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ENERGY AND TECHNOLOGY SUBSTITUTION OPPORTUNITIES IN FROZEN FOOD PROCESSING

SUMMARY OF A STUDY
PERFORMED FOR THE DEPARTMENT OF ENERGY

by

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SYNOPSIS

This study is an economic and technological assessment of the frozen food industry, with primary emphasis on energy expenditures and on ways to reduce them, while at the same time reducing total production cost.

One way to reduce energy expenditures is to substitute more suitable and inexpensive energy forms for the fossil fuels used in processing at the present time. We focus on geothermal energy as a substitute for electricity and natural gas in vegetable processing, freezing and storage.

Another way to reduce energy expenditures and production cost is to replace the frozen food process by some other process that supplies a product of equal or greater acceptability in the marketplace. To this end we select the retortable pouch as a potential challenger candidate.

As a base case we choose frozen broccoli. The chain of unit processes carried out in growing, harvesting, freezing and marketing broccoli are applicable to a number of frozen vegetables including spinach, asparagus, cauliflower, carrots and string beans. Frozen broccoli cannot, however, serve as an accurate prototype for frozen potatoes or for formulated frozen meals.

As a first task, the production of frozen broccoli is examined step by step, from the farm to the retail checkout counter. Contributions to cost from various factors of production are made quantitative for each process step, with special emphasis on energy contributions. The same procedure is then used for the substitutions. Thus, the second task deals with the substitution of geothermal for fossil energy in processing. In the third task, the retortable pouch process is substituted for food freezing, but using conventional energy forms. Lastly, the retortable pouch process is considered in combination with the application of geothermal energy.

Our main findings are:

Energy expenditures contributed 7% to the cost of the final product in 1979.

Energy price escalation alone (i.e., even in the absence of general inflation) will cause this contribution to increase to almost 9% in 1980, and may push it to the 12 to 15% range in the next 3 to 5 years. These figures are higher than those previously reported.

Geothermal energy appears cost-effective now as a substitute for fossil fuels (centrally generated electricity and natural gas) in frozen food processing, and will become more attractive with additional energy price escalation. However, it can conveniently replace only about one-seventh of the total energy input for the process chain. The cost savings to be gained from this substitution are therefore at best modest, and may be offset by negative factors unless the geothermal site has favorable geographic characteristics.

Retortable pouch packing is a submarginal challenger of freezing for vegetables at this time, if one confines oneself to economic considerations up to the retail checkout counter. Both cost and energy expenditures appear fractionally higher, in large measure due to the assumed requirement for a pouch laminate material plus a paper product overwrap. The need for more capital equipment, due to the slow processing speed of pouches, has only a minor impact on costs.

Geothermal energy appears somewhat more cost-effective as a substitute for fossil fuels in pouch processing than in food freezing. Even here, however, the impact on total cost is small.

Some technological opportunities that may reduce energy consumption and total costs in frozen food processing are identified.

CONCLUSIONS

A. Summary of Results

1. A detailed analysis of the operations in frozen food processing (with emphasis on broccoli) permits the following generalizations:

   a. The cumulative value added at the retail checkout counter comes well within range of observed retail prices.

   b. Contributions to this cumulative value added come about 20% from farming (growing and harvesting), 35% from frozen food processing per se (preparation, packing and freezing), 20% from wholesaling and distribution (storage, transportation and brokerage), and 25% from retailing (storage and display).

   c. The two most costly operations along the chain are (6) Pack, wrap and case, and (13) Store and display (retail), with the latter the larger. The former is costly because of the labor intensiveness of handpacking of cartons, and because of the expensive input of packaging materials. The latter is costly because retailing in general is labor-intensive, and because retailing of frozen foods requires investment in expensive display cases.

   d. The energy contribution to value added was about 7% in 1979. While not large, this contribution is much larger than has generally been reported in the literature. Major contributions come from farming (15%), transportation (20%), processing (35%) and wholesaling and distribution (minus transportation), and retailing (15% each). Of the energy expenditures for processing, over 50% (and 20% of total energy expenditures) was due to packaging materials.

e. Another way of breaking energy expenditures down is into direct fuel inputs (55%), indirect inputs embodied in other purchased inputs such as fertilizer and packaging materials (28%), and energy embodied in capital (17%), mostly in buildings.

f. In energy accounting and especially in energy cost forecasting, it is best to "purify" the factors of production by separating out the energy contributions to cost or value added from all other contributions. By then relating the energy costs to those of the raw material resource that "drives" the price (crude oil at present), it is possible to make some simple forecasts. These say that energy expenditures should account for about 9% of the frozen food price in 1980, and should go to a 12.5% equilibrium value if the price of crude oil should level off at about $40/bbl (in 1979 $).

2. An analysis of the feasibility of substituting energy from geothermal water for electricity and natural gas in frozen food processing indicates that

a. Fossil fuel prices have risen sufficiently so that this substitution looks economically feasible and even attractive on the basis of return-on-investment considerations. As these prices rise further, the safety margin for success should increase.

b. However, the effect on value added is small (less than 1¢/lb), and the energy saving modest. At issue is a substitution involving one-seventh of the energy cost along the whole process chain. Consequently, only such geothermal locations as have reasonable land rents, a good spectrum of high-yield vegetable production nearby, and excellent transportation links to market areas come under consideration. Otherwise the gain is cancelled by other factors.

c. There remain some uncertainties in the analysis that require further investigation. These center around the need for fresh cool water, and the disposal of "spent" fresh and geothermal water.

3. Analysis of the operations in retortable processing of fresh vegetables leads to the conclusions that

a. Based on value added (as a surrogate for market price), at present the retortable pouch is not a serious threat to frozen fresh vegetables at the checkout counter. Its cost appears some (13 $\pm$ 10)% higher. Of course, this is not to claim that market price is the only consideration. Taste, and economy and ease of handling at the final consumption stage may still lead to market penetration of pouched vegetables. And pouched formulated foods may have additional advantages going for them. But it would appear that frozen vegetables' main competition will continue to come from fresh market produce which, in high-yield, well-located growing areas, commands the highest agricultural land rents.

b. The contributions to value added are now shifted noticeably. Farming (18%) more or less holds its own, but retortable pouch processing (45%) grows at the expense of wholesaling and distribution including transportation (17%) and retailing (20%).

c. As before, the two costliest operations are (6) Fill, seal, etc., and (13) Store and display; but now (6) has jumped greatly ahead of (13), because of the high cost of packaging materials, especially pouch laminate. Surprisingly, the higher capital costs of this process do not make a major contribution to value added.

d. The energy contribution to the value added of pouched vegetables was 7% in 1979, just as in the case of frozen foods. Major contributions now came from farming (14%), transportation (19%), processing (60%), and wholesaling and distribution (minus transportation) (1%) and retailing (7%). Of the expenditures for processing, over 60% (and 37% of total energy expenditures) was due to packaging materials.

e. Broken down another way, energy expenditures for pouch processing consisted of direct fuel inputs (45%), indirect inputs embodied in other purchased materials (44%), and energy embodied in capital (11%).

f. As presently envisaged, pouched foods are as vulnerable to energy price escalation as are frozen foods.

4. An analysis of the feasibility of substituting energy from geothermal wells for natural gas in pouched food processing indicates that

a. The substitution looks economically feasible, and, in fact, appreciably more attractive than for food freezing.

b. The effect of the substitution on value added is still small, so other factors may govern.

c. Here, too, there remain some uncertainities in the analysis. These center around the amount of natural gas to be used in pouch processing, and therefore to be saved with the substitution of geothermal energy; and on the need for fresh water, and the disposal of "spent" fresh and geothermal water. Indications are that water problems could be considerably smaller with pouch processing.

B. Further Leads

These are of two types: further analysis to reduce uncertainties in certain aspects of this study; and investigations of new ideas arising from this study.

1. Further analyses.

   a. Frozen food processing.

      1) Obtain more specific data on the labor costs of handling frozen food at the retail level.

      2) Derive better-grounded figures for fresh water needs (both cool and otherwise) at a geothermal site, taking full advantage of opportunities for recycling.

      3) Scope out the waste water treatment and disposal problem at a geothermal site in conjunction with frozen food processing.

   b. Retortable pouch processing.

      1) Obtain better estimates for labor in pouch processing.

      2) Obtain more specific data on labor costs for handling pouched food at the retail level.

      3) Estimate fresh water needs at a geothermal site, taking full advantage of opportunities for recycling.

      4) Scope out the waste water treatment and disposal problem at a geothermal site in conjunction with pouch processing.

   c. Applicable to both frozen and pouched food processing.

      1) Follow the analysis all the way to the dinner table, and broaden it to include formulated foods.

      2) Apply the same type of analysis to a comparison of canning as the pouch.

2. Ideas arising out of this study.

   a. Frozen food processing.

      1) Should tunnel freezing be phased out? Preliminary investigation in this study seems to indicate that it is less

economical and less energy-conserving than plate freezing.

2) Would it make economic sense to develop a package or carton that

   a) is less costly,

   b) embodies less energy,

   c) can be filled by machine,

   d) is specifically designed to be put in standard shape during plate freezing,

   e) has an insulating, printable overwrap with radiation barrier, put on directly after freezing?

   The notion is to adapt pouch technology (but without sealing problems), and create a more easily frozen, better insulated package for more economical handling at every stage to the final consumer.

3) Would it make economic sense to design a better insulated warehouse for cold storage; perhaps one with individually accessed, insulated, thermostated interior compartments or bulkheads? This might be most effective in conjunction with 2) above.

4) In conjunction with geothermal energy, what are the opportunities and payoffs for increasing the utilization factor U_F, for example by round-the-clock operation?

b. Retortable pouch.

   1) Examine the possibility for minimizing the expense, weight and energy content of the overwrap, or for dispensing with it entirely.

2) Investigate ways in which pouch cost could be reduced. The figure of $80.00 per 1,000 10-oz pouches used in this study comes to about $5.00/lb. This is about a factor of 5-10 higher than the cost of the components such as aluminum or propylene foil.

c. Geothermal energy.

Investigate ways in which geothermal energy at a site can be used symbiotically in several applications; for example, in frozen food and/or pouch processing and in paper products and plastic manufacturing, including the packaging materials for the food processing lines; or in completely unrelated fields, such as mult-stage distillation of alcohol from the fermentation of beets, corn or other grains, etc.