to 9.5%. Thus 8.4%, an average of the above rates was used as a required rate of return for comparison with the calculated IRR values. Using this criterion all three projects were judged to be potentially profitable.

Sensitivity analysis

Single-shift versus double-shift operation Table IV summarizes the results obtained for a 4000-hour operation per annum. Double shift operation increased the net return of each establishment considerably. Based on the estimated costs and benefits, the assumed discount rates, and the projected production periods and the distribution channels, the following values were obtained for the measures of profitability. The NPVs for frozen pork, ocean perch and MAP pork were $9.98M, $7.77M and $18.50M, up from base run values of $2.40M, $1.77M, and $3.38M, respectively. Thus under this scenario, the NPV more than quadrupled and the IRR more than doubled in all three cases.

Effect of product price changes A case of a 10% change (decrease and increase) in both the raw material and final product prices was investigated. The results of this scenario indicate that the IRR ranged from 11% to 21% for frozen pork, from 7% to 17% for frozen fish, and from 13% to 23% for MAP pork. Thus the variation in IRR was 10 percentage points in each case as a result of the 20% change in the product prices. The price sensitivity analysis indicates that not all projects would be profitable given a 10% decrease in raw and finished product prices. The frozen fish processing plant most likely would be unprofitable when its IRR is compared to the required rate of return of 8.4%. The pork processing plants, on the other hand, generated acceptable returns even when faced with the risk of 10% price decline.

Table III. Summary of results for financial analysis for single shift operation (2000 hours per year).

Project	NPV*	IRR	BCR*
Frozen pork	$2,404,000	15%	1.09
Frozen fish	1,766,000	13%	1.09
MAP- pork	3,382,000	18%	1.10

* Discount rate of 8%
NPV -net present value
IRR - internal rate of return
BCR - benefit-cost ratio

Table IV. Financial analysis for double shift operation (4000 hours per year).

Project	NPV*	IRR	BCR*
Frozen pork	$9,982,000	35%	1.10
Frozen fish	7,771,000	30%	1.10
MAP- pork	18,501,000	57%	1.12

* Discount rate of 8%
NPV -net present value
IRR - internal rate of return
BCR - benefit-cost ratio

CONCLUSION

Based on the estimated costs, the selected pork and fish processing plants represented an investment in plant and equipment of about \$4.3M for a life span of 20 years. However, on an annual basis these costs were fairly small (about \$280,000) compared to the annual operating costs of about \$26M. The results indicated that all three processes/technologies were financially feasible under the base run scenario. The MAP pork processing plant showed the highest internal rate of return (IRR) of 18% followed by frozen pork loin and frozen fish at 15% and 13%, respectively.

The sensitivity analysis of individual projects indicated that operating these plants with a double instead of a single shift increased the IRR by more than double in each of the three cases. The robustness of the results was also tested by varying the product and the raw material prices by 20% (i.e. 10% decrease and 10% increase from the base level prices). From this it can be concluded that in all three cases the resulting IRR would vary by 10 percentage points around the base run IRR level. The risk of 10% decline in prices made the fish processing plant non-profitable. However, the pork processing seemed to be profitable under the same risk scenario. This research shows that under the 1995 market conditions, the MAP technology for processing pork in Quebec is much more profitable than frozen pork or frozen fish processing alternatives.

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