ECONOMIC TRENDS AND TECHNOLOGY ISSUES

IN THE MAINE FOOD PROCESSING SECTOR

AN INITIAL ASSESSMENT

MAINE SCIENCE AND TECHNOLOGY COMMISSION

JULY 1989

John R. McKernan, Jr.
Governor

David M. Coit
Chairman

Patricia Tanski
Executive Director

MAINE SCIENCE AND TECHNOLOGY COMMISSION

July, 1989

On behalf of the Maine Science and Technology Commission, I am pleased to present the results of the Commission's study of the food processing industry in Maine. The study is the result of extensive surveys of industry members, interviews with researchers and food processing experts throughout the nation.

The purpose of the profile is to provide the Maine Science and Technology Commission, other policy makers, industry members and others interested in the food processing industry with important information on trends and industry issues in Maine, the nation and the world. We view the report as one of many steps to maintain and cultivate vitality for this important industry.

Other initiatives undertaken by the Commission include the establishment of the Food Processing Development Committee to design and implemnt strategies for industry growth through science and technology, and technical assistance in product development, process technology and quality control on a fee-for-service basis through the Maine Research and Productivity Center.

We appreciate the contributions and dedication of all who participated in this important effort. Particular recognition goes to Lloyd Irland and Alison Webb of the Irland Group for their careful research and incisive analysis. Our appreciation to those who evaluated and commented on methodology and content prior to publication.

The Commission strongly believes that the partnership of industry, education and government is crucial in developing effective long term strategies for a vital food processing industry in Maine. We thank all who participated in this effort for their commitment to that partnership and the industry.

Sincerely,

David M. Coit
Chairperson

State House Station 147, Augusta, Maine 04333 — *Offices Located at* 45 Memorial Circle
Telephone (207) 289-3703

Report to

Maine Science and Technology Commission

Economic Trends and Technology Issues in the Maine Food Processing Sector

An Initial Assessment

The Irland Group

7 North Chestnut St.

Augusta, ME 04330

November 17 1988

Table of Contents

Table of Figures

Table of Tables

1 EXECUTIVE SUMMARY

a. The objective of this project is to provide a factual basis for the design of Technology Assistance programs to assist firms in the Maine food processing sector.

b. Food processing is a diverse sector of businesses employing nearly 8,000 persons in Maine. Though its employment has declined, there remain many product lines with considerable development potential.

c. Technology is only one of several key problems facing firms in this industry. Efforts to implement technology improvements must link closely with market development, marketing techniques, and other business needs. In fact, many firms rate market development as a higher priority than technology.

d. Instead of choosing individual products the MSTC should support action on generic technologies, like waste recycling, that are broadly applicable. Specific suggestions include:

-- seek technology suitable for small plants;

-- push market development;

-- develop value added products for by-products and low-value products (e.g. cull potatoes; spent hens);

-- target the general problem of microbusinesses; and

-- address treatment or use of waste streams.

e. A process for moving forward should consist of:

-- inventory technical expertise;

-- select 2-4 target generic technologies;

-- assess the target technologies; and

-- design a delivery strategy.

2 INTRODUCTION

This was prepared by The Irland Group for the Maine Science and Technology Commission. The report has benefited from comments supplied by roughly a dozen outside experts and participants in the industry. We are grateful for their assistance.

Our objective is to suggest criteria and objective economic guidance for the later design of Technology Assistance programs for the food processing industry. This is a survey-level analysis designed to support broad program design as to product lines, markets and key technologies. It does not offer a detailed technology assessment of any particular industry. It was not within the scope of this project to assess the cost, profitability, or development status of equipment in the broad areas of technology identified. The technologies that we discuss are clearly important but no conclusions can be drawn as to their financial and practical applicability in Maine in any particular product line.

Hence, it is not our objective to select winning products or equipment types that technology transfer should support. Our objective is to provide an informed basis for a later selection process.

We have not discussed the important but highly complex technologies bridging the gap between the farm and the factory in agronomic practice, harvesting, storage, and hauling as they affect the industry's raw material quality and costs.

We have relied on available economic data and extensive interviewing.

Initial economic data gathering was performed by the Center for Research and Advanced Study, University of Southern Maine, under the direction of Robert A. Goettel. Interviewing, analysis and initial drafting of this report were carried out by Alison Jones Webb, Irland Group Associate.

3 THE FOOD PROCESSING INDUSTRY

3.1 General

Maine's food processing sector is an important part of the state's economy, especially in many rural towns. Under pressure from changing industry structure, declines in farming, and stiff interregional and import competition, the sector has undergone wrenching adjustments. At the same time, changing markets and technology have created new opportunities that are being grasped by aggressive firms.

The food processing sector covers a vast array of products, from bagels to frozen fish (Table 1). The sector currently employs about 8,000 Maine workers. The sector has been extensively studied (Connor, 1985; Blaine House Conference, 1987; Konrad, 1986; Vail, 1987; FAME, 1986), but much remains to be analyzed and put into useful form for firms and public agencies to use. Likewise, the sector has received much attention concerning its development policy options and research and technology needs (Maine Tomorrow, 1988; EMDC, 1988; FAME, 1988; Barringer, 1987).

Table 1

Maine Food Processing Sector, 1984

	Value of Product($MM)	Average Wage($)	Total Number of Workers
FOOD	709.2	14,327	7,886
Meat Products	112.9	13,675	1,062
Dairy Products	102.7	18,051	657
Preserved Fruits & Veg.	161.6	12,879	1,987
Froz. Fruits & Veg.	92.4	12,455	1,446
Grain Mill Products	64.7	17,392	270
Prepared Feeds, NEC	41.2	15,446	75
Bakery Products	102.2	17,463	1,356
Perishable Bakery Prod.	102.2	17,463	1,356
Beverages	55.4	19,011	574
Soft Drinks	44.8	18,308	532
Miscellaneous	106.6	10,913	1,912
Canned & Cured Seafood	56.8	10,553	1,046
Fresh or Frozen Seafood	42.4	10,388	734
All Nondurable	6,139.7	17,897	66,824
All Manufacturing	9,457.9	18,926	110,273

Source: Maine Dept. of Labor, Census of Maine Manufacturers, 1984

3.2 Maine and Food Processing in the National Economy

Over the past decade, Maine's share of the nation's Food and Kindred Products industry has remained small. The state continues to lag behind US averages in virtually every area of productivity and growth; however, there have been improvements in some sectors.

The total value of Maine's food and kindred products sector was $745.4 million in 1985, compared to $713.7 million in value of shipments in 1977. Maine's share of US shipments declined from 0.39% in 1977 to 0.26% in 1977. In that time period, Maine's value of product as a percentage of the US total declined in every major sector of the food processing industry (Figures 1 and 2). Maine exported $14 million in food products to foreign countries in 1987.

Figure 1

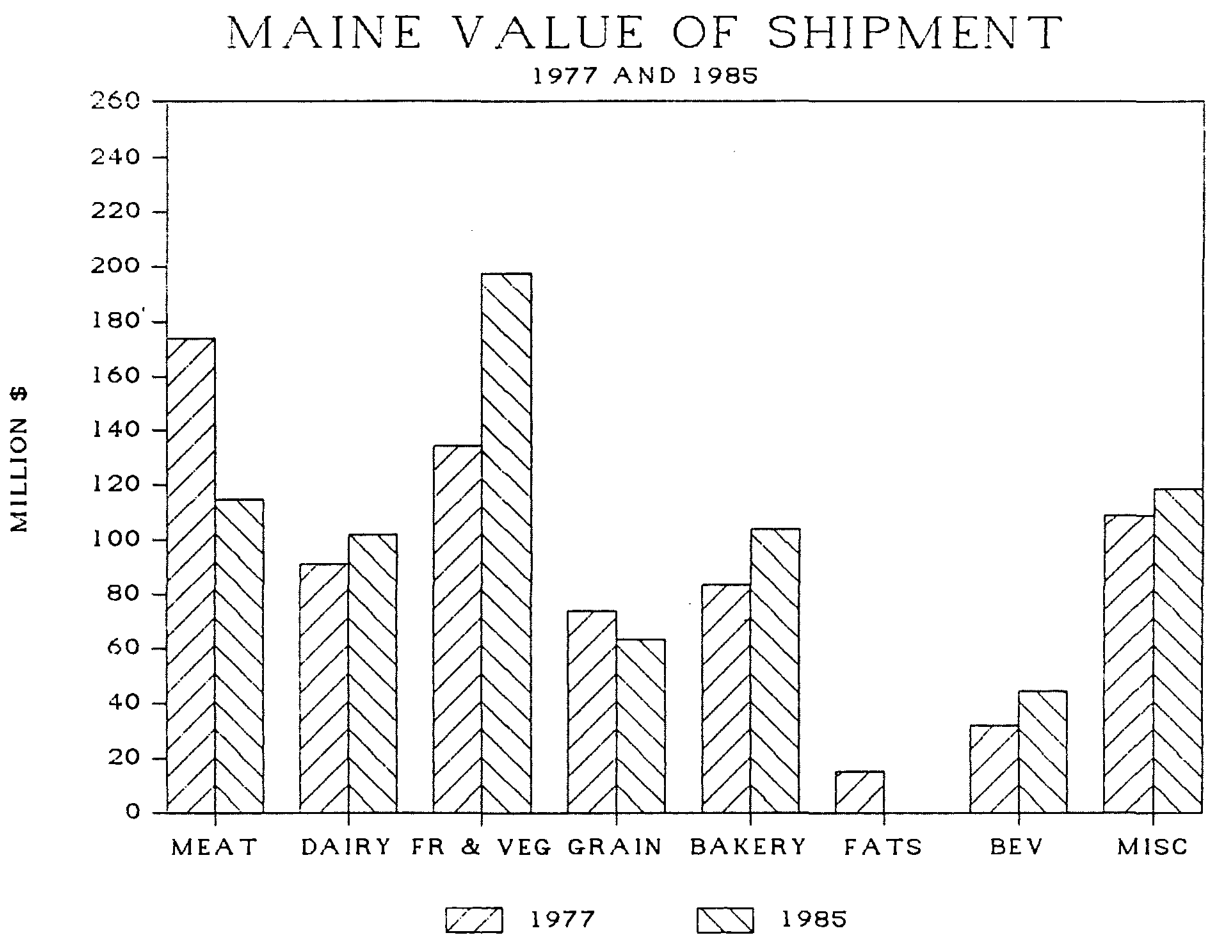
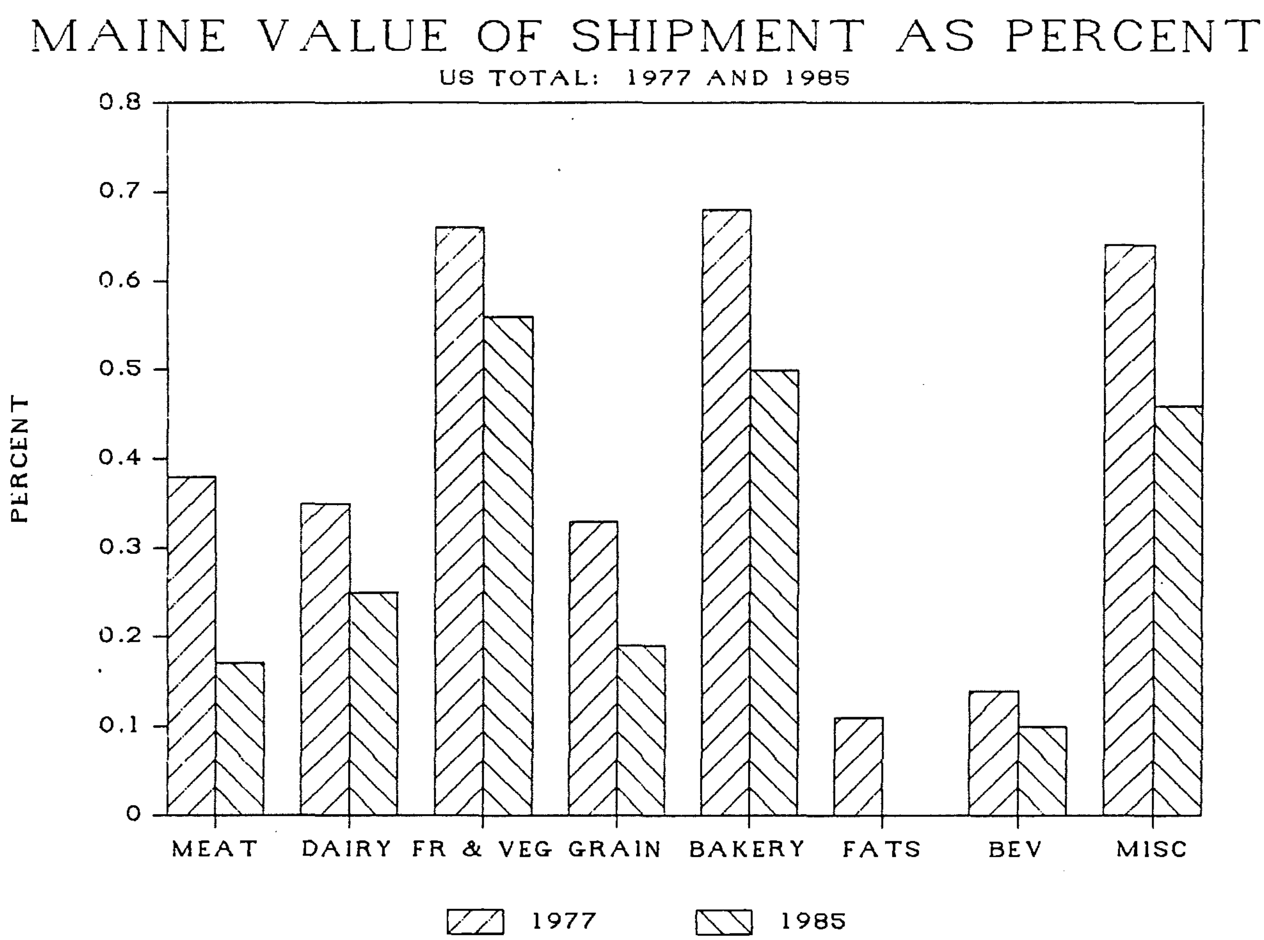

MAINE VALUE OF SHIPMENT
1977 AND 1985
MILLION $
260
240
220
200
180
160
140
120
100
80
60
40
20
0
MEAT
DAIRY
FR & VEG
GRAIN
BAKERY
FATS
BEV
MISC
1977
1985

Figure 2

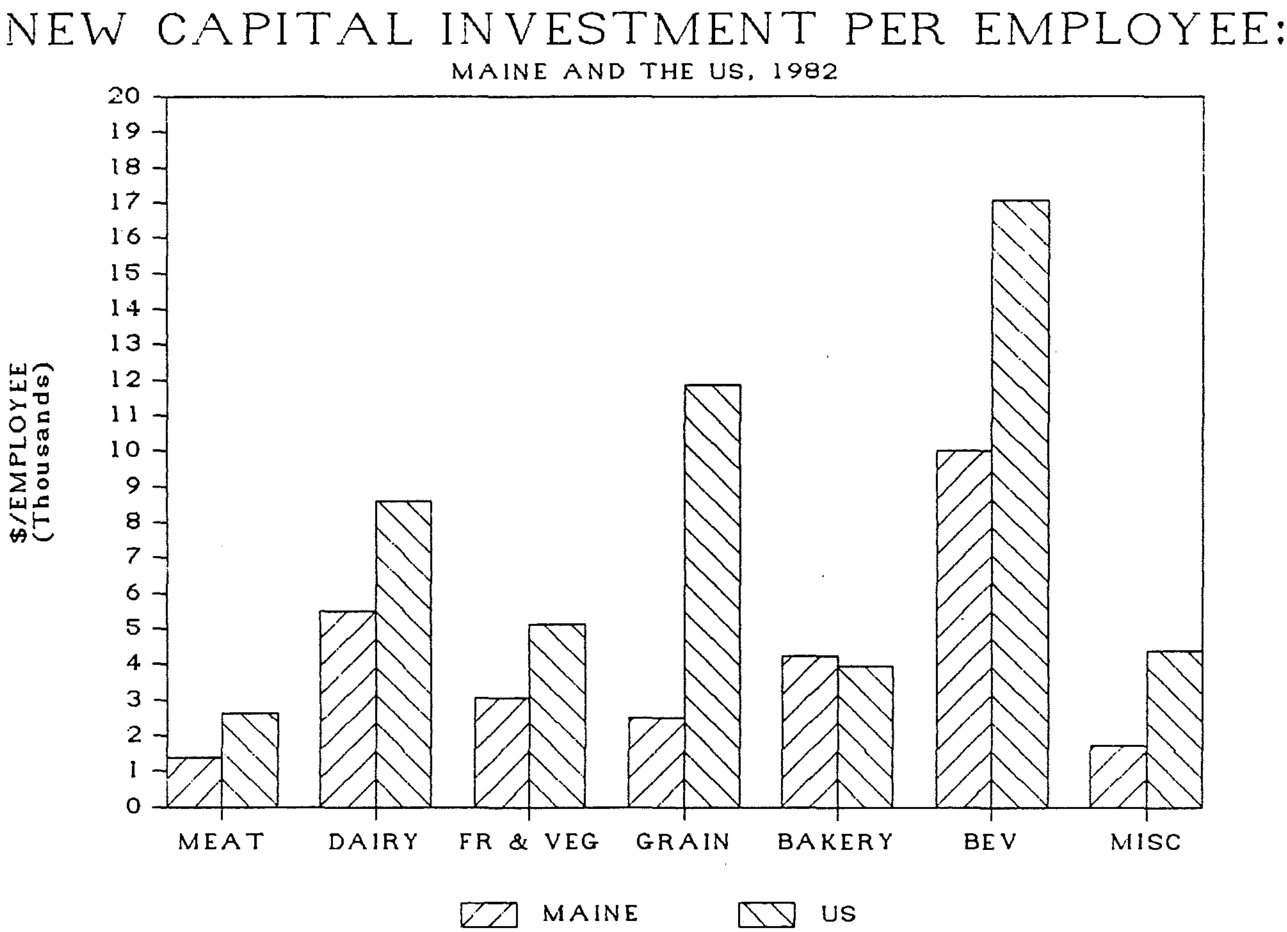


Maine's average annual wage in the food processing industry rose from $9,517 in 1978 to $14,401 in 1985, a 51% increase.

The range of growth in the food processing shipments in Maine between 1977 and 1985 was from -100% (a fats and oils industry no longer exists in Maine) to 47% (preserved fruits and vegetables). During that same period, the range of growth in the US was between 21% (fats and oils) and 85% (beverages). In 1987, shipments of the US Food and Kindred Products industry grew at about 1.7% in real terms. This rate of growth, (equal to the population growth rate), was due in large part to the introduction of more value-added and convenience foods and from growth in beverage consumption. The real value of shipments is expected to increase by about 2% in 1988.

Maine's bakery products sector compares favorably to that of the US in new capital investment per employee (in 1982). In that sector, Maine's new capital investment was 107% of the US figure. For other sectors of the industry, the percentages ranged from 21% for grain mill products to 64% for dairy products (Figure 3).

Figure 3



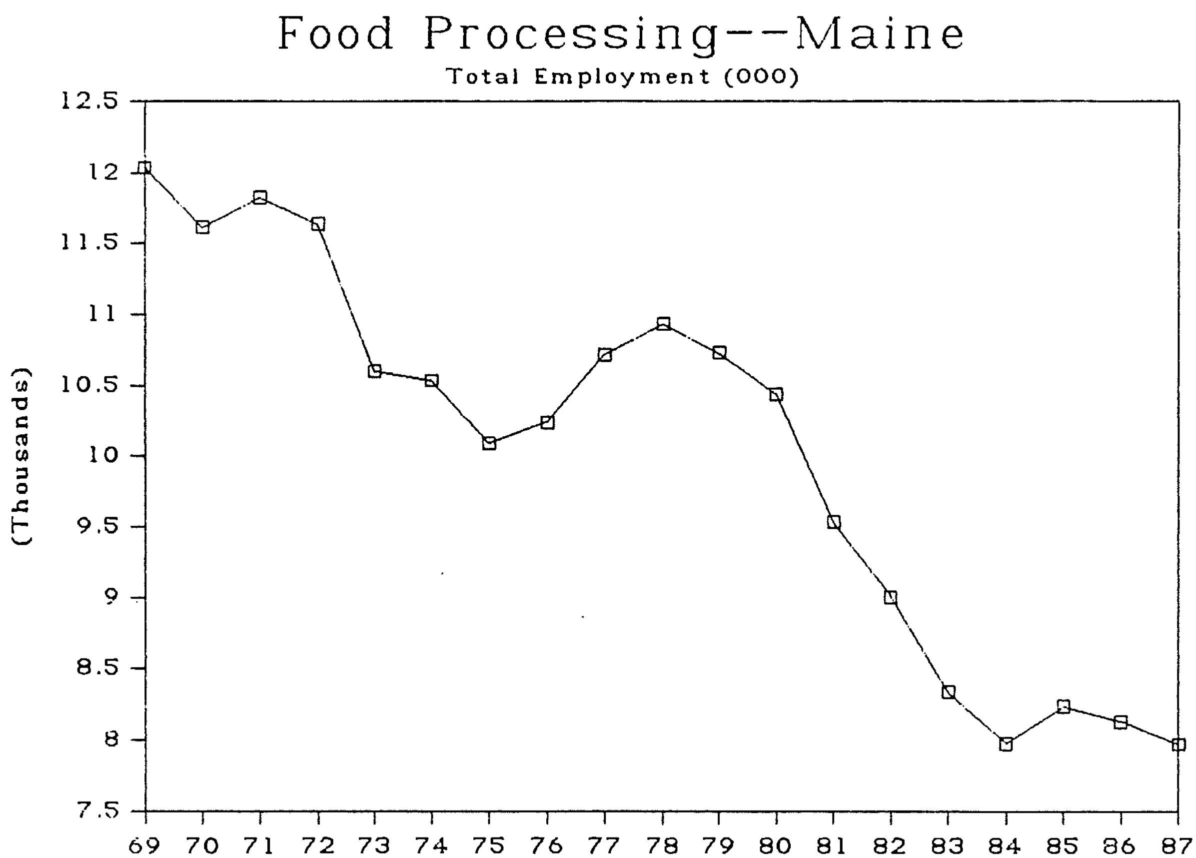
In 1977, value added per worker hour was $26.53 for the US and $15.02 for Maine. By 1985, those figures were $53.65 and $32.25 respectively. For the US, these years saw a 102% increase in value added. For Maine, the increase was 115%.

3.3 The Importance of the Food Processing Industry to Maine

The Food Processing Industry's share of Maine's value of manufacturing product declined from 16.4% in 1975 to 7.5% in 1984; and that percentage is even lower today, after the collapse of the broiler industry in 1980's (Figures 4, 5 and 6).

Employment in the food processing sector accounted for 10.4% of the state's total manufacturing employment in 1975. By 1984, the figure had fallen to 7.2% (Figure 7).

Figure 4



Source: US Dept. of Commerce, BEA

Figure 5

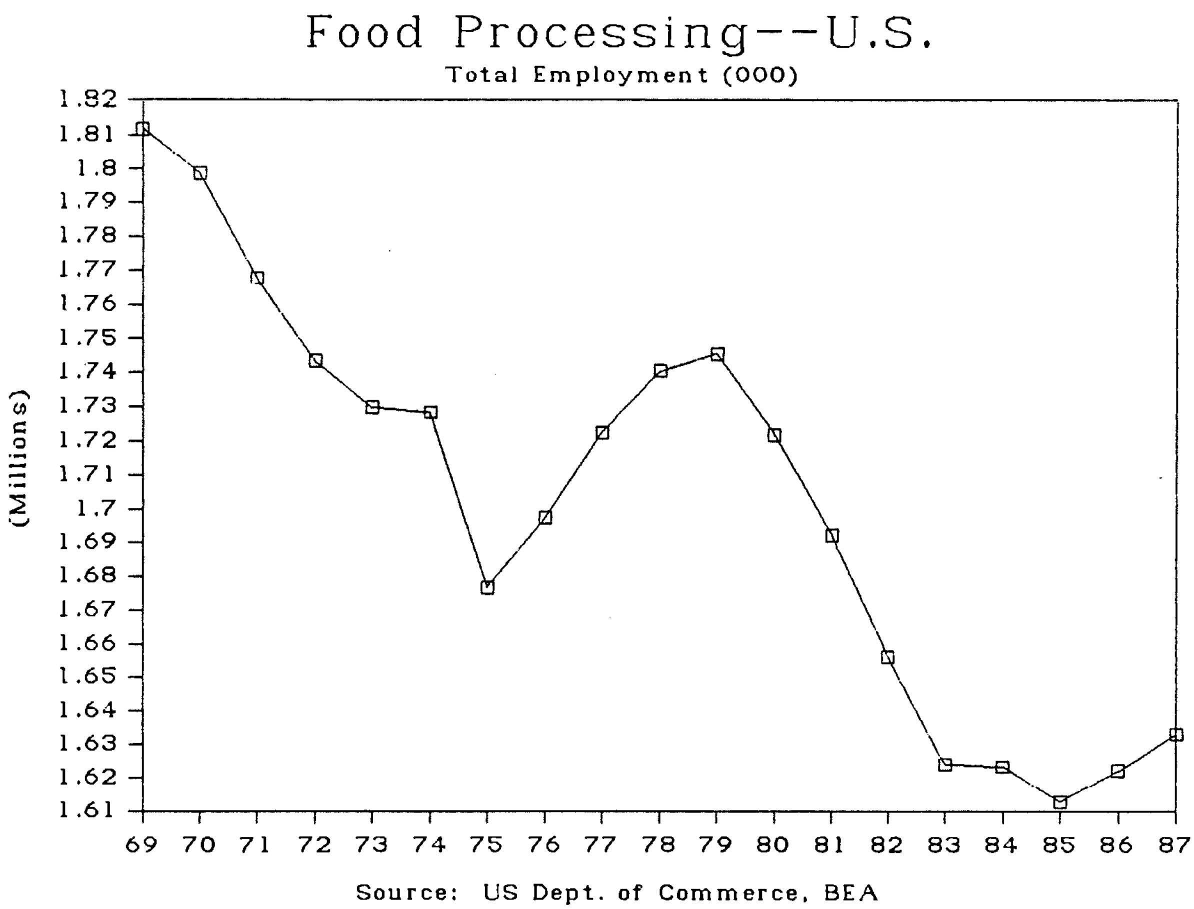

Food Processing--U.S.
Total Employment (000)
(Millions)
1.82
1.81
1.8
1.79
1.78
1.77
1.76
1.75
1.74
1.73
1.72
1.71
1.7
1.69
1.68
1.67
1.66
1.65
1.64
1.63
1.62
1.61
69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87
Source: US Dept. of Commerce, BEA

Figure 6

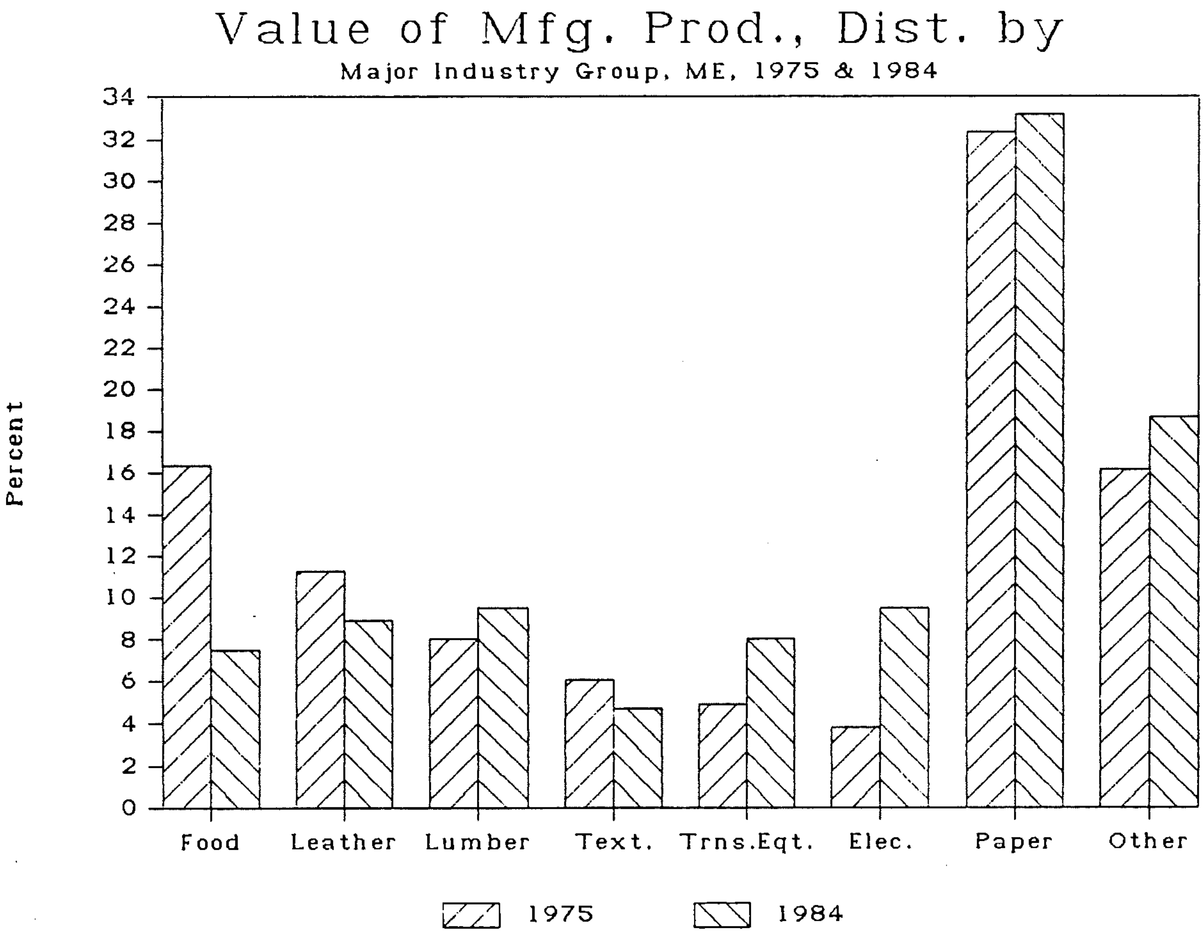
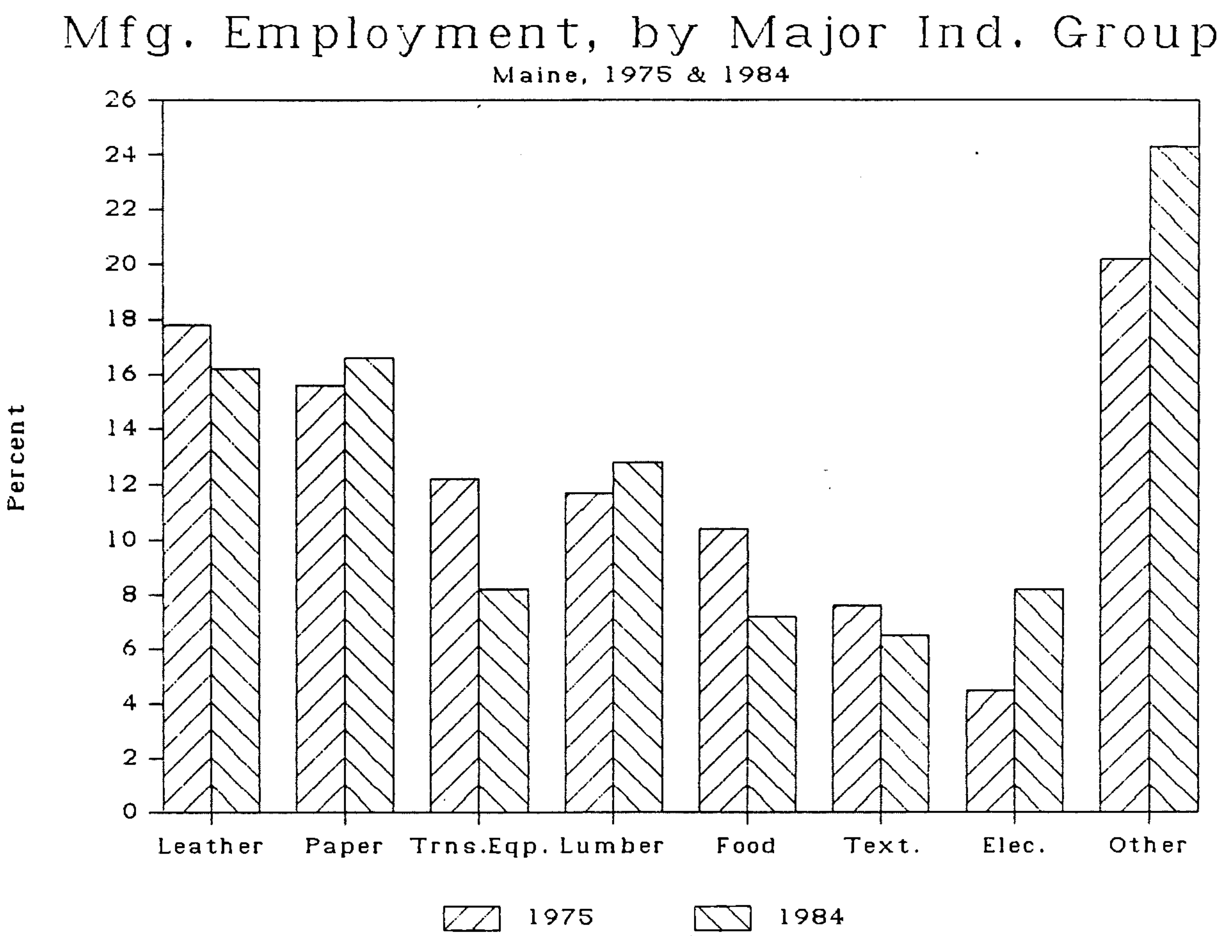
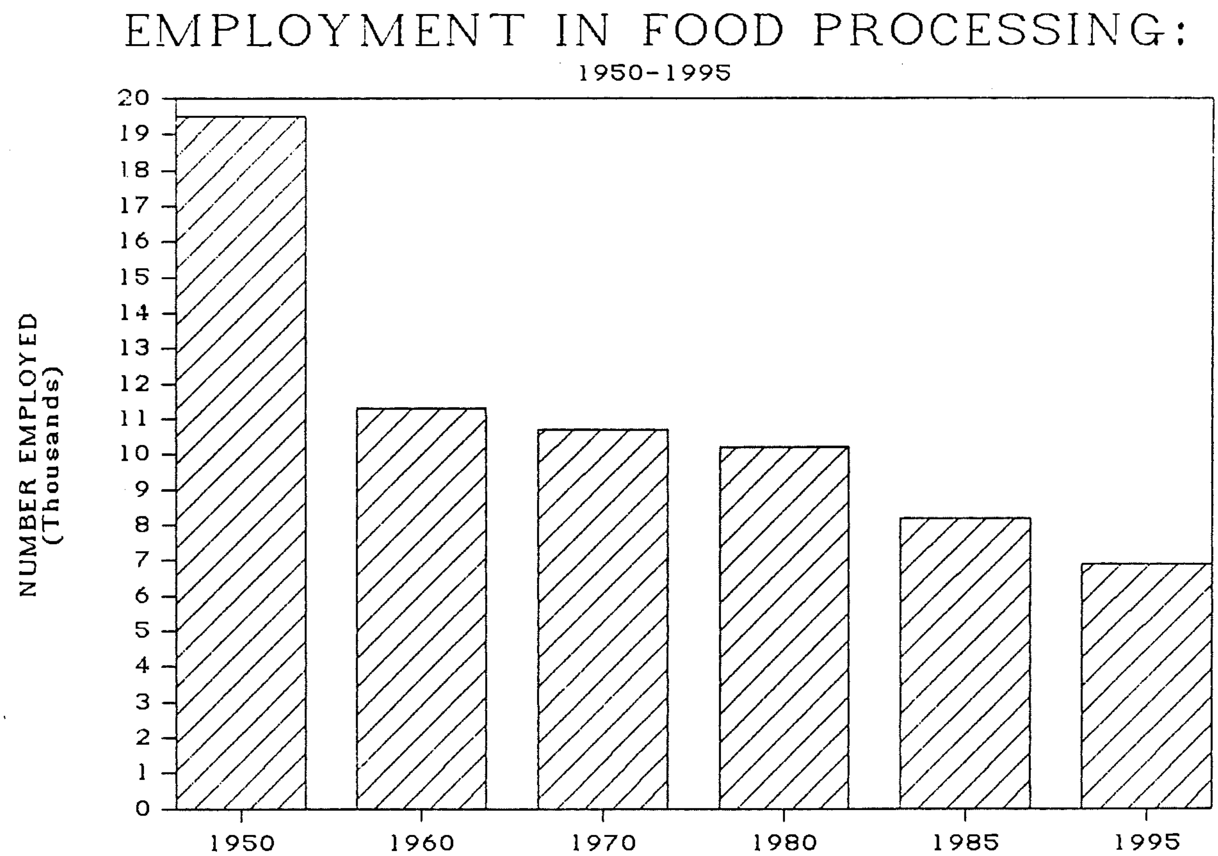

Value of Mfg. Prod., Dist. by
Major Industry Group, ME, 1975 & 1984
Percent
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Food
Leather
Lumber
Text.
Trns.Eqt.
Elec.
Paper
Other
1975
1984

Figure 7



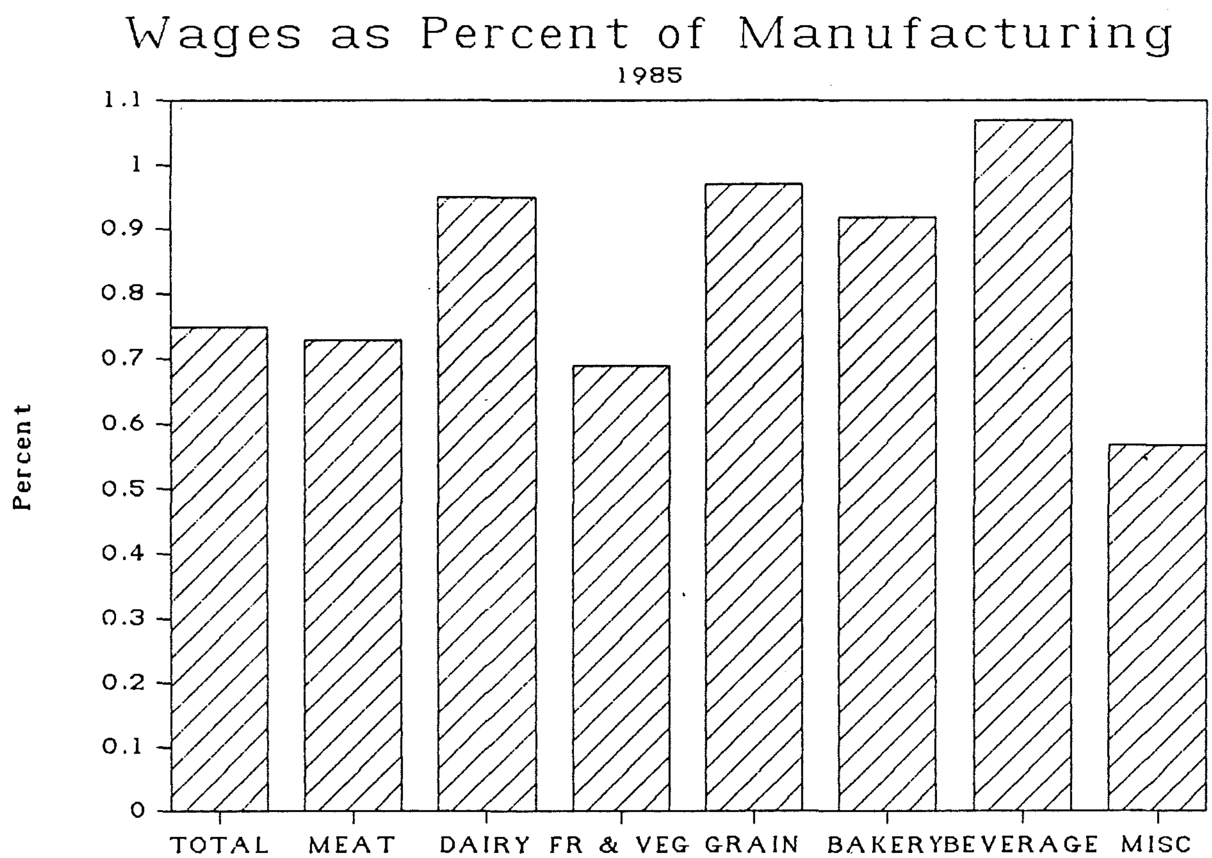
A decline in total employment in the food processing sector, which began in the 1950's, is expected to continue. By 1995, only 5900 people are expected to be employed in food processing, compared to 8200 in 1985 and 11,300 in 1960. The importance of this sector to rural employment, where other opportunities now exist, may be diminishing as well (Figure 8).

Figure 8



Wages in the food processing industry are lower than the average state manufacturing wage, and the gap is widening. In 1978, the average gross wage in food processing was 85% of the average state manufacturing wage. By 1982, the figure was 81%, and in 1985 it was 75%. However, wages in Dairy, Grain Mill, Bakery and Beverage products have been close to or exceeded the average state manufacturing wage for the past decade. Wages in Meat, Fruits, and Vegetables and Seafood products have been consistently much lower for that period (Figure 9).

Figure 9



In 1985, 71% of the industry's product value was produced in Cumberland, Aroostook, Waldo and Androscoggin counties. Cumberland and Aroostook alone produced just under 50% of the state total. Employment was concentrated in Cumberland, Aroostook, and Androscoggin Counties. These counties accounted for almost two-thirds of all jobs in the food processing industry (Figures 10 and 11). With the closing of Penobscot Poultry in 1988, Waldo County's share of both value produced and employment has declined.

Figure 10

VALUE OF PRODUCT BY COUNTY

1985

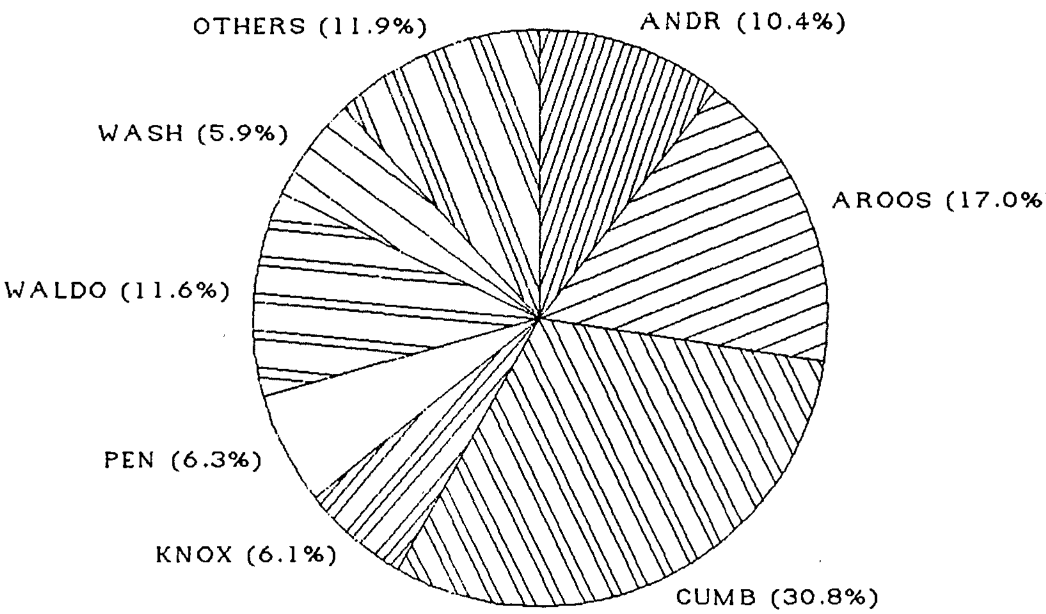
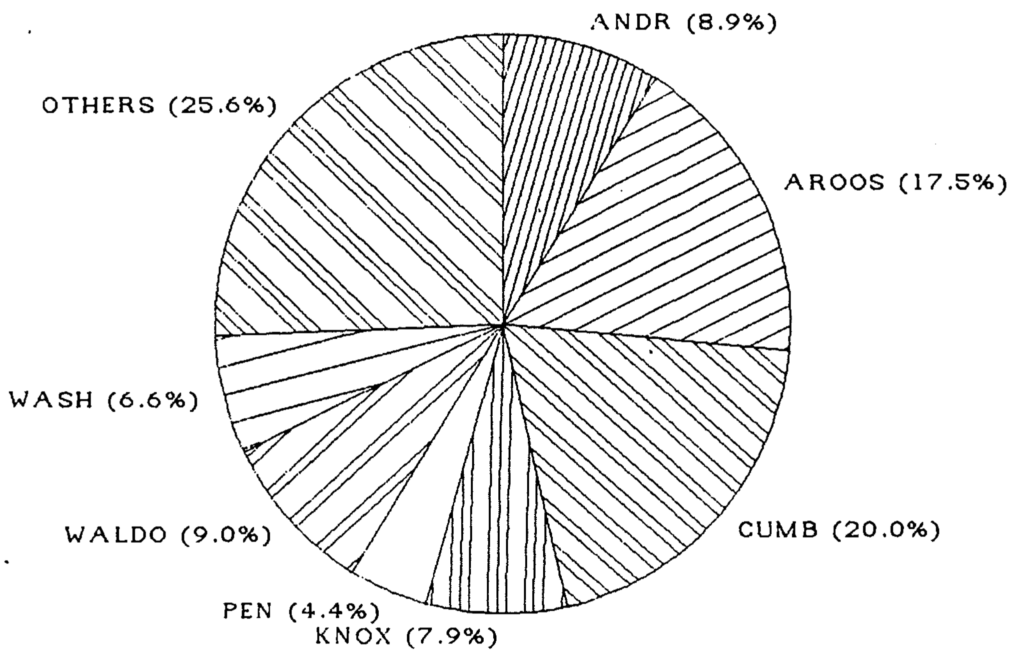


Figure 11

EMPLOYMENT IN FOOD PROCESSING BY COUNTY

1985



There is little information on economic linkages or multipliers in this sector. State multipliers available for the Maine Food and Kindred Products industry indicate that the total dollar change in Maine worker earnings for each additional dollar in output delivered to final demand is $0.39. The total dollar change in output for each additional dollar in output delivered to final demand is $1.80. The total number of jobs for each additional job in the industry is 1.8 (US Department of Commerce; Veazie).

The use of Maine produce in food processing varies from product to product. For example:

-- 1% of blueberries are consumed fresh, 95% frozen and 5% canned immediately after harvest;

-- 54% of potatoes are sold fresh, 30% go into processing, 6% are considered cull, and 8% are used for seed;

-- 54% of milk is consumed as fluid; 46% is processed (mainly into ice cream);

-- shellfish and ground fish are consumed predominantly fresh; and

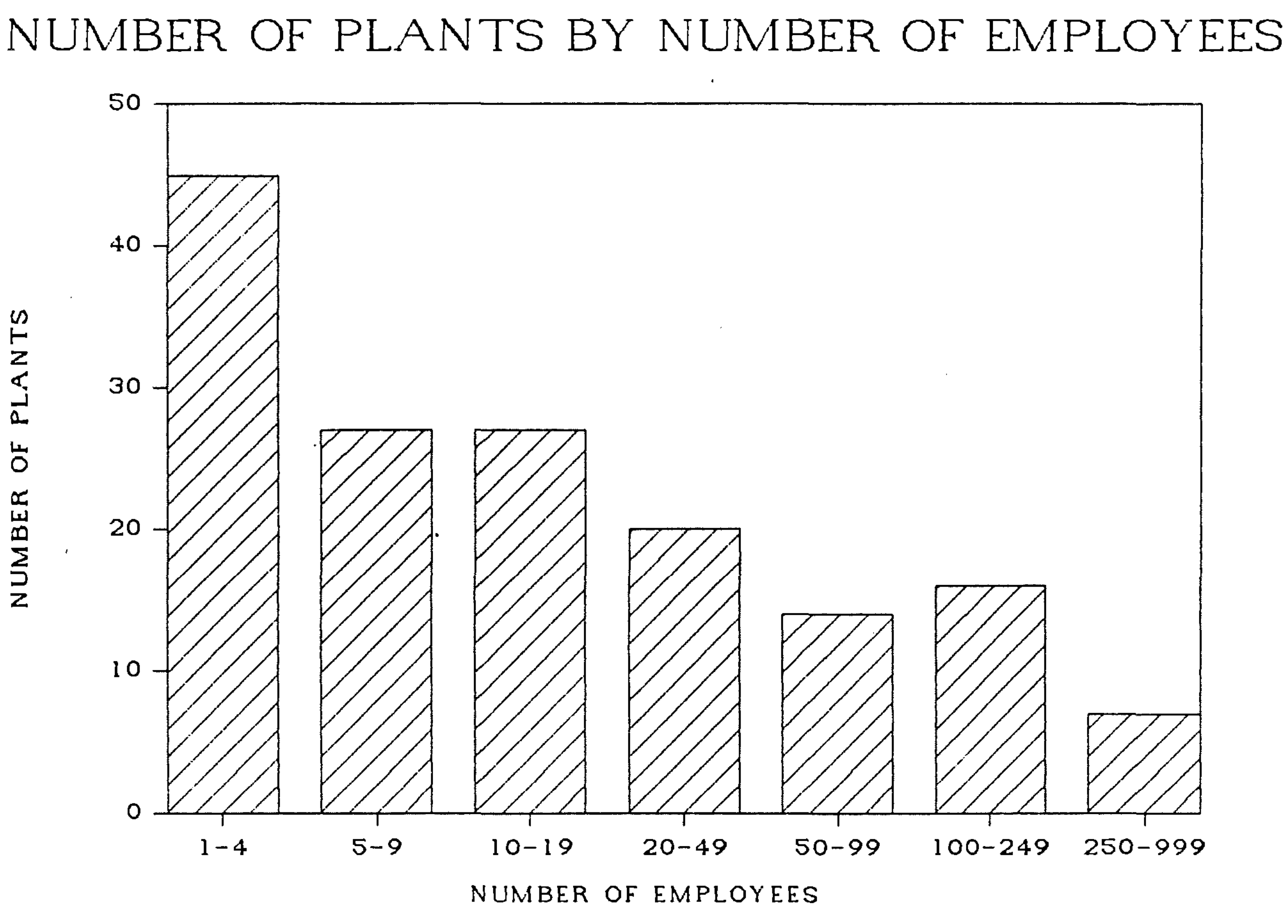
-- fish by-products including pet food, can account for up to 60% of fish after filleting.

Backward linkages to fruits and vegetables, potatoes, seafood and dairy are quite strong. For meat and poultry (with the exception of eggs) the linkages are weaker.

3.4 A Profile of Maine's Food Processors

Of Maine's 156 food processing establishments in 1985, 23 had more than 100 employees. These 23 establishments (15% of total) accounted for approximately two-thirds of the 7882 food products employees in Maine (Figure 12).

Figure 12



The largest processors, employing over 250 workers, in 1985 were in meat products (Penobscot Poultry, which closed in February 1988), fruits and vegetables (Cherryfield Foods, B&M Baked Beans, McCain Foods, and Penobscot Frozen Foods), and bakery products (Nissen Bread and Country Kitchen-LePage Bakery).

The number of employees declined by 39% between 1972 and 1985. 2000 jobs, almost half of the total decline since 1972, were lost (mostly in poultry) between 1982 and 1985.

Small family-owned establishments account for over a quarter of all establishments. There is potential for this microbusiness sector to stabilize part-time and seasonal employment patterns, which are characteristic of parts of the food processing sector in Maine. In 1985, 29% of all establishments employed 1-4 employees, 46% of all establishments employed fewer than 10 employees. In 1985 preserved fruits and vegetables accounted for 17% of the employment in the 1-4 employee size class. Similarly, miscellaneous foods (including seafood) accounted for 17% of those establishments.

4 NATIONAL MARKET TRENDS AFFECTING FOOD PROCESSING

4.1 General

This section reviews the principal national market forces affecting the food processing sector.

4.2 Demographic Change

Recent changing demographic patterns in the US have had a strong impact on the nation's food processing industry. An increasing number of women choose to work outside the home, and 54% of these women have preschool children. There is an increasing number of dual income families. The US population is "graying": 1 in 15 people are over 65. By 2020, almost one-third of the US population will be 55 or older. There is an increasing number of single-parent and single-person households. By 1995, 45% of the increase in number of households will be accounted for by this group. The greatest percent increase in population will be in the 39-54 year age group. Total population is projected to increase by 21 million by 1995.

4.3 Changing Demand

These demographic shifts mean an increased demand for high price, value added, high quality convenience foods, microwavables, and single-portion processed foods. By 1995, 80% of American households will own microwave ovens, and the value of the US consumer food market is expected to increase to over $800 billion (from about $450 billion in 1985).

Similarly, demographic changes have increased the demand for institutional food services -- hotels, restaurants, fast food, etc. Nationwide, the eating and drinking industry experienced a sales gain of 10.6% in 1986. Real consumer spending on meals and beverages away from home increased by almost 4.7% in the first half of 1987, while spending on foods and beverages consumed at home declined by 2.9% during this period.

Coupled with changing demographic trends is a growing interest in health and nutrition. Low sodium, low fat, low cholesterol, no caffeine, lite foods, "organic", and fresh foods are becoming more popular. For example, at least 454 new food or beverage products listed as "low," "light," or "natural" were introduced during the first six months of 1987. Ethnic, foreign, and outdoor-oriented foods are also currently in demand. Packaging which increases shelf life, preserves the quality of fresh produce and which retains the fresh taste in canned and processed foods will be in greater demand. Also, packaging is increasingly emphasizing portions suited to preparation for one or two people.

4.4 Marketing Obstacles

Increases in income have meant that greater disposable income is available to spend on food. Competition in new products is fierce. Some US retailers now demand up front cash payments from manufacturers for selling new products. Manufacturers pay "slotting allowances" in addition to their regular promotion programs and advertising allowances. These allowances may penalize the smaller, less capitalized manufacturer. This practice is under review by the courts in some states and may be ruled unfair competition.

4.5 Summary

Food processing has become highly dynamic in national markets, as markets become more segmented and as demographic and marketing forces change the way food products are marketed. In particular, "up-scale", high margin versions of basic products like the "Yuppie sodas" are growing in popularity. These forces continue to create new opportunities for agile marketers, as we see in reviewing key Maine industries in the next section.

5 MAINE FOOD PROCESSING: MARKETS AND TECHNOLOGY

5.1 General

Given the size of food processing firms in Maine, the technological status of the industry, in general, is competitive. Linkages between the producing and processing sectors are good. However, Maine processors may be able to further improve their competitive position by meeting current market demand for fresh, frozen, microwavable and specialty foods. Since much of Maine's farm and fishery sector is oriented to the fresh market, this is an advantage for processors.

For example, there is an opportunity for Maine processors using minimal processing techniques--controlled atmosphere/modified atmosphere packaging--to meet demand for high quality fruits, vegetables and seafood. (See Glossary for definitions). Maine producers could also expand into prepared dinner entrees for microwavable meals and for the institutional food market, where demand continues to grow. Similarly , there is an opportunity for Maine firms to move into the institutional market by selling pre-peeled, diced, sliced or chopped raw fruit or vegetables which are minimally processed and packaged. Fruit purees and juices, made by reverse osmosis, could enter the growing beverage market. Fruit growers and processors could respond to a Massachusetts OceanSpray request to introduce cranberry production and processing in Maine. Dairy producers could capitalize on the current interest in calcium consumption by making new beverage products.

Maine's competitive advantage has long been relatively lower wages and an abundance of natural resources. This may no longer be the case, as cheap labor in newly industrialized countries (NIC's) makes mass-produced items almost an impossible option for many industries in the US. However, NIC's may not be able to provide satisfactory quality control in the food processing sector; and Maine food processors may be able to capitalize on this by producing high quality specialty items. Niche agriculture may complement the production of high quality, high value specialty items; but the idea of niche farming and food processing is not universally accepted.

5.2 Blueberries

Annual per capita consumption of blueberries (including cultivated blueberries) increased by 47% (from 7 ounces to 10.3 ounces) between 1980 and 1984, though sales dipped in 1985 and 1986. Less than 5% is consumed as fresh fruit; the rest is processed before sale. Blueberries for the retail market are mostly frozen, no longer canned. About 70% of the processing of wild blueberries from Maine and Canada combined is done in Maine, thereby extending Maine's crop season. Canada has expanded its facilities and has successfully marketed wild blueberries in Western Europe. Canada has also developed a new market in Japan.

Maine's blueberry industry is highly competitive and perfectly positioned to compete in today's market. Major Maine producers have IQF (individual quantity freezing) state of the art equipment now. New products being developed by Maine producers include the blueberry raisin, blueberry concentrate and blueberry puree.

Asceptic packaging for the wholesale market ("bag-in-a-box" style packaging) may be of interest to the industry; and exploration of a market for blueberry juice (or a combination of blueberry and apple, for example) in asceptic packaging may be worth a try. Maine processors should also aggressively seek new markets in Europe, where demand for specialty products is rising, and where many forms of fruit and berry juices and concentrates are popular.

5.3 Potatoes

The national market for fresh potatoes has been strengthening in the last 2-3 years, despite the trend toward convenience foods. There has been a small decline in the french fry market. The chip market remains strong. Demand for processed and frozen potatoes increased 21% between 1978 and 1983. The technological status of Maine's potato processors is competitive. However, the current emphasis on raising quality standards has increased the supply of cull potatoes. Technology to allow their profitable use is needed.

The institutional market demand for fresh potatoes represents a great and unexplored opportunity for potato processors. UMO is operating a cooperative program with the Agriculture Economics Department, the Food Science Department, and the Extension Service. This program sponsors research in vacuum packed pre-peeled, pre-sliced, diced, and chopped potatoes in bulk. In effect, the program will test markets for existing firms, which then explore the possibility of producing for that market.

The demand for microwavable fresh potatoes is great and unmet. The market is ripe for a fresh potato which could be included in microwave dinners, for example. The technology is available but has not yet been marketed. Maine producers may be well-positioned to move into this market when the technology becomes available.

5.4 Vegetables

Maine produces a variety of vegetables; but its processing capacity has dwindled. Two crops receiving attention lately are broccoli and cauliflower. The national market for fresh broccoli is booming. Imports of frozen broccoli, mainly from Mexico, have increased dramatically from 34 million pounds in 1983, to almost 120 million pounds in 1987. This increase in imports occurred because US production has not kept pace with rising demand.

Between 1978 and 1986, the harvested acreage of broccoli in the US increased by 90%. Maine's broccoli industry was possible "in large part because of a state marketing order which established quality standards and made Maine broccoli more attractive to wholesale and retail purchasers" (Vail, p. 27). Before 1982, no commercial broccoli was grown in Aroostook County. In 1986, 3000 acres were grown (Vail, p. 58). However, current production is down and Maine may lose its share of the market.

A possible market for cauliflower exists, as the "cauliflower has joined broccoli as a favorite among the veggie expansionists." The national harvested area has risen 65% between 1978 and 1986, fresh market cauliflower production increased from 1.85 million hundred-weight in 1978 to more than 5.9 million hundred-weight in 1986. California has a climatic advantage during some parts of the year, but competition from other states is significant during the summer and fall (Waterville Sentinel, 3/29/88). However, research in producing a cold climate variety of cauliflower needs to be done.

5.5 Fruits

Currently, the market for fresh fruits is strong. Various forms of modified atmosphere packing should be vigorously pursued by apple producers. Another possible market niche is in the fruit juice market. Juices packaged asceptically in cardboard containers account for a large part of the US juice market. Massachusetts has successfully developed such a food processing sector (OceanSpray and VeryFine), and Maine could follow suit. In addition, new uses for cull apples should be pursued. Cider, apple powders, chunky applesauce, and pie fillings are possible uses of cull apples.

5.6 Seafood

Customer preference is currently shifting away from red meat. 1987 was the first year in which more poultry than beef was eaten in the US. In 1977, per capita consumption of beef was 91.7 pounds. In 1987, that figure was estimated a 76.4 pounds, and consumption is expected to continue declining. Fish and poultry consumption have risen as a result. US demand for fish for human consumption, though, rose only 3% between 1977 and 1984, while demand for chicken rose 25% in that same period. One reason may be the relatively high cost of fish to chicken.

Given Maine's species mix of high value fish, continued production of fresh fish is appropriate. These species, and lobster, are usually more valuable as a commodity than as a value added product. However, the possibility of value-added products should not be overlooked. For example, microwavable entrees for the US market, or prepared lobster entrees for the French market could be explored as important long-term markets.

Great Eastern Mussel Farm has demonstrated successful production and marketing strategies. Great Eastern has spent over $1 million in advertising and is developing new products which include individual frozen entrees like mussels marinara and mussels scampi. Great Eastern is also introducing mussel salads to supermarket deli counters and is billing mussels as a lower cost substitute for clams. Maine's mussel production accounts for approximately 85% of the national total. Maine's output grew in 1986 to 65.24 million pounds of shucked meat, up from only 512,000 pounds in 1975. Maine's coast may be ideally suited for aquaculture of other species, as well. For example, trout and salmon aquaculture has recently been introduced in Eastport.

Forward linkages in the seafood industry could be strengthened by giving greater attention to value added products, as mentioned above. In addition, underutilized species could be further exploited for value added products. For example, dogfish could be deep fried (as they are in Florida), mackerel could be smoked, or crab could be used in microwavable entrees.

A current challenge in the seafood industry (as well as others) is to induce processors to look at waste as a productive resource. Rockland processors use Seapro, a fish meal processor. Some Portland processors use Seapro, though Seapro is not large enough to handle all the waste; but most

Portland processors sell waste for bait, not a reliable long term value-added solution. However, this situation will change within the year, as Seapro will close at the end of menhaden season this fall.

Alternatives to fish meal as a value added by-product should be developed. Pilot projects have been undertaken. Current possibilities include production of liquid fish protein, which can be used as feed for newborn pigs or for salmon aquaculture, to name just two possibilities. Fish compost could be used as a soil enhancer for broccoli, blueberries, and in the horticultural market.

5.7 Meat and Poultry

The limited volume of cattle raised in the state has resulted in small meat processing plants, few having have the resources to pack to standards required by commercial customers. For example, Hannaford Brothers purchases from Kirschner and Jordan's, but relies on out of state suppliers as well. Meat used in processing is primarily purchased from out of state and even overseas, keeping local backward linkages with beef production weak.

With the broiler business now defunct, poultry production may not be the wave of the future for Maine. But processing opportunities exist. One successful food processor, Poultry Products of Winslow, purchases chicken out of state and prepares chicken pieces for the institutional market. This same producer purchases spent fowl (laying hens which no longer produce eggs) from Maine egg producers and sells diced or shredded chicken on the institutional market. Barber Foods purchases chicken out of state and prepares chicken entrees, also for the institutional market. Another firm is doing a growing business in "free-range" chicken. With US per capita consumption of poultry increasing (from 53.2 pounds in 1977 to 78.2 pounds in 1987) and with US exports of poultry and red meat rising rapidly, markets in Japan and the Pacific are expanding. Processors need to continue this type of value-added production.

After broiler producers folded in the early 1980's, Maine's egg producers realized that an aggressive strategy was necessary to stay in business. The industry now spends $250,000 each year advertising brown eggs, a regional preference, and has held its own, while 50% of the nation's egg operators have gone out of business since 1980. Maine has 3 of New England's 5 major egg processing firms; and with the use of processed eggs on the rise (per capita consumption rose from 36 to 42 eggs between 1980 and 1987) research in this area would insure Maine's competitive position.

5.8 Dairy

Given the size of Maine's dairy farms, the dairy processing industry's technological status is competitive. Reverse osmosis, already used by large processors in the US, is now being developed for on-farm use and will be introduced into Maine in the near future. But the process may not be cost efficient for herds of less than 200-300 cows.

Maine dairy processors successfully sell their ice cream to supermarket chains and also have successfully moved into specialty ice cream cakes and pies, high value, low bulk items. The quality of Maine's fluid milk is quite high compared to milk from other states; and per capita consumption of fluid milk in Maine is the highest in the nation. Taking advantage of this, there may be technological potential in the further processing of fluid milk. For example, flavored, carbonated milk is a new product under consideration in the US, and Maine producers may have a competitive advantage in its production.

5.9 Summary

In general, Maine food processors use up-to-date technologies which are used by competitive processors nationwide for traditional products. However, producers have been slow to acquire technology which would allow them to compete in new product markets. No processor, example, uses asceptic packaging in Maine. In addition technologies of the future that will be used in new products are often designed for processing plants of larger scale than exist in Maine, putting smaller processors at a disadvantage in the market.

In the future, technology in food processing will be increasingly market-driven. This means that the leading innovations will be driven more and more by product design, packaging, quality, and marketing considerations, and relatively less by production, volume, cost, and resource considerations.

6 NEW TECHNOLOGY IN FOOD PROCESSING

6.1 General

The food processing sector presents a bewildering array of products, markets, technologies, and economic development opportunities. As a way to organize the technological options for further discussion, we present Tables 2 and 3. These tables display major areas of technology as they relate to product lines, stage of processing, and user benefit.

These tables present a general initial assessment of important new technologies nationwide. The costs of implementation and use, as well as the scale of production appropriate to each technology, have not been included in this study. It is likely that some of these technologies will have no particular application to Maine producers in the near future. The costs and merits of each technology would have to be considered by individual processors before implementation. Determining actual applicability and profitability can only be done by in-depth assessment of specific product lines and equipment designs, a task beyond the scope of this review.

The displays in these tables should be helpful in assessing the breadth of impact of programs attempting to implement different technologies. For example, Table 2 shows that 6 major technologies have potential applications in all the industries considered.

Note again that in our definition of the scope of this project we began at the food processor's receiving dock. Many important technology issues are involved in growing, harvesting, and delivering the crops as they affect raw material quality.

Table 2
Categories of New Technology and Applicability to Sectors of the Food Processing Industry

	Meat	Dairy	Fr/Veg	Grains	Bakery	Bev	Seafood
COMPUTERS							
Full Systems	x	x	x	x	x	x	x
Vision Inspection Systems	x	x	x	x	x	x	x
Automated Processes	x	x	x	x	x	x	x
Sensors	x	x	x	x	x	x	x
CONTINUOUS PROCESSING							
Fewer Moving Parts	x	x	x	x	x	x	x
Integrated Processes	x	x	x		x	x	x
IQF (Individual Quantity Freezing)	x		x				x
Reverse Osmosis		x				x	
Ohmic Heating		x	x				
UHT (Ultra High Temperature)		x				x	
PACKAGING							
Tamper-Proof	x	x	x	x	x	x	x
Co-Extrusion		x	x			x	
Aseptic	x	x	x			x	x
Minimal Processing (MAP,CA)	x		x				x

Table 3
Categories of New Technology and Applicability to Stages of Food Processing

	Raw Mat Handling	Storage	Proc.	Pkg.	Residuals Mgmt.
COMPUTERS					
Full Systems	x	x	x	x	x
Vision Inspection Systems	x		x	x	
Automated Processed	x	x	x	x	x
Sensors			x	x	
CONTINUOUS PROCESSING					
Fewer Moving Parts	x		x	x	
Integrated Processes			x	x	x
IQF (Individual Quantity Freezing)			x		
Reverse Osmosis	x		x		
Ohmic Heating			x		
UHT (Ultra High Temperature)	x		x	x	
PACKAGING					
Tamper-Proof				x	
Co-Extrusion				x	
Aseptic	x		x	x	
Minimal Processing (MAP,CA)	x		x	x	

Table 3 (cont.)
Categories of New Technology and Applicability to Stages of Food Processing

	Energy Savings	Quality Control	Reduce Costs	Meet New Market Demand
COMPUTERS				
Full Systems	x	x	x 1,2,3,4	x
Vision Inspection Systems		x	x 1,4	
Automated Processes	x	x	x 1,2,4	
Sensors		x	x 1,4	
CONTINUOUS PROCESSING				
Fewer Moving Parts	x		x 2,3	
Integrated Process	x		x 2	
IQF (Individual Quantity Freezing)	x		x 2	x
Reverse Osmosis	x	x	x 2	
Ohmic Heating	x	x	x 2	x
UHT (Ultra High Temperature)	x	x	x 2,4	x
PACKAGING				
Tamper-Proof		x		x
Co-Extrusion				x
Aseptic	x	x	x 2	x
Minimal Processing (MAP, CA)	x	x	x 2,4	x

1) Labor Savings; 2) Energy Savings; 3) Maintenance Costs Reduced; and 4) Waste Reduced

7 CONCLUSIONS

7.1 General Themes

This report has identified several broad themes which can serve as a basis for planning technology support for the food processing sector.

First, Maine employment in food processing has fallen. Maine's competitive advantage depending on cheap labor has eroded. But there are many successful firms which have become more market-driven.

Second, processed food markets are becoming more segmented and dynamic. Technology must be seen as a way to increase market opportunities in addition to more traditional concerns of return on investment, yield, and volume.

Third, there are a number of generic technologies that cut across many of Maine's food processing lines. This creates an opportunity for well-planned technology support programs to simultaneously benefit a number of industries.

Lastly, programs aimed at developing new products which are to be handed to private firms for development may not be the wisest way to target assistance to this sector.

7.2 Technical Assistance Programs: Criteria for Selection

There is potential for value added processing in virtually every sector of Maine's food processing industry. Criteria for technical assistance priority-setting should include:

a. Past performance and openness of firms to change, based on each firm's history.

b. Severity of current stimuli for change, based on employment trends market analysis by food processing experts.

c. Firm willingness to invest and capacity to absorb new technology, based on interviews with individual firms and on past performance.

d. National, regional, and export market growth prospects, based on analyses by market experts.

e. Short-term return on investment considerations, based on financial analyses.

f. Current level of productivity and gap between existing and best practice, based on productivity measures such as current and potential output/hour.

g. Extent and importance of backward linkages in the Maine economy, based on data from the Maine Departments of Agriculture and Marine Resources and the University.

h. Existing or potentially available technical expertise within the state.

i. Importance as employer in rural portions of the state, based on State Planning Office and Department of Labor data.

Note that we do not believe that the size of the firm or the industry are important criteria. These criteria expand upon those advocated in the Technology Strategy Report (MDF, 1984).

7.3 High-Impact Generic Technologies

a. Many new technologies are designed for processing very large quantities. Adopting these new technologies may not be as important as creating markets for products made on a smaller scale, given the small size of most Maine firms.

b. Market development for existing products should be given top priority, followed by the introduction of new process and packaging technologies, and lastly by new product development.

c. Develop value added products out of by-products or lower-grade products. For example, low-grade potatoes for potato skins; fish oils as a lubricant; markets for spent hens.

d. Develop targeted programs to address the generic problems of "microbusinesses", which include many questions of management, planning, finance, and marketing, as well as technology (Allen and Watkins, 1986).

e. Technologies to treat or recover by-products to re-use waste streams are general concerns in many food processing sectors. Successful implementation of these systems would result in better competitiveness as well as improved environmental quality.

f. As a companion to this project, a review should be undertaken of the opportunities for improving the Maine food processing industry's backward linkages and upgrading its "feedstock" quality. The issues range from plant varieties, cultural and harvesting methods, storage, transportation, and product grading practices. These issues cut across many of Maine's food processing lines.

7.4 Priorities for Individual Products

This study was designed to provide a broad sectoral assessment to support program design in technology transfer. It is not possible within this highly complex sector to select specific products or product lines that would be most promising. In particular, we are not convinced that public development of new products as such should receive high priority.

In fact, to the extent that technology may be a limiting factor in the food processing sector, it would be more appropriate, in our judgment, to select a small number of broadly applicable technologies that could be widely used, rather than to pick specific individual products.

7.5 New Directions and Further Research

In the survey done by Maine Tomorrow on Technology Resource Sharing, nearly 90% of the respondents regarded marketing assistance as a very important issue facing their firm. Research for this report has found this to be a recurring theme in the food processing industry. Market development research and technical assistance should be the top economic development priority for Maine's food processors, followed by product development and other issues.

Generic advertising is being replaced by brand advertising, as brand identification becomes increasingly important, placing small producers in precarious position. The ability to accurately analyze market trends and then meet market demand is essential.

Once markets have been identified, the further objectives of technical assistance should be to lower processing costs, improve product quality, improve yield, extend shelf life, and generate new products. For the state, the key objectives of technical assistance should be to reinforce and expand linkages to agriculture and to expand export markets.

Further research to enhance technical assistance to Maine's food processors would study:

a. Financing available to food processors and the effect of various forms of finance on firm competitiveness.

b. The investment pattern of the industry, as a share of profits, for example.

c. Successful technical assistance or outreach programs at universities elsewhere. For example, Cornell University, Ohio State and the University of Massachusetts have strong outreach programs.

d. Technical Assistance programs in neighboring areas, for example, in Quebec, New Brunswick and Massachusetts.

e. Ways to bring to bear existing counselling and technology expertise on the specific problems of microbusinesses.

f. An inventory could be conducted to characterize the amounts and nature of industry waste streams to identify treatment, recycling, or by-product recovery potential.

g. Continue to study the opportunities for technology sharing.

h. Devise improvements in technology that will upgrade quality and uniformity in the farm to market links that supply Maine food processors with Maine-grown crops.

8 A PROCESS FOR FURTHER ACTION

Based on the analysis conducted for this report, and on our experience with similar problems in other industries, we suggest the following process. This broad approach can be used to design a specific technology transfer program.

8.1 Inventory Technical Expertise

Identify expertise on technology, engineering, and marketing that is now available to the industry.

8.2 Select Target Generic Technologies

Based on discussion with a small group of people close to the industry, select a short list of 2-4 generic technologies that meet the criteria in section 6.1 above. Carefully analyze the potential for each.

8.3 Assess Target Technologies

Contract for specific engineering, economic, and marketing assessments of the target technologies as applicable to the principal potential users. These assessments will indicate the practical and business feasibility of the candidate technologies. Results will indicate needed R&D and will have major implications for the design of the TA program.

8.4 Design a Delivery Strategy

Working with existing systems such as Cooperative Extension and the SBDC's, design a means of identifying potential users of the technology and devise the best communications strategy.

9 GLOSSARY

9.1 Asceptic Packaging

This packaging process, which involves sterilization of the product, sterilization of the packaging material, and maintenance of sterility during the filling and sealing operation, is currently the event in packaging, though the technology has been available for many years. In the US, fruit juices are now packaged asceptically; and in Europe, a wider range of liquids (milk, tomato paste) have been packaged in this way for some time. This method provides shelf-stable food in inexpensive containers and is generally more energy-efficient than traditional canning methods of processing and packaging.

Various packing materials are under experimentation for use in asceptic processing. For example, paperboard laminates and plastics, which reduce packaging costs considerably relative to glass and metal containers, can be chemically presterilized. This has been accomplished by producing thin co-extruded sheets of plastic or paperboard with a peelable outer layer which is chemically treated. Underneath the layer is a sterile surface, exposed only during packaging. Other presterilization techniques include high-energy radiation, steam sterilization and application of a combination of hydrogen peroxide and ultraviolet light.

Just around the corner is the possibility of processing foods with solid (particulate) matter--soups and stews, for example--and packaging them asceptically. Use of ohmic heating (see below) may be key to making this commercially possible. This will provide a higher quality product at lower energy and packaging costs. This particulate packaging will have a dramatic effect on the food market if the FDA approves it.

An additional use of asceptic packaging which is currently under experimentation is a method for quick bulk sterilization of particulate products in large containers. This would be ideal for fruits, for example, which could be semi-processed and packaged asceptically just after harvest for later canning in different finished products.

9.2 Co-Extrusion

A recent development in packaging which seems simple, but is actually quite sophisticated technologically, is the use of multi-layered plastic bottles and cans produced by co-extrusion. While this method of packaging provides the supplier with reduced shipping costs, it is otherwise a consumer-driven change in packaging.

We can expect to see more and more co-extruded packages in the near future. Plastic cans may come into commercial use for beverages, soups, canned meats, etc. In microwave packaging, we can expect to see new shapes and types of plastic containers.

9.3 Computerized Automated Processes

This refers to computerization at various stages of food processing. For example in canning, computers control process time and make adjustments when machines fail. Micro-computers are used in weighing and "batching" (adding ingredients to batches) in dry product cake mixes, instant soups, salad dressings, etc. Color monitoring is used in cooking, frying, roasting and toasting operations, where a computer uses color information to control baking times. Ratiometric and bichromatic sorters are available which sort fruits and vegetables according to shade.

9.4 Computerized Vision Inspection Systems

This refers to computers programmed to recognize optical patterns, thereby enabling the computers to perform quality inspections of manufactured items. These are currently in use for a variety of purposes, from detection of particles in fluid to the detection of minute container defects (for example, a container with a poor vacuum or a poorly closed seam), packaging flaw location and frequency. Some systems include a microprocessor which activates reject mechanisms which discard flawed containers without reducing line speed. The microprocessor can be interfaced with a host computer to allow integration with other computerized processes in the plant.

9.5 Computerized Sensors

This refers to computers programmed to measure mass, volume, temperature and density of liquids. The development of fast, accurate and reliable computerized sensors to measure moisture, flow character, texture and presence of contaminants in food will vastly improve computerized food processing. Use of near infrared (NIR) spectroscopy in on-line measurement and control of such characteristics is a research topic of long-standing interest. New research adds the use of fiber-optics into NIR spectroscopy.

9.6 Full Systems Computerization

This refers to the computer coordination of all aspects of the food processing plant, from raw materials treatment to packaging the finished product. This approach has been applied experimentally in some areas. Entire new systems are conceived and developed for continuous processing (versus batch processing). This fundamental process modification represents a move away from the incremental modification of some part of the production process practiced in the past.

Computer graphics, via mathematical representation of a food processing system, are being used to facilitate the optimization of a given process with respect to minimizing costs, maximizing profits, reducing the use of expensive ingredients, etc. Technologies are being developed which, within the next few years, will allow the plant manager to envision and implement the optimal production strategy for a given product. Computer simulation to assist in scheduling (defining the sequence in which multiple products are optimally produced) is currently academically possible but not yet on line commercially.

9.7 Individual Quantity Freezing

This refers to various methods of freezing individual quantities of food--a single shrimp or pea, for example. One method uses brine to freeze food; another consists of moving food along on currents of rapidly moving air. This eliminates the contaminating lubricants of mechanical systems and minimizes waste by transporting materials more gently. Individual quantity freezers of various types are used around the country and will become more and more important as demand for microwavable foods increases.

9.8 Integrated Processes

This refers to the consolidation of two or more processes into one. For example, a recent invention is the "integrated blancher/cooler" which allows heat removed in the cooling process to be used in the blanching process. A major advance in this field will be the integration of aseptic packaging of particulate foods with the cooking and sterilization processes.

9.9 Minimal Process Technology

Also known as minimal thermal processing, the process extends the shelf life of fresh fruits, vegetables, fish and meat. Irradiation and controlled atmosphere/modified atmosphere packaging (CA/MAP) are the two main types of minimal processing technology.

CA/MAP is currently used in some areas of the US, particularly in the fertile valleys of California. Fresh produce is treated with a chlorine wash to rid the produce of bacteria, chilled and then packed with inert gases (usually nitrogen or oxygen) which lower the respiratory activity of the produce. The produce can then be shipped in controlled temperature vehicles. An estimated 80% of the major fruit and vegetable species respond favorably to some form of CA/MAP; and experiments are underway to make CA/MAP commercially possible for a wider range of fresh foods.

Permeable films for MAP which allow the optimum equilibrium to be reached between the outside air and the inside of the wrapped food and container will soon be commercially available, as will CAP foam trays for meat and poultry products. The development of a deferentially permeable fruit coating for modified atmosphere storage of fruit is currently being tested. This water-soluble coating would retain the quality of apples, for example, during storage for up to 180 days.

In the US, irradiation of foods is currently restricted to a few items (potatoes to prevent sprouting and spices to prevent insect infestation, for example). There is, however, long term potential for irradiating fresh fruits, vegetables, meat and fish. Low does irradiation of fish and meat is insufficient to kill all microorganisms, but rather is intended to minimize bacterial growth. When combined with oxygen-permeable, moisture-impermeable packaging, or with vacuum packaging, shelf life is extended. For fruits and vegetables, irradiation can be used to kill certain molds, fungi and insects; and for some fruits and vegetables, ripening is delayed by irradiation.

Further technological development in minimal processing includes the laser treatment of food. Experiments to determine which wavelengths would kill certain microorganisms but not change the texture and composition of foods is currently underway.

Note one concept presently under development which may affect the widespread use of minimal processing is the use of a series of sensors which allow selective heating of specific areas of the food. The sensors permit sequential thawing and cooking of the food and then are consumed in the heating process. The possibility of using this technique in conjunction with minimally processed foods in microwavable dinners--so that the fruits, for example, remain cold while other foods are heated--is being researched.

9.10 Ohmic Heating

A recent development in continuous processing is ohmic heating, whereby an electrical current is passed through food, causing its temperature to rise. Many kinds of foods, including particulate foods, can be rapidly heated to sterilization temperatures using this method. Products that have been processed in this manner on a pilot scale include custard and other dairy products, vegetable soups, and whole fruit products.

9.11 Reverse Osmosis

In the dairy industry, "reverse osmosis," or "ultra filtration" is currently revolutionizing the cheese-making industry. Large cheese producers in the US and Europe no longer employ the vat or batch technique, using renin or fermentation. Rather, the continuous removal of water is used. This less expensive, more reliably uncontaminated process will make vat cheese a thing of the past for all but the smallest cheese producers in the near future. Current technology also allows large cheese producers to convert whey permeate removed by reverse osmosis to ethanol, which is then sold. Technology for small cheese producers to dispose of their by-products in this way is being developed and may soon be commercially available.

Reverse osmosis is currently a topic of research for use in other areas of the food processing industry. Reverse osmosis eliminates flavor loss during traditional evaporation processes (in making juice concentrate, for example); and in addition, reverse osmosis is an intrinsically energy-saving process.

9.12 Tamper-Proof Packaging

In response to overwhelming consumer demand, tamper-evident packaging for a wider range of foods is currently being developed, including tamper-evident packaging for suppliers of bulk material. On the horizon are new dispensing designs, micro-encapsulating dyes which appear when a seal is broken, and oxygen-sensitive dyes inside hermetically-sealed packages.

9.13 Ultra High Temperature

UHT treated milk is currently available in Europe in asceptic packaging. This process adds considerably to the shelf life of milk. While the energy cost of production of pasteurized milk is roughly the same as for sterilized milk, no refrigeration is needed in distribution and storage, thereby producing considerable energy savings. However, UHT milk is not yet available commercially in the US, as Americans have shown a dislike for the taste of the milk, which is somewhat altered by the UHT process.

10 BIBLIOGRAPHY

Allen, Thomas G. and Dennis A. Watkins, "Microbusiness Concentration in the New England Economy," Department of Agricultural and Resource Economics Staff Paper, University of Maine, Orono, 1986.

Barringer, Richard, et al., The Western Mountains of Maine: Toward Balanced Growth. The MaineWatch Institute, October 1987.

Blaine House Conference on Economic Development. Working papers. Sept. 1987. pp. B-9 8ff.

Connor, John M. et al., The Food Manufacturing Industries: Structure, Strategy, Performance and Policies. Lexington, MA: Lexington Books, 1985.

Eastern Maine Development Corp. "Food product development and processing center: a center for innovation" Bangor. Proposal dated Feb. 19, 1988.

Finance Authority of Maine (FAME). Strategy for investing in the natural resource industries of Maine. Augusta: May 1986.

FAME. Natural Resources Financing and Marketing Board Policy Statement. Feb. 10, 1988.

Konrad, Victor _et al._, _Resources Economies in Emerging Free Trade_. Proceedings of a Maine/Canadian Trade Conference, University of Maine, Orono, January 9-10, 1986.

Maine Development Foundation. Technology Strategy for Maine. n.d. (ca. 1984)

Maine Tomorrow. Technology sharing report. 1988.

US Department of Commerce, _US Industrial Outlook, 1988._

US Department of Commerce, _Regional Multipliers_, May 1986.

Vail, David, ed., _Sunrise Agriculture in the Northeast: Foundations of a Sustainable Agriculture for the Twenty-first Century_. Proceedings of an International Conference, Maine Agricultural Experiment Station, University of Maine, Orono, September 1987.

Veazie, Carl, _The Economy of Maine_. Center for Research and Advanced Study, University of Southern Maine, May 1985.

11 LIST OF CONTACTS

Charles Davis, Eastern Maine Development Foundation, Bangor

Theron Downes, Michigan State University, School of Packaging

Don Downing, Co-op Extension Agent, Agriculture Engineering Station, Cornell University

Wally Fengler, USDA/Processed Product Inspection Branch, Portland

Jane Fowler, Maine Potato Commission

Robert Garfield, Milk Industry Foundation

Robert Goettel, University of Southern Maine

Dallas Hoover, Department of Food Science, University of Delaware

Joseph Hotchkiss, Department of Food Science, Cornell University

James Jermann, Vice President, Merchandising, Hannaford Brothers

Alan Kezis, Department of Agricultural Economics, University of Maine, Orono

Manfred Kroger, Penn. State University, Department of Food Science

Russell Libby, Director of Research, Maine Department of Agriculture

Linda McCashen, National Potato Board

Michael Moser, Maine Department of Marine Resources

Rosalie Patten, NorthCenter FoodService, Augusta

Raoul Pelletier, Food Industry Consultant

John Riley, Department of Agricultural Engineering, University of Maine, Orono

Donald Schlimme, Department of Horticulture, University of Maryland

R. Paul Singh, Food Engineering Department, University of California-Davis

Michael Solberg, Food Science Research Center, Rutgers University

Hugh W. Symons, American Frozen Food Institute

David Vail, Department of Economics, Bowdoin College, Brunswick, Maine