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Trends in Milling and Baking

Editor's Notes

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As we think about the environment and our relation to it, we are reminded to think globally, act locally.

We as individuals and as a generation do not own the earth and its resources. Future generations will depend on these same resources. Therefore, we must be good caretakers, or stewards. Thinking globally, acting locally involves stewardship—the careful management or wise use of resources.

We need resources to feed, clothe, and shelter ourselves. We also require resources for recreation and leisure activities, such as when we enjoy mountain scenery, a tennis match, or even read a book. Sometimes our needs and interests compete for the resources we have available to us.

We are consumers, requiring resources to go about our business, but we are also producers, working to transform resources into desired goods and services. However, not all who produce have a say as to what is produced or how, and what prices are charged.

Often we are unaware of the human effort required to produce goods or provide services. Human resources, just like natural resources, can be exploited. Thus, the treatment and compensation of labor become part of the costs associated with using resources wisely. Our desire for more goods and services at lowest possible prices, or more time to enjoy what we already have, takes its toll on the environment and workers. Improving our personal welfare often comes at the expense of common resources.

Balancing the demands of the competing interests of the environment, other consumers, workers, and ourselves is the crux of stewardship. For example, consider the choices an organic fruit and vegetable farmer makes in trying to be a steward of his resources. Not wanting to cause any chemical pollution, the farmer chooses not to use synthetic fertilizers or pesticides. While organic practices may lessen the impact of agricultural activity on the environment, they often come at the cost of reduced farm output and increased labor. Higher costs mean the farmer needs higher prices, but higher prices drive away consumers who otherwise would purchase his produce.

The organic farmer might cut expenses by reducing the wages he pays his workers. However, he doesn't want to offer lower cost organic produce at the expense of those who toil to produce it. Instead, he could accept less profit for himself. But he has needs, such as educating his children or providing for his parents. Of course the farmer could abandon his prohibition against synthetic fertilizers and pesticides, but this goes against his environmental concerns.

Balancing the competing interests of our limited resources isn't easy. All of us have to make choices every day. Every time we get into our cars, turn on our home heater or air conditioner, make a charitable contribution, or recycle our aluminum cans and newspapers we are balancing the competing interests of the environment, ourselves, other consumers, and those who provide us with goods and services.

In this issue of the *Food Review* we explore some of the economic-environmental relationships involved in producing, processing, and transporting food.



Stephen L. Ott
Economics Editor

FoodReview

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Pesticides: How Safe and How Much?

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Pesticides are used extensively in agriculture to protect commodities from damage caused by insects, disease, weeds, and other pests. Their use in the production and storage of crops is profitable. They return more to farm income than they cost. However, people who are concerned about the environment question the safety of pesticides in relation to food, water quality, farm workers, and endangered species.

Changing the types and amounts of pesticides that can safely be applied requires thoughtful consideration to the costs, benefits, and risks involved, both to farmers and consumers. Costs can be considerable. For example, one study from USDA's Economic Research Service on the soil insecticides used on corn and soybeans states that a ban would cause an economic loss of \$2.2 million annually after 5 years. Another study shows that a ban on soil fumigants would raise consumer prices for fresh tomatoes 53 percent and for potatoes 11 percent.

These are some of the environmental issues:

- **Food Safety**—Studies continue to show that people rate pesticide residues as their top food safety concern. Reports by scientists that show pesticide residues in foods as insignificant health risks do not allay these fears. Even the Food and Drug Administration's residue surveillance monitoring program that showed that two-thirds of the food tested had no pesticide residues and that less than 1 percent were over established tolerances for pesticides are not dispelling consumer concerns. Nor are studies that show food-borne organisms, such as salmonella or aflatoxin, are far more critical health

concerns than pesticide residues, calming consumers fears.

- **Water Quality**—Increasingly, pesticides are being found in ground and surface water. More are being discovered, for a number of reasons, including more refined water testing. Also, large quantities of pesticides are currently being used—over 95 percent of corn and soybean acres are treated with pesticides annually. Pesticides have been used for long periods of time, which is why they may have reached receiving waters. The damage, if any, caused by various levels of contamination of ground or surface water with pesticides is not known, but the existence of pesticides in ground water often is sufficient reason to cause public concern.

- **Farm Worker Safety**—Workers entering fields where pesticides are used has been an issue of public concern for a number of years, especially in California. Farm workers who mix, load, or apply pesticides are exposed to potential health hazards when performing these operations. The Environmental Protection Agency (EPA) requires, for some pesticides, special procedures such as posting warning signs, restricting field reentry, wearing protective clothing, and using respirators or closed tractor cabs. Also, there are various educational efforts on the part of the extension services and the pesticide industry to instruct workers on how to avoid exposure to pesticides.

- **Endangered Species**—The Endangered Species Protection Act was established a number of years ago but has not been fully implemented by EPA. Currently, EPA is drafting and circulating for comment bulletins that contain information on specific endangered species. The bulletins include information on species'

habitats and pesticides that could adversely affect them. Proposals could involve restricting or eliminating the use of certain pesticides in habitats occupied by endangered species.

The implementation of this act raises a number of difficult problems. It is extremely complex to identify occupied habitat and the pesticides that could adversely affect species. Furthermore, it is not clear that pesticide use is a more detrimental factor than loss of habitat. While it is not expected that implementation of the Act will have a large negative impact on agriculture in aggregate, it appears it could negatively affect individuals who are farming in areas where endangered species live.

In the last Congress, a variety of legislative issues were raised but not resolved. It is possible that many, if not all, of these issues will be raised by future Congresses. Some of the issues included revising the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to more quickly address pesticide reregistration, dealing with pesticide export reform, mandatory recordkeeping and reporting of pesticide use, and replacing the Delaney Clause (which prohibits the presence of any known tumor-causing pesticide that concentrates in processed food) with a negligible risk concept.

These are some of the legislative issues:

- **Shorten Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) processing time**—FIFRA is the legislative authority that enables the EPA to register and regulate pesticides. It requires the EPA to periodically review pesticide registrations. In addition, FIFRA provides the mechanism to cancel or suspend a pesticide registration if cancer, birth defects,

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Farmers use pesticides in production as well as storage to protect crops from the damage caused by pests, weeds, and diseases.

mutations, etc., are discovered to be associated with the pesticide or its derivatives. Currently, when such a risk is discovered and confirmed it can take 4 years or more for EPA to remove the pesticide from the market. Amendments to FIFRA were being discussed that would shorten that time period.

- **Pesticide Export Reform**—A bill was introduced, but not passed, that would have prohibited the export of pesticides not registered or that have been suspended or canceled in the United States. The intent is to protect foreign users of U.S. manufactured pesticides, to prevent U.S. farmers from competing against foreign farmers having access to less expensive pesticides, and to lessen the opportunity for commodities to be imported that have residues of undesirable pesticides. The cost of such a regulation is subject to debate and is being explored. There is a question, however, whether the bill, if adopted, would accomplish all its purposes. Technology associated with the production of banned or suspended pesticides is often well known and not

complex. Thus, the pesticides could be produced abroad. Also, to insure increased protection for U.S. consumers, monitoring and testing as well as other preventive measures would have to be increased with a likely high administrative cost.

- **Mandatory recordkeeping and reporting**—Several bills were introduced to include mandatory reporting and recordkeeping of pesticide use in the 1990 Farm Bill. The outcome of the debate was that pesticide users are to keep records of their use of restricted-use pesticides (RUP's) and that USDA, in cooperation with the EPA, will annually survey applicators about their use of RUP's. A restricted-use pesticide is one that cannot be applied except by a certified applicator or someone under the direction of a certified applicator. To obtain certification, an applicator must complete a 1-day course conducted by State Extension Services. From an informational and research viewpoint, mandatory recordkeeping for RUP's provides only a portion of the data base required for analysis.

- **Negligible risk**—Replacing the Delaney Clause with a negligible risk concept (see "*The Delaney Clause: New Interpretations*," elsewhere in this issue) would allow a tumor-causing pesticide to be present in processed food, providing the risk was negligible. Negligible risk is generally being defined as one additional incidence of contracting a tumor per one million people over a 70-year life span. Currently the probability of incurring cancer from any source over a 70-year life span is about 1 in 4.

The Need to Analyze Costs

In an analysis of the costs of dealing with pesticide issues, four items of information are basic: How extensively are specific pesticides used? How do alternative pest control methods affect yield and quality? How much do alternative pest control methods cost? How are product prices affected by alternative production methods and how willing are customers to pay such prices?

- **Pesticide use data**—It is important to know where and to what extent a pesticide is used in order to assess the cost and price effects associated with the use of an alternative. The most effective way to obtain this information is through a survey of users. Although other methods such as soliciting expert opinion have been used, they leave much to be desired. The major drawback to the survey approach is the high cost. Within USDA, this approach is being expanded.
- **Yield and quality effects**—If the solution to a pesticide issue, regardless of the cause for concern, is the use of an alternative pest control (another pesticide, biological or cultural control, or some combination of alternatives), it is necessary to compare yield and quality effects of the alternative with the original method. Analyzing the impact of total production requires more than information about yield per acre. Alternative control measures can achieve high yields per acre but may require a fallow period or time to grow a cover crop. Such practices reduce the quantities of crops that can be produced unless more resources of land, labor, and other inputs are devoted to the production process.

Information about how alternative pest controls affect agricultural production often is not readily available under actual growing conditions. Test plots provide some insight but are limited and require expert judgment to translate results to actual agricultural production. Expert judgment can be criticized as being subjective, which reflects on how people may view the credibility of the data, but good alternatives (including other pesticides) do not appear to exist for all pests. Test plot data are generated under carefully controlled circumstances, such as hand weeding. And harvest is often done by hand or with the use of small machines which enhance yields. Under actual growing conditions, test plot data may not allow for control of other important factors such as soil fertility and individual farmer ability.

- **Cost of alternative methods**—Costs of alternative pesticides and alternative forms of application can be obtained

from a variety of sources. Such information comes from surveys of pesticide prices conducted by government agencies or private sources that develop information in a variety of ways. This information is critical to an analysis and generally can be obtained. The costs, however, of non-chemical controls, such as rotations, may not be readily available.

- **Demand relationship**—The effect of alternative production levels upon prices (how prices respond to output changes and consumers' response to changing prices) is an important component of an analysis. In other words, how much will the price of a commodity change given a certain percentage change in output. Often this is referred to as a consumer effect and it usually is the largest impact. For many agricultural commodities, in the short run, small changes in output lead to large changes in price. Because the consumer effect is usually the most important impact, conclusions can often hinge on the values used. While the relationship between output and prices can be quantified, economists do not always agree on actual numbers.

Benefit Analysis Needs

FIFRA requires a risk/benefit analysis when a pesticide registration decision is made. FIFRA's "benefits" refer to those that come from the use of the pesticides or from the antithesis—the cost associated with not using the pesticide. "Risk" refers to the health or environmental impact of pesticide use, or benefits derived from not using the pesticide.

Risks may take many forms including residue levels in food, contamination of water, and effects on non-target species. Generally risks are hard to quantify. It may be relatively easy to identify a residue or water contamination level, but it is much more difficult to identify what the residue or contamination level means in terms of life span, health, days of work missed, or other factors. It is unlikely that definitive risk data will become available in the near future. Consequently, the risk element will continue to be the weak link in any risk/benefit analysis.

Economic Analysis of Specific Pesticides

Over the past 10 to 15 years, a large number of studies have been conducted on the potential economic implications of pesticide regulatory actions. The results have been highly variable, ranging from little economic impact in the case of a pesticide such as toxaphene, to large impacts for the herbicide trifluralin (Treflan). Briefly, these are the results of three recent studies:

- **Potential bans on corn and soybean pesticides**—ERS researchers Craig Osteen and Fred Kuchler found that the loss of certain corn and soybean pesticides could increase U.S. agricultural production costs, crop prices, farm incomes, and consumer expenditures. In this study, the losses to consumers outweigh gains by producers. The greatest losses would result from banning all triazines, such as atrazine—\$3.3 billion to \$3.8 billion annual loss, banning acetanilides (*Dual* and *Lasso*)—a \$2.1 to \$2.7 billion annual loss, and banning soil insecticides—a \$2.2 billion annual loss. These losses of \$2 to \$4 billion compare with the average farm value for both corn and soybeans of \$26 billion.

- **Banning Phorate and Terbufos**—Phorate and terbufos are soil insecticides used to control various soil insects. The following statement is in the executive summary of a draft report of USDA's Phorate and Terbufos Assessment Team. "The economic impact on producers and consumers of agricultural products in the United States caused by the cancellation of phorate would be an annual loss of \$21 million. Corn and potato producers would sustain the greatest economic loss if phorate was no longer available. Losses would be less than 1 percent of the value of farm production for these crops. The economic impact caused by the cancellation of terbufos would be \$127 million, including a loss of \$118 million to corn producers and consumers. The aggregate economic effect on producers and consumers caused by the cancellation of both phorate and terbufos would be an annual loss of \$168 million."

- Banning soil fumigants—Joseph R. Barse and Walter Ferguson, ERS researchers, reported, “Producers who formerly used fumigants to control soil-borne pests would be worse off by \$100 million to \$200 million per year, despite higher prices, if soil fumigants were banned for citrus fruit, potatoes, tomatoes, tobacco, and a few other crops, because crop output would decline sharply. Producers who did not use fumigants would be better off by \$400 million to \$800 million per year because of higher product prices received. Consumers would pay \$3 billion to \$5.1 billion more, annually, in the short run. Average annual consumer prices would rise 53 percent for fresh tomatoes, 11 percent for potatoes, 8 percent for canned tomatoes, and 4 percent for cigarettes. Loss of fumigants would have no effect on prices of cotton products, citrus fruit, or frozen juice. This report estimates the economic effects on producers and consumers of certain crops if the use of all soil fumigants were lost because of EPA cancella-

tion, suspension, or manufacturer withdrawal.”

Future Events

Over the next few years, environmental and health concerns will be receiving public attention, and demands will be placed on the public and private sector to address these concerns. Environmental concerns will focus on water contamination by pesticides and nitrates, and the effects of pesticide use on economically viable pest management options and adverse impacts on non-target species, especially the endangered. Human health concerns will be for food safety with attention given to pesticide residues, food-borne organisms, and natural toxicants. Worker safety also will be an issue.

Public concerns will lead to new programs. Already within the USDA, water quality and food safety initiatives are being developed in cooperation with other government agencies. The Water Quality Initiative researches water contamination and ways to reduce it. The Pesticide Initiative measures pesticide

residue levels in food and develop ways to reduce them. The initiatives also will study the economic implications of these measures. Both water quality and food safety concerns will place pressure on the pesticide regulatory process. It can be expected that the National Agricultural Pesticide Impact Assessment Program (NAPIAP), a cooperative Federal/State program to generate information and analyses for pesticide assessments, will be revitalized in some form, and ties with EPA will be strengthened. Public awareness of environmental quality and human health has heightened and will continue to be strong in the future. ■

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The Delaney Clause: New Interpretations

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Responding to concern over food safety and questions about chemical residues in the food supply, the Environmental Protection Agency (EPA) has changed the method by which it will consider granting registrations to new pesticides, and reviewing both new and old uses of established pesticide products.

In order to be more consistent in the manner in which pesticide products are registered for sale and use, the EPA is attempting to reconcile the often conflicting stipulations of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) with the Delaney Clause portion of the Federal Food, Drug, and Cosmetic Act (FFDCA).

Under FIFRA, EPA registers pesticide products and their uses after determining that the pesticides will cause no unreasonable adverse effects to man or the environment. Under the FFDCA, the Delaney Clause applies to processed food and indirectly to raw foods that have a processed form. The Delaney Clause ensures that none of the additives in processed foods are carcinogenic (interpreted to be tumor causing). For FFDCA purposes, pesticides are considered food additives. The Delaney Clause applies only to pesticides that concentrate in food processing. Therefore, if a carcinogenic pesticide concentrates in processed food and is detectable (Delaney Clause), the pesticide could not be issued a registration under FIFRA.

Under EPA's new policy, the agency applies a uniform set of criteria to all FIFRA registration, tolerance, and food additive regulation decisions. EPA shifts from zero tolerance for carcinogenic

pesticides under the Delaney Clause to negligible risk (generally defined as one additional incidence of cancer per 1 million people over a 70-year life span). If the residues of a pesticide on a particular food pose no carcinogenic risk or only a negligible risk, the pesticide's use on that food is approved under both acts provided they meet the other requirements of FIFRA and the FFDCA.

Tolerance Setting Methods Studied

In 1985, the National Academy of Sciences (NAS) was provided a grant to study EPA's methods for setting pesticide tolerance levels and to examine the current and likely effects of the Delaney Clause on the tolerance-setting process.

The NAS study determined that about 55 percent of total dietary carcinogenic risk arises from pesticide residues on specific crops that have raw and processed food forms. Of this 55 percent, 20 percent stems from the consumption of the processed form of these crops, and 35 percent derives from the consumption of the raw form. However, 45 percent of estimated dietary carcinogenic risk arises from foods considered by EPA to have no processed forms, such as all red meat, milk, and poultry products as well as fruits and vegetables which have no processed form.

These foods without any processed form are not under the Delaney Clause. Therefore, strict application of the Delaney Clause would eliminate only about 55 percent of the estimated dietary carcinogenic risk from consumption of pesticide residues in foods. The remaining 45 percent would be beyond the scope of the Delaney Clause. By applying the new negligible risk approach in pesticide registration decisions rather



The Delaney Clause of the Food, Drug, and Cosmetic Act assures that none of the additives in processed food, or raw foods that have a processed form, are carcinogenic. Pesticides are considered food additives.

than the zero risk Delaney Clause method, NAS estimated that total dietary risk from the carcinogenic pesticides included in their study would be reduced by 98 percent.

There is at least "limited evidence" of carcinogenicity (virtually all from animal studies) for 66 or more of the approximately 350 pesticides already approved for food use. EPA expects this number to become somewhat larger as it receives and evaluates more studies on pesticides used in food production.

Economic Implications

EPA's new interpretation of the Delaney Clause could have considerable economic implications for growers and consumers. By shifting from zero tolerance to negligible risk, many new pesti-

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cide products would potentially be able to be registered and subsequently marketed. At the same time, older product registrations not able to meet the negligible-risk standard would be canceled.

The new interpretation also could allow some of the "old" materials to remain, which, from an economic standpoint, would be significant. For instance, older pesticide products are generally much less expensive than newly patented products and farmers are comfortable with using products that are familiar to them. In addition, maintaining a large complement of diversified pesticide products helps prevent the buildup of resistance by pests to any single pesticide product or pest control method.

To register a pesticide use, pesticide manufacturers must provide the EPA with information describing the acute and chronic effects of human exposure and toxicity, as well as environmental fate studies. Exposure means the level to which people are subjected to the pesticide products' residues in air, water, and food. Toxicity information details the health effects of a given level of exposure. An assessment of the level of risk associated with a particular pesticide is the combined effects of exposure and toxicity.

FIFRA takes into account the economic, social, and environmental costs, and also the benefits of pesticide use when considering registration. The act allows specific uses of a pesticide, with explicit terms and conditions for effective and safe handling and application. The terms and conditions of use must be on the container or package label, and the label must include precautionary statements such as the restriction of use to trained applicators, and the time interval after which farm workers may reenter fields after a pesticide application. Other conditions of registration may require modification of product use or formulations, and packaging limitations.

Under FFDCA, the EPA establishes pesticide tolerance levels defining the maximum amounts of pesticide residues that may be legally present in raw and processed food and animal feed sold in interstate commerce. Before the "negligible risk" allowance, a pesticide could not be granted a tolerance if concentrated residues of the carcinogenic pesticide

appeared in foods after they had been processed. The benefits of pesticide use were not considered. Without FFDCA approval, a tolerance cannot be granted for use of the pesticide in producing that food under FIFRA, regardless of the possible benefits that particular use of the chemical would have.

An important problem is that sequential tolerance revocations or denials for one active ingredient at a time could, in some cases, actually increase human dietary carcinogenic risk by possibly increasing the use of a more hazardous compound after tolerances for a less toxic compound are revoked.

The Delaney Clause applies only to processed foods. For raw foods, such as fresh market fruits and vegetables, the FFDCA implicitly recognizes that pesticides can be both beneficial and risky and that both should be weighed when setting tolerances in produce. If a food crop is not processed in any form, the potential benefits of a carcinogenic pesticide that may be used in producing that crop are included in making a pesticide registration determination.

EPA's current pesticide reregistration procedure, which aims to make all pesticide products conform to modern safety and environmental standards, is thorough and time consuming. Older pesticide products remain in use pending the outcome of the reregistration evaluation.

Ironically, the Delaney Clause bars new pesticides from registration that are shown by pesticide manufacturers or EPA data to pose comparable or lower risks than older pesticide products currently in use. Given the high costs of data development, there is little incentive to develop a new pesticide that shows carcinogenic potential, even if the risk is minimal, and even if the new pesticide could replace an old product that poses a higher risk. Thus, EPA's past implementation of the Delaney Clause retarded the development of new, lower risk pesticides.

EPA's policies toward the uses of older pesticides may likely change as technology continues to become increasingly sophisticated in detecting pesticide residues in processed food. Compelling questions that must be addressed include what level of determined risk will ensure sufficient food and the economic viability

of the agricultural sector, and are any pesticide residues acceptable in the food supply that could be carcinogenic to humans?

Government Studies Continue

The issue of pesticide residues in food and acceptable levels of exposure remains the object of efforts to amend the FIFRA and FFDCA in Congress. In addition, the USDA has launched, for fiscal 1991, a Pesticide Data Initiative that will provide funding for the collection and analysis of data describing pesticide use, residue levels, and potential exposure levels from selected commodities in the Nation's food supply. This program is designed to develop information which will improve regulatory decisions substantially.

Some consumer and environmental groups have mounted or announced their intention to mount a judicial challenge to EPA's decision to adopt a negligible-risk approach in determining pesticide registration potential. They argue that the intent of Delaney was and continues to be the prohibition of carcinogenic food additives in processed food, and therefore EPA's de facto abrogation of Delaney is in violation of the FFDCA. The issue is not settled and may not be for some time.

Lacking any change in the governing Federal codes or improvement in the information base describing the present food residue and exposure situation, EPA must make regulatory decisions based on current interpretations of the law. EPA's recent changes in interpretation of the Delaney Clause afford the regulatory decisionmaking process greater efficiency with little or no increase in health risk. Increased efficiency allows the EPA to speed the reevaluation of older pesticide products and remove only those that pose greater than negligible health risks, which benefits both consumers and producers of agricultural products. ■

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Environmental Concern Sparks Renewed Interest in IPM

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Environmental movements during the 1960's inspired a system to control crop pests with fewer synthetic pesticides, and the recent revival of concern for the environment has renewed interest in this approach.

The system of pest control called Integrated Pest Management (IPM), partially funded by the Federal Government, is saving participating farmers significant pesticide expense. A national evaluation team has estimated that in the 1980's, total annual benefits to farmers in 15 States using IPM exceeded \$500 million.

IPM evolved as entomologists and other agricultural scientists became concerned about the unintended effects of pesticides, such as killing nontarget species, or causing pests to build immunity or create mutations. Today's concerns are about the potential risks from pesticide residues on food and in groundwater supplies, and about the sustainability of heavy pesticide use in agriculture. IPM offers farmers a variety of pesticide-reducing techniques which allow them to produce high quality, abundant food supplies while minimizing environmental impacts.

Although few farmers in the United States use no pesticides, the conventional practice of applying pesticides by the calendar is becoming uncommon for cotton, canning tomatoes, and other crops where IPM is having success. Instead, pesticides are applied only when pests reach economically damaging levels, and pest-resistant varieties, biological control, and other non-chemical techniques are often used as well.

The Federal Government began funding IPM research through several large,

nationally coordinated projects in 1972. Funding gradually increased to approximately \$7 million annually during the early 1980's, and has remained at that level. State and private funding of IPM research has also been growing. Today, the Federal Government funds IPM research projects for over 100 major and minor crops grown in the United States.

IPM practices have reduced pesticide use, especially insecticides, on some of the major crops such as cotton and soybeans. Although less data are generally available for minor crops, the IPM program for apples in New York, documented since 1975, shows consistently fewer applications of pesticides (*figure 1*).

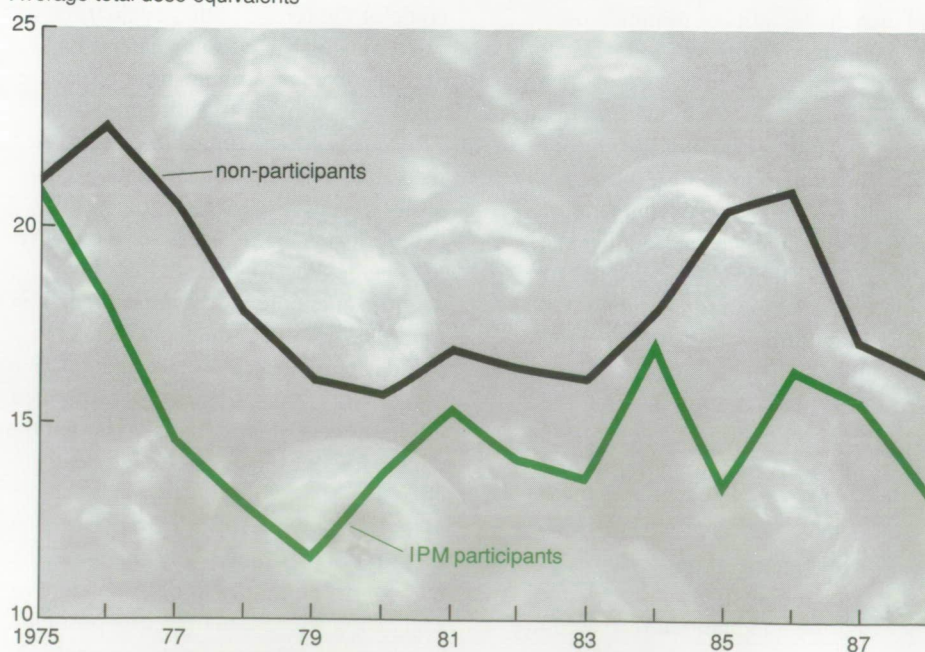
A national evaluation of Federal Extension IPM programs conducted during the mid-1980's found that 3,500 farmers of 9 major crops in 15 States earned \$54 million more annually in net revenues from decreased chemical costs and increased crop yields than those not using IPM. And the evaluation team found that total benefits to all IPM-using farmers in the 15 States exceeded \$500 million.

Scouting is the Cornerstone

IPM uses both efficiency and substitution approaches to control pests. Making better use of synthetic pesticides is the

Figure 1. IPM Permits New York Apple Growers To Use Fewer Pesticides

Average total dose equivalents¹



¹Is a measure of pesticide use calculated by dividing the actual rate of product applied per acre by the Cornell University recommended rate.

Source: New York State IPM Program, 1989 Annual Report, Cornell University.

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focus of the efficiency approach. Pest populations are monitored and pesticides are applied only when the population exceeds an economically damaging level. This approach, called scouting, has been the cornerstone of IPM for several decades.

The economic threshold, or level, at which pests are damaging depends on crop prices, pesticide costs, the types of pests, pest population densities, and other factors. Because economic thresholds must be developed separately for each crop and each crop pest, researchers have many thresholds yet to develop.

With the substitution approach, a variety of biological, cultural, and other nonchemical techniques and management practices are used to control pests. Biological control uses parasites, predators, and pathogens to lower the population of crop pests. For example, seven parasitic wasps, predators, viruses, and bacteria have been developed to control tomato pests in California, although only two, *Trichogramma* and *Bacillus thuringiensis*, are commercially produced and used by growers.

Cultural controls include crop rotation, field sanitation, mechanical cultivation, irrigation, pruning, and other beneficial management practices that reduce or prevent pest problems. Other IPM techniques include the use of pest-resistant varieties, natural chemicals such as pheromones (substances secreted by pests that influence specific behavior patterns by others of the same species) and botanical pesticides (derived from plant sources as opposed to synthetic pesticides made from petro-chemicals). Botanical pesticides, such as rotenone and sabadilla, are generally recognized as breaking down more quickly in the environment than synthetic pesticides.

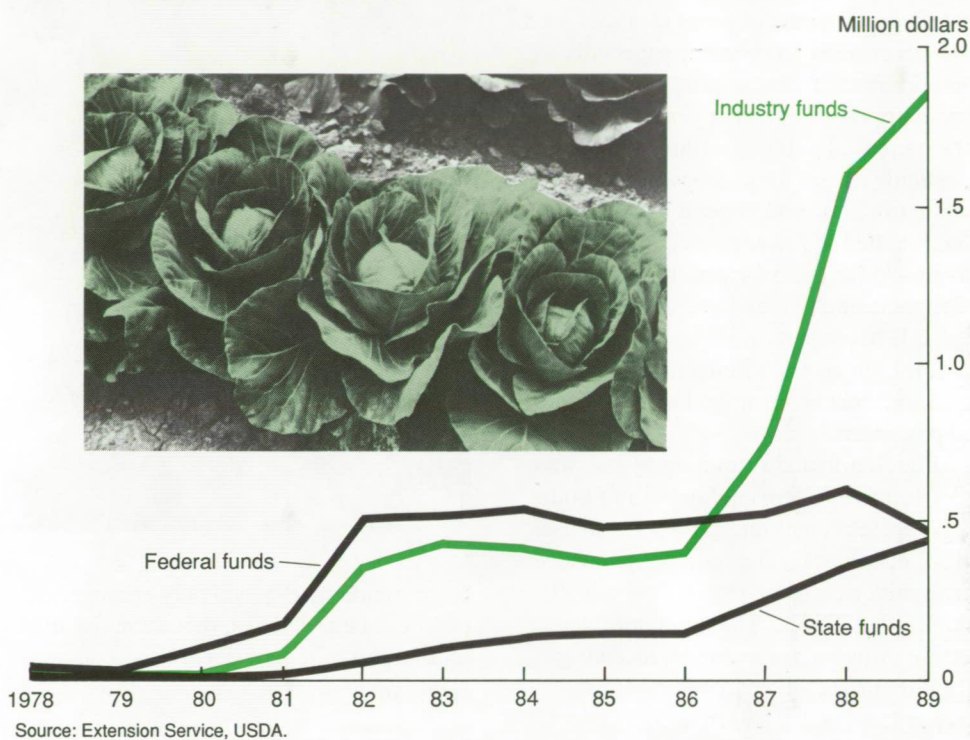
IPM Funding Expands to Specialty Crops

Annual reports indicate a dramatic increase in the funding and use of IPM for specialty crops during the 1980's. The number of States with Extension IPM programs for vegetable crops increased to 22 by 1989. Combined funding from governments and industry for

vegetable IPM projects rose from approximately \$64,000 in 1978 to almost \$3 million in 1989 (figure 2). During this time, State funding for vegetable projects tripled to almost \$500,000 and industry funding quadrupled to almost \$2 million.

Federal IPM funding of vegetable projects was fairly constant during the 1980's at approximately \$500,000 annually, which represents approximately 8 percent of total Federal IPM expenditures.

Figure 2. Vegetable IPM Funding Increases



The conventional practice of spraying pesticides by the calendar has become uncommon for canning-tomato growers who use the integrated pest management systems.

Federal and State funds are used to conduct basic scientific research on cropping systems and pests, to develop IPM techniques (including additional economic thresholds, sampling and monitoring methods, pest-resistant crop varieties, and biological controls), and to implement commercial use. IPM research originally focused on field crops where the largest volume of pesticides was used. However, IPM has become especially important for fruits, vegetables, and other specialty crops in recent years because of the increased public pressure to reduce pesticide use on these crops. Also, changing State and Federal legislation has resulted in fewer pesticides being available for use on specialty crops. Congressionally mandated objectives of these IPM projects are to reduce pesticide use, minimize environmental contamination, and reduce farm workers' exposure to pesticides.

Funding includes training by the State Cooperative Extension Services of both IPM professionals and growers who use IPM techniques. The training associated with minor crops increased dramatically during the 1980's. The number of vegetable growers, for example, receiving training increased nearly eightfold between 1984 and 1989, from 555 to 4,419, and the number of vegetable scouts trained more than doubled to 665.

Industry is the predominant funding source for IPM programs in most of the top vegetable States, especially in California and Florida. Industry funding of Extension projects generally represents grower payments for IPM services such as scouting. However, grower payments to Cooperative Extension Services are frequently pooled with Government funds to cover both research and implementation. Although industry funds mainly reflect payment for services, private industry also conducts IPM research. IPM consultants sometimes develop their own economic thresholds and other techniques. U.S. vegetable processors conduct research on pest-resistant varieties, cultural practices, and other products and management practices to reduce chemical dependence in the production process. Also, U.S. corporations are developing a wide array of new products and technologies, including



Cotton farmers in Texas use integrated pest management systems extensively.

biopesticides and genetically engineered pest-resistant varieties, that share the IPM philosophy to reduce dependency on synthetic pesticides.

Vegetable IPM Acreage Increases

Vegetable acreage under IPM increased from 742,000 in 1984 to nearly 2 million in 1989 (33 percent of total vegetable acreage in 1989), according to USDA Extension Service reports. Management of IPM acreage ranges from minimal (monitoring a single pest) to intensive, where multiple insects, diseases, and weeds are monitored and resistant varieties, natural predators, crop rotations, and other nonchemical strategies are used.

IPM acreage for some of the larger vegetable crops illustrates the differences in IPM adoption among States. New York, for example, had 59 percent of its onion acreage under IPM in 1989, while Georgia had only 1 percent. California had 80 percent of its 1989 tomato acreage under IPM, while total U.S. tomato IPM acreage was only 55 percent. These differences are partly a result of different priorities within States.

Growers themselves managed the biggest portion of vegetable IPM acreage (39 percent) in 1989. They were followed by industry representatives, including advisors for contracted processing acreage as well as chemical companies' advisors, who handled 37 percent. IPM acreage was also managed by private IPM consultants and firms, 11 percent; Cooperative Extension Services, 9 percent; and cooperatives and other grower organizations, 3 percent.

The primary group handling IPM acreage differs significantly between different types of vegetable crops and States. Some States have a highly developed private consulting industry or good Extension IPM programs. Others have well-established grower organizations providing IPM services for particular crops. Sometimes advisors or neighboring growers are the most important sources of IPM services.

For example, all of the Wisconsin potato IPM acreage is handled by private consultants, while 83 percent of the Idaho acreage is handled by grower organizations. Most sweet corn acreage in Ohio (80 percent) and half of Oregon's is under Extension-sponsored IPM programs. Industry representatives are the primary

source (84 percent) for New York's onion IPM acreage, while growers manage their own in Georgia.

The intensity of IPM use varies among these different groups handling vegetable acreage. IPM acreage handled by growers may not be as intensively managed as that handled by Extension programs, consultants, grower organizations, and industry advisors.

According to a 1984-85 survey of Florida vegetable growers, those using commercial IPM scouting recommendations applied 80 percent fewer insecticides after adopting IPM, while growers who did their own scouting used only 50 percent less. Fungicide use was reduced by 31 percent for growers using commercial scouts and 17 percent for those doing their own scouting.

Current IPM issues

There is growing public concern about the environmental impacts of production agriculture. In response to this environmental concern, low-input (chemicals) sustainable agriculture (LISA) production systems are being developed. LISA integrates pest control, plant nutrient and water requirements, and livestock feeding into production systems that minimize the need for synthetic pesticides and fertilizers. IPM is the component of LISA that addresses pest control. IPM focuses on reducing pesticide inputs while maintaining crop yield and quality.

Other growers have responded to consumer environmental concerns by going organic. In organic agriculture, it's the process—the nonuse of synthetic pesticides and fertilizers—that's most important. Organic growers are willing to sacrifice yield or quality to ensure that no synthetic chemicals are used in the production process. Today, less than 1 percent of our food is produced organically. To help facilitate organic food sales, Congress approved legislation last year to create national standards and a consumer label for organic food. (*For more details about organic legislation see "Congress Mandates National Organic Food Standards" in the January-March 1991 issue of the Food Review.*) However, there is concern that widespread adoption of organic production techniques may not be sustainable be-

cause it could generate a different set of problems. Potential problems include a damaged marine ecology due to excess harvest of kelp for organic fertilizer. Increased acreage needed to maintain production levels would increase soil erosion because of cultivation practices such as tillage for weed control.

Because consumers are concerned about both food safety and the effects of agriculture on the environment, several States have become interested in promoting the environmental benefits of IPM-grown food in the marketplace. A preliminary study in California, however, indicated that consumers would be confused by an "IPM-grown" label. Other surveys showed that consumers wanted assurances of no pesticide residues. Instead of promoting IPM-grown food, States could promote low or no pesticide residue foods in which IPM is used.

The California study also suggested that consumers would be interested in more general educational materials explaining the efforts of growers, processors, and retailers to ensure food safety and reduce environmental pollution. The New York IPM program recently experimented with one approach for educating consumers about IPM. A poster explaining the goals and techniques of IPM, provided to growers for display at farm stands and U-pick operations, received favorable responses.

Although IPM adoption has been good in some States and for certain crops (for example, cotton in Texas and tomatoes in California), other growers have lagged in adopting IPM. Some growers perceive that IPM involves more production risk. Not all crops have IPM programs, due in part to stagnant Federal funding for IPM research. Also, in some States and in some crops there is a smaller advantage for its use. For example, hot, humid Southeastern States generally have heavier pest problems, and some crops, like fresh-market tomatoes, have more insects and diseases.

IPM is both an approach to pest control and a developing set of techniques. While synthetic pesticides are still a critical component in most IPM systems, new strategies for preventing pest damage to crops are still being developed. The suppression of pest populations below economically damaging levels, and

the development of alternative pest control techniques are goals of both sustainable agriculture and IPM.

Development of gene-transfer procedures, systems management techniques, and other new technologies are allowing more rapid advances in pest management. However, although revolutionary pest control solutions may become available during the next century, State and Federal regulations on pesticide use are already tightening, and IPM programs that reduce pesticide use will continue to be important during the coming decades. ■

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Agriculture and Water Quality Conflicts

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Water quality problems, thought to be caused in part by cropland runoff or nonpoint source pollution, affect drinking water and the Nation's lakes, streams, and estuaries. Actions taken by public officials to protect our water resources may change the diversity, quality, and quantity of farm products, production systems, and ultimately the prices consumers pay.

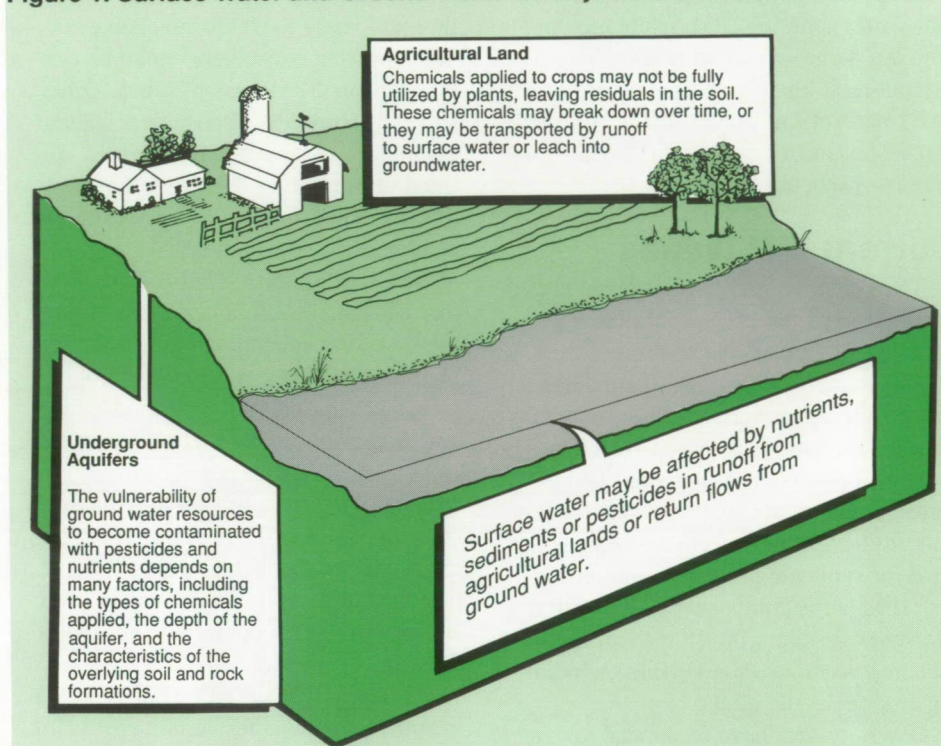
Losses from impaired water quality can cost billions of dollars, not just to agriculture but also to recreation, commercial fishing, municipal water treatment, and river navigation. Estimated annual costs to nonagricultural water uses when quality is impaired range from \$4 to \$12 billion. One-time testing of all private drinking wells vulnerable to nitrates or pesticides could cost up to \$2.2 billion.

Ground water resources are vulnerable to contamination from many directions (*figure 1*). When animal wastes, fertilizers, herbicides, insecticides, and fungicides are applied to cropland, some residues remain in the soil after plant uptake and may leach into subsurface waters, or the residues may move to surface water by dissolving in runoff or adsorbing to sediment. Spray drifts during application may carry pesticides to surface waters also.

Chemical or physical processes transform residues into products that may also contaminate water. For example, nitrogen fertilizer or nitrogen from animal waste may be transformed first into ammonium and then into nitrates. Nitrates can turn into nitrites and both are detrimental to human health.

Nutrients, particularly nitrogen and phosphorus from fertilizers, promote

Figure 1. Surface Water and Ground Water Quality Are Inter-related



algae growth and premature aging of lakes, streams, and estuaries (a process called eutrophication). Suspended sediment impairs aquatic life by reducing sunlight, damaging spawning grounds, and may be toxic to aquatic organisms. Pesticide residues that reach surface water systems may also affect the health and vigor of freshwater and marine organisms.

Water Quality Concerns

Humans drinking water from contaminated wells are exposed to pesticide and fertilizer residues. A well-documented human health risk from nitrate contamination is infant methemoglobinemia, a condition where nitrates are converted into nitrites in the digestive system, im-

pairing the ability of infants' blood to carry oxygen. Nitrites are also considered carcinogenic (tumor causing) by some analysts.

Concentration of nitrates or pesticides in drinking water may be below levels at which acute health effects have been observed. However, continued exposure may result in chronic effects (i.e., reproductive impairments, cancer, etc.) to humans or other organisms. The degree of health risk associated with drinking water containing traces of pesticides or nitrates at, or below, levels where human health could be endangered is poorly understood.

Some pesticides are considered carcinogenic in large doses, and as a result, the U.S. Environmental Protection

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Agency (EPA) has issued health standards defining maximum allowable contamination levels for 26 pesticides.

Contaminated groundwater that resurfaces also affects nontargeted plants, birds, or aquatic organisms (some of which are endangered) in the environment.

The share of pollution from point sources, such as discharges from sewage treatment plants or industrial sources, appears to be diminishing following several years of control efforts. But nonpoint source pollution resulting from agricultural tillage, pesticide application, and urban development sites is the chief cause of surface water degradation today, according to the EPA.

Agricultural runoff is the single most extensive source of surface water pollution, accounting for 55 percent of impaired river miles and 58 percent of impaired lake acres assessed by the States in 1986 and 1987.

In a recent study by USDA's Economic Research Service (ERS), the degree to which agricultural runoff contributed to delivery of nutrients and sediments to lakes and streams was calculated. Of 99 watersheds examined, 48 had excessive levels of nutrients or sediment. The study found agriculture to be a "significant source" (defined as contributing more than 50 percent of pollutant discharge) of nitrogen in nine watersheds. Agricultural sources of sediment were significant in 34 watersheds. Thirty-one watersheds had significant agricultural discharge of phosphorus.

Another recent ERS study identified the scope and significance of agricultural contributions to coastal water pollution. For the 78 estuarine systems considered, agricultural runoff supplied an average of 24 percent of total nutrients and 40 percent of total sediment. Agriculture contributed more than 25 percent of total nutrients in 22 of the 78 estuaries. High rates of pesticide losses to surface waters were found in 21 systems. Fifteen estuarine systems showed both significant agricultural nutrients and high pesticide losses.

The extent to which the Nation's groundwater resources are affected by agricultural chemicals is less well known. Discoveries of chemical residuals in groundwater during the late 1970's and

early 1980's dispelled the commonly held view that groundwater was protected from agricultural chemicals by impervious layers of rock, soil, and clay. Groundwater may also be contaminated by other sources, including nonagricultural use of pesticides and fertilizers, and leaking underground storage tanks. In addition, the extent to which detected pesticide residues are due to normal field applications or to improper storage, mixing, loading, or disposal near wellheads is unclear.

The EPA recently completed a survey of agricultural chemicals in drinking water wells. Conducted over a 5-year period, this survey evaluated the presence of pesticides and nitrates in both community and private drinking water wells in the United States.

The survey showed that while at least half of the Nation's drinking water wells contained detectable amounts of nitrate, only about 1.2 percent of community water systems and 2.4 percent of rural private domestic wells contained nitrates at levels higher than the EPA's recommended levels. About 10 percent of community wells and 4 percent of domestic wells surveyed contained detectable levels of one or more pesticides, but the EPA estimates that less than 1 percent of the surveyed wells contained pesticides at concentrations higher than those considered to pose an immediate risk to human health.

Costs of Impaired Water Quality

The economic losses from impaired water quality can take a number of forms, including the costs of alternative sources of drinking water, increased treatment at public and private water systems, lost boating and swimming opportunities, and damages to valuable recreational and commercial fishery resources.

ERS economists have analyzed some of the costs incurred by consumers to avoid drinking water which may contain agricultural chemicals. One-time testing of all private drinking wells in areas thought to be vulnerable to nitrates or pesticides could cost between \$890 million and \$2.2 billion. Testing public wells could cost an additional \$14 million.

Estimated costs of damages caused by agricultural nonpoint source pollution of surface water range from \$4 to \$12 billion per year, with a "best guess" estimate of \$7 billion annually. These annual costs consist primarily of damages to freshwater fishing, boating, and recreation, \$1.9 billion; water storage facilities, \$1.1 billion; navigable waterways, \$680 million; commercial fishing, \$400 million; and municipal treatment plants, \$350 million.

Efforts To Minimize Water Quality Impairments

In response to growing concern about agriculture's impact on water quality, several initiatives have been developed at both Federal and State levels to help farmers use chemicals wisely and to minimize any adverse environmental impact. Even though water quality problems from agricultural production have been recognized for some time, developing programs to control these types of pollution is a difficult task. Unlike water pollution from point sources (such as industrial plant discharges), it is very difficult to establish a cause-and-effect relationship between agricultural production, agricultural chemical use, and the eventual impact on water quality when the sources of pollutants are widespread and diffuse. Moreover, when water quality is affected by many different sources of pollution, it can be difficult to assess the degree to which controlling one pollutant source (such as cropland runoff) can contribute to the overall quality of a given water resource.

The President's Water Quality Initiative is a multi-agency program to assess water quality problems and to develop means to prevent or reduce the contamination of the Nation's surface and groundwater resources. The USDA and other Federal agencies will provide farmers, ranchers, and foresters with additional knowledge and technical means to respond independently and voluntarily in addressing on-farm environmental concerns and related State water quality requirements.

A principal emphasis of the Initiative is groundwater protection, particularly protection from agricultural chemicals.

Since water quality problems related to the use of agricultural chemicals tend to be localized, policies and programs stress the importance of joint, cooperative efforts across Federal, State, and local governments. There is Federal funding for several departments, including USDA, to support these efforts.

Principal activities under the Initiative include: 1) research on the impact of agricultural chemicals on water quality, and development of new farming techniques to reduce these adverse impacts; 2) education, technical assistance, and cost-sharing to promote the voluntary adoption by farmers of production systems that protect water quality; and 3) data collection efforts to improve information on agricultural chemical use.

The recently passed 1990 Farm Act also contains a number of provisions pertaining to water quality. The Conservation Title of the Act broadens the existing Conservation Reserve Program (CRP) to include cropland that adversely affects water quality. An Agricultural Water Quality Protection Program authorizes payments of up to \$3,500 per person per year and cost-share assistance of up to \$1,500 to farmers who enroll land near wellheads, or where agricultural production poses a threat to ground water or surface water supplies. An Integrated Farm Management Program will permit farmers planting conserving crops to maintain farm program payments and crop base.

The EPA continues to take a major role in the research, data collection, and development of plans to control nonpoint sources of water pollution. EPA-administered programs are currently underway to address water quality problems related to agriculture, both at a national level and from a regional approach. These activities are mandated or authorized under several Federal statutes, including the Clean Water Act of 1987, the Federal Insecticide, Fungicide, and Rodenticide Act, and the Safe Drinking Water Act.

Most States have laws and regulations regarding agricultural chemical use, but only about one-third have developed preventive or remedial programs for ground water quality. The EPA has given the States primary responsibility for ground-water protection and requires the development of State ground water strategies.



Federal, State, and local officials are working on ways to protect the Nation's water resources.

Some examples of State water quality programs include Iowa's Groundwater Protection Fund and Groundwater Protection Strategy (supported in part by a tax on nitrogen fertilizer), Massachusetts' wellhead protection program that established land use controls and restricted pesticide use in critical recharge areas around wells, Wisconsin's Risk Assessment Program (based on numerical groundwater standards), and Minnesota's agricultural chemicals fee system that creates a fund for monitoring research into the effects of chemicals on ground water.

States have also become more active in regulating agricultural chemical use. California's Proposition 65 imposes penalties for discharging carcinogenic chemicals or reproductive toxins into water supplies. Iowa recently restricted the use of atrazine. Permitted application rates were reduced from 4 pounds per acre to 3 pounds per acre in normal use, and to 1.5 pounds per acre where atrazine has been detected in groundwater. No use is permitted within 50 feet of a sink-hole, well, lake, or other water surfaces.

Costs of Protecting Water Quality

Public policies to protect water quality have economic effects on agriculture. To comply with various State, Federal, and local laws, farmers may be faced with restrictions and possibly higher production costs. They may be required to implement management practices to reduce soil erosion and nutrient runoff, restrict or limit the use of leachable pesticides, or pay higher taxes on certain fertilizers and pesticides.

Any of these actions could affect farm

operations. Fertilizer and chemical use may be reduced as farmers modify cropping practices and substitute less polluting inputs. Structures may be built to reduce runoff and prevent pollutants from entering surface or ground water. Tillage practices may change as more farmers adopt reduced or no-till methods. Crop rotations may also change as farmers are encouraged to include meadow or pasture, or less erosive crops in their rotations.

These responses by farmers to water quality programs could affect the economic performance of the farm sector. Yields in major crops could decrease if fertilizer use is reduced or widely used pesticides are banned without an equally effective substitute. Weed control may be achieved by additional cultivation but only at the expense of higher labor, machinery, and fuel costs. Increased farm costs may, in turn, be passed on to distributors, processors, and consumers as higher food prices.

The degree to which water quality programs will affect total farm sector income will depend on several factors. If steps taken to protect water quality are only in environmentally sensitive watersheds, and if the crops affected are already in surplus, the decreased income would be confined to those local areas directly affected by efforts to protect water quality.

On the other hand, if environmental policy is nationwide, such as a total ban on a widely used pesticide, the effect on the farm sector will be more widespread. (For some cost estimates of eliminating selected pesticides see "Pesticides: How Safe and How Much?" elsewhere in this issue.) ■

Ethanol in Agriculture and the Environment

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The use of ethanol, or grain alcohol, a potential alternative high-octane fuel source, could help the United States reach three major policy goals: improved environmental quality, enhanced energy security, and stabilized farm income (see box, "Ethanol as a Fuel"). Recent events have refocused public attention to ethanol's role in these policy goals.

Last year, the 1990 Amendments to the Clean Air Act became law, requiring States to meet pollution standards. Ethanol, splash-blended with gasoline (splash-blended means it is mixed at the wholesaler), increases the amount of oxygen in gasoline, which reduces carbon monoxide emissions. The blend also reduces emissions of toxic chemicals that are known to cause cancer.

Also last year, Iraq's invasion of Kuwait disrupted world oil markets. Ethanol, produced from domestically grown grains, could displace some imported crude oil and refined oil products.

Finally, current U.S. budgetary concerns have led policy-makers to reduce Federal support to the agricultural sector. Ethanol creates an additional market for corn, reducing farm commodity program payments.

However, splash-blended ethanol has limitations. It increases some volatile organic compounds that are limited under the 1990 Amendments to the Clean Air Act. Also, the quantity of ethanol produced is unlikely to be sufficient to contribute significantly to national energy supplies in the near term. And to produce ethanol requires government tax exemptions to make it competitive with gasoline.

The Current Fuel-Ethanol Industry

The current fuel-ethanol industry was created by a mix of Federal and State tax credits, excise tax exemptions, and loan programs. While producing about 825

million gallons of ethanol per year, the industry continues to depend on Federal and State tax credits and/or exemptions to remain viable. Before the Budget Reconciliation Act of 1990, an income tax credit of \$0.60 per gallon of ethanol was allowed to producers and blenders of

Ethanol as a Fuel

Ethanol, which is sometimes referred to as grain alcohol, contains over 84,000 Btu's per gallon, roughly two-thirds as much energy as regular unleaded gasoline. According to researchers at the Oak Ridge National Laboratory, it takes almost 24,000 Btu's per gallon to grow the corn and another 49,000 Btu's to process it into ethanol. The by-product feed produced has an energy credit value of 8,000 Btu's per gallon, producing a positive energy balance of 19,000 Btu's per gallon. The liquid fuel energy balance is even greater when coal is used to fuel the ethanol processing plant.

The energy balance for ethanol is based on using it neat (or unblended) in current gasoline engines. Such use requires only minor modification to carburetors. However, straight ethanol causes poor ignition in cold weather and fewer miles per gallon.

A more common use for ethanol is to mix it with gasoline. The most common mixture is 10 percent ethanol and 90 percent gasoline and is often referred to as "gasohol." When mixed with gasoline, ethanol raises the fuel's octane rating and oxygen content. Raising the fuel's octane rating allows ethanol to replace high-cost carcinogenic aromatic compounds. Greater

oxygen content improves combustion, which lowers carbon monoxide emissions.

Drawbacks to mixing ethanol with gasoline include potential increases in some volatile organic compounds, water contamination, and a slight—2 percent—decrease in mileage.

Ethanol does not mix well with diesel fuel. However, a diesel engine can be modified to burn unblended ethanol by adding spark plugs. The higher compression ratios of diesel engines take advantage of ethanol's high octane rating resulting in a more efficient ethanol use than a gasoline engine modified to burn unblended ethanol.

An innovative approach to burning ethanol in diesel engines is to add an ethanol mist into the engine air flow. Aspirated ethanol reduces diesel fuel consumption and the resulting carbon particle emissions, a major diesel pollutant. Another advantage of ethanol aspiration is that pure ethanol (200 proof) does not have to be used. Lower proof ethanol is less expensive and easier to produce than 200 proof ethanol. A disadvantage to aspirating ethanol can be increased engine wear.

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alcohol (190 proof or greater) for use as a highway motor vehicle fuel.

Alternatively, a \$.06 per gallon exemption from the Federal excise tax on gasoline, diesel fuel, or special motor fuels used to finance the Highway Trust Fund was allowed on the sale of alcohol-motor fuel mixtures that contained at least 10 percent alcohol. The minimum 10-percent blend requirement translates the \$.06 per gallon exemption into an effective \$.60 tax exemption per gallon of alcohol. Gasohol, 10 percent ethanol and 90 percent gasoline, qualifies for the exemption.

Under the Budget Reconciliation Act of 1990 that became effective December 31, 1990, the income tax credit was reduced to \$.54 per gallon (190 proof or greater) and the excise tax exemption was reduced to \$.054 per gallon (reducing the effective tax exemption to \$.54 per gallon). The income tax credit and the excise tax exemption have been extended to December 31, 2002, and September 30, 2003, respectively. In addition, the Budget Reconciliation Act of 1990 created a Small Producers Credit. The Small Producers Credit is an additional \$.10 per gallon income tax credit on the first 15 million gallons of ethanol and is available to producers with annual production capacity of up to 30 million gallons of ethanol.

Current Production Costs

Relatively high production cost is one reason why ethanol has not gained a larger share of the gasoline market (*see box, "The Real Cost of Petroleum"*). Most important are the prices of corn and ethanol by-products (*see box, "Ethanol Processing and By-products"*).

Over the past 10 years, corn prices moved from a high of \$3.16 per bushel in 1981 to a low of \$1.59 per bushel in 1987. The prices of ethanol by-products have also varied but not nearly as much as corn prices. With ethanol yields at 2.5 to 2.6 gallons per bushel of corn, the net cost of corn at a typical wet-mill varied from a high \$0.70 per gallon in 1981 and 1984, to a low \$0.13 per gallon in 1987 (*table 1*).

The Real Cost of Petroleum

One of the disadvantages of ethanol is its high cost. With wholesale gasoline priced at approximately \$.70 per gallon, and ethanol at least \$1.00 per gallon, it is not surprising that ethanol needs tax exemptions. However, some analysts conclude that the market price of gasoline does not equal its true cost to society.

When all costs are not included, consumption is greater than what is socially desired. To reflect an item's true cost in the marketplace, a tax can be levied. Alternatively, consumption can be decreased by subsidizing substitutes.

Some costs associated with gasoline include environmental damage, national security, and sustainability. Environmental damages include declining ambient air quality, the inci-

dence of cancer from toxic fumes, and the potential for global warming. Large petroleum price increases due to world events, such as the Persian Gulf war, disrupt our economy and endanger our national security. Finally, petroleum is a finite resource. Today's petroleum consumption lessens the quantity available for tomorrow's consumers.

Estimating the cost of petroleum requires placing values on environmental quality, national security, and sustainability. Consequently, the costs associated with petroleum are subject to debate and vary among researcher with some estimates being much greater than the market price of petroleum.

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Table 1. By-Products Decrease Cost of Wet-Milling Corn Into Ethanol

	Corn price	By-product prices		Corn gluten	Total by-product value	Percent of corn price	Net corn costs	
		Corn oil	Corn gluten feed					
	\$/bu.	\$/lb.	\$/ton	\$/ton	\$/bu. ¹		\$/bu.	\$/gal. ²
1981	3.16	0.24	115.06	257.03	1.42	45	1.74	0.70
1982	2.48	0.24	113.53	235.31	1.38	56	1.10	0.44
1983	3.12	0.25	123.83	267.15	1.50	48	1.62	0.65
1984	3.11	0.30	94.05	243.12	1.37	44	1.74	0.70
1985	2.52	0.26	75.63	200.40	1.14	45	1.38	0.55
1986	1.95	0.18	94.78	213.92	1.16	59	0.79	0.32
1987	1.59	0.22	98.28	251.62	1.27	80	0.32	0.13
1988	2.36	0.24	122.01	306.14	1.52	64	0.84	0.34
1989	2.46	0.21	113.17	281.39	1.40	57	1.06	0.42
1990 ³	2.53	0.26	100.92	245.92	1.36	54	1.17	0.47

¹Based on the following per bushel by-product yields: corn oil, 1.6 pounds; corn gluten feed, 12.5 pounds; and corn gluten meal, 2.5 pounds. ²Based on 2.5 gallons of ethanol per bushel of corn. ³First-third quarters.

Source: *Sugar and Sweeteners Situation and Outlook*, USDA, ERS, June and December 1990.



To reduce costs, wet-milling ethanol plants are often combined with corn sweetener production facilities.

Production costs vary considerably by plant size. Cash operating expenses include the costs of energy, ingredients excluding corn, personnel, management, insurance, and taxes. Using 1987 data, ERS researchers estimated that cash operating expenses for large plants ranged from about \$0.40 to \$0.59 per gallon of ethanol produced.

Estimated operating costs for small and medium sized plants vary in a wider range—from \$0.32 to \$0.65 per gallon. Small plants have higher costs because they are less able to take advantage of coal boiler cogeneration (steam and electricity) applications while meeting environmental regulations. Also, small plants have less efficient waste heat recovery and high per gallon personnel costs.

The investment required to build an ethanol plant can range from an estimated \$1.00 to \$2.50 per gallon of installed capacity. These investment expenditures translate into amortized capital costs ranging from \$0.19 to \$0.48 per gallon of ethanol. Where wet-mill capacity associated with corn fructose production exists, the fermentation and distillation capacity for ethanol production can be added at an estimated amortized capital cost of \$0.19 to \$0.29 per gallon. Converting abandoned ethanol plants or oil refineries have amortized capital costs between

\$0.33 to \$0.38 per gallon while estimated amortized capital costs for new dry-mills with annual capacities of 40 million gallons or wet-mills with annual capacities of 100 million gallons are \$0.38 to \$0.48 per gallon of capacity.

The estimated full costs of production of ethanol (without the tax exemption) from a new stand-alone plant ranged from as high as \$1.60 per gallon in 1981 and 1984 to \$1.03 per gallon in 1987. An ethanol plant addition to an existing wet-mill could save as much as \$0.20 per gallon.

Ethanol and Energy Security

The primary goal of U.S. energy policy is to ensure both short-term and long-term energy stability. Policy initiatives for short-term energy security are intended to minimize the effects on the U.S. economy of global energy market disruptions. Major policy initiatives for long-term energy security look to research and development to ensure timely commercial production of alternative fuels based on plentiful domestic resources.

Energy security also includes the ability of the United States to defend itself in time of war. A broader concern

is to inhibit the ability of foreign countries to exert control over the United States by withholding or threatening to disrupt energy supplies. Using tax exemptions to encourage ethanol production from domestically produced grains reduces our dependence on foreign oil.

However, ethanol cannot be relied upon in the short term to play a significant role in meeting future energy needs. In 1988, ethanol production reached 825 million gallons per year. In the same year, the United States produced from domestic sources almost 3 billion barrels (124 billion gallons) of crude oil and imported almost 1.9 billion barrels (78 billion gallons). In addition, the United States imported almost 840 million barrels (35 billion gallons) of refined oil products. Therefore, a doubling of the ethanol industry will be inadequate to meet the total U.S. petroleum energy demand.

Even if domestic energy independence could be attained, international energy shocks would reduce global income and continue to affect the United States through international trade. The recent Iraq-Kuwait conflict highlights the importance of interrelated global markets. While less than 8 percent of U.S. crude oil imports were from Iraq and Kuwait,

disruptions in world oil markets had a quick impact on U.S. markets. Also, higher energy prices reduced income in foreign countries, which decreased the demand for U.S. exports.

Ethanol and the Environment

Environmental concerns in many parts of the United States have renewed interest in reducing automobile emissions and led to passage of the Clean Air Act Amendments of 1990. The Amendments include a wide array of provisions designed to improve ambient air quality by requiring that concentrations of certain air pollutants not exceed standards set by the Environmental Protection Agency (EPA). States in areas where concentrations of those pollutants exceed the standards are required to develop plans to control emission sources to meet the standards.

Of the pollutants listed, ozone and carbon monoxide are furthest from meeting the desired standards. Cleaner, reformulated gasoline is mandated in the nine

cities (Baltimore, Chicago, Hartford, Houston, Milwaukee, New York, Philadelphia, Los Angeles, and San Diego) with the most severe ozone pollution in 1990. Reformulated gasoline is required, by 1995, to have 15 percent lower emissions of volatile organic compounds (VOC's such as hydrocarbons and nitrogen oxides that react with sunlight to produce ozone) compared with conventional gasoline.

Starting in 1992, the Act also establishes an oxygen content level of 2.7 percent in gasoline in the 44 cities with serious carbon monoxide pollution. EPA attributes 66 percent of all carbon monoxide emissions (80 percent in many urban areas) to imperfect combustion in motor vehicles.

One answer to the problem of imperfect combustion is to increase the amount of oxygen in gasoline. Adding ethanol, ETBE (ethyl tertiary butyl ether which is 42 percent ethanol), methanol (wood alcohol), or MTBE (methyl tertiary butyl ether which is 35 percent methanol) to gasoline creates "oxygenated" blends.

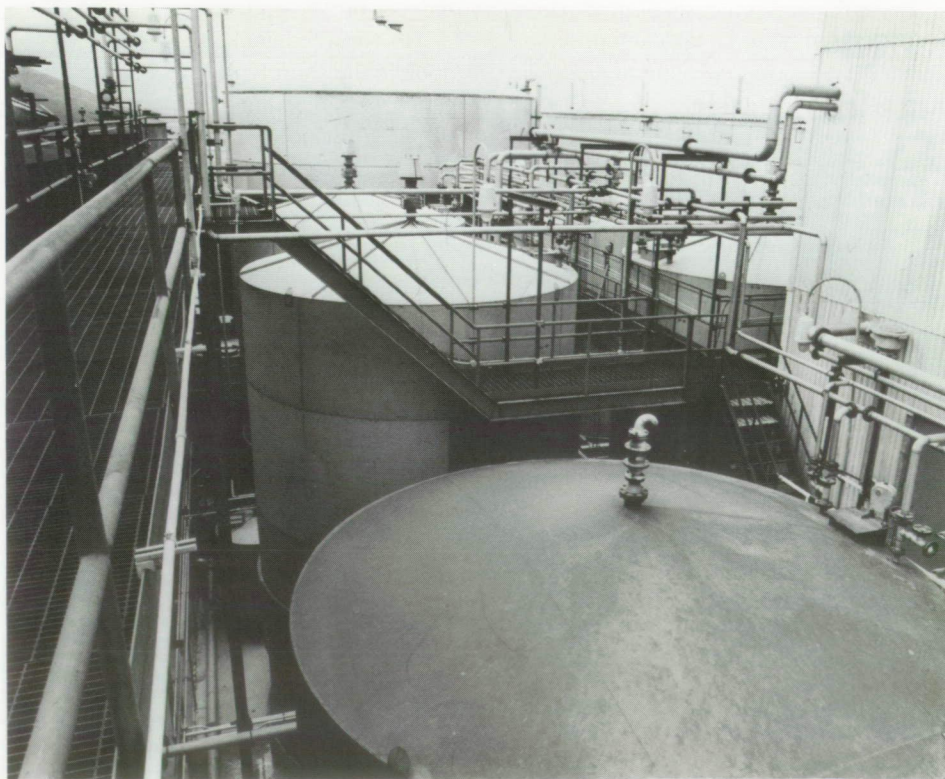
Oxygenated blends have a greater air/fuel ratio which improves the combustion of gasoline and therefore reduces exhaust emissions including carbon monoxide. Blended fuels are similar to straight gasoline, which enables vehicles to use them without changing existing engine designs.

Carbon dioxide emissions from motor vehicles are also potentially serious environmental problems. Carbon dioxide may contribute to the "greenhouse effect" of trapping the sun's heat and causing the earth's temperature to rise. Because corn absorbs carbon dioxide as it grows, replacing gasoline with ethanol processed from corn by-products reduces the quantity of carbon dioxide added to the atmosphere.

Burning gasoline creates environmental health problems. At one time, lead was used to raise the octane level of gasoline. Lead was phased out because of health problems associated with lead poisoning.

To replace lead as an octane enhancer, gasoline refiners often use aromatic compounds such as benzene, toluene, and xylene. But aromatic compounds are toxic chemicals, and EPA estimates that 56 percent of cancer incidence due to toxic chemicals comes from gasoline emissions. Over time, the amount of aromatic compounds in gasoline has increased as the demand for high octane (premium) gasoline has risen. Using splash-blended ethanol as an octane enhancer, instead of aromatic compounds, would reduce the quantity of toxic chemicals released from car tailpipes and gasoline filling station pumps.

A potentially negative environmental impact of adding splash-blended ethanol to gasoline is increased fuel volatility, which increases the amount of ozone-causing evaporative hydrocarbon emissions. Evaporative emissions from ethanol-blended fuels can be reduced by reformulating the gasoline to have a lower vapor pressure or by converting the ethanol into ETBE before blending with gasoline.



Starch from grains is fermented into ethanol fuel.

Ethanol and U.S. Agriculture

The amount of production of ethanol depends on commodity market conditions, the nature of farm programs, and the size of the ethanol industry. Ethanol creates an additional market outlet for corn, which increases the price of corn. The amount of the price increase depends upon how much corn is demanded by ethanol producers and the ability and willingness of farmers to shift idle acres and land used for competing crops into the production of corn. Depending on the government incentives in place, farmers

would be expected to increase their plantings of corn at the expense of soybeans.

Farmers would make the shift for two reasons. First, returns to corn relative to other crops would be higher because of rising corn prices. Second, high protein animal feeds, which are a by-product of ethanol production, would cause the price of soybeans to fall (*see box, "Ethanol Processing and By-products"*).

The livestock sector is also affected by ethanol production because feed energy (corn) prices rise relative to high protein feed prices. Because livestock rations contain primarily energy feeds, ethanol

production can increase the cost of feeding livestock.

A moderate expansion in ethanol production would likely have a small effect on consumer prices. ERS researchers estimate that a 2.7-billion gallon ethanol program could cost consumers an additional \$150 million per year in food expenditures while a 3.4-billion gallon program would cost consumers as much as \$350 million.

Increases in consumer prices could be minimized if the set-aside requirements associated with current farm programs were relaxed. In 1990, for example, 26 million acres of cropland were idled

Ethanol Processing and By-products

Two similar technologies for producing ethanol are now in commercial operation: dry- and wet-milling. In most ethanol producing dry-mills, corn is ground, slurried with water, and cooked. Enzymes convert the starch to sugar and yeasts ferment the sugars to produce beer. The beer, which contains alcohol, water, and dissolved solids, is separated. The alcohol and water are then distilled and dehydrated to create anhydrous (without water or 200 proof) ethanol. The remaining solid solubles are dried and sold as dried distillers grains and solubles (DDGS). DDGS is a high-protein livestock feed (27 percent crude protein with about the same feed energy as corn).

The primary difference in the wet-milling process is that the individual portions of the corn kernel are separated prior to cooking, producing an almost pure starch. The starch is converted to sugars, which are then fermented into ethanol. (Because an ethanol wet-milling plant is identical to a corn sweetener plant through the starch production phase, the two facilities have often been combined.) The by-products associated with a wet-milling process include corn oil and 2 high protein feeds, corn gluten feed (20 to 21 percent crude protein),

and corn gluten meal (60 percent crude protein).

Under both processes, about 2.5 to 2.6 gallons of ethanol are produced from each bushel of corn. The per bushel by-product yields are 18 pounds of DDGS if dry-milled, or 12.5 pounds of corn gluten feed, 2.5 pounds of corn gluten meal, and 1.6 pounds of corn oil if wet-milled. Both processes also generate about equal amounts of carbon dioxide.

Use of these by-products for feed limits the influence of ethanol production on agriculture. For example, the protein component of DDGS produced from an acre of corn processed into ethanol replaces the soybean meal produced from 0.6 of an acre of soybeans. Because DDGS has a lower protein content than soybean meal, the substitution of DDGS for soybean meal results in extra feed energy. This additional feed energy replaces corn from 0.2 acres. Therefore, the initial affects of producing ethanol on the agricultural sector are minimal because 80 percent of the cropland for ethanol production can come from released soybean and corn feed production.

Ethanol by-product feeds are limited in swine and poultry feed rations and can substitute for only a portion of the soybean meal. Cattle don't face the same limitations and much of their diet can consist of by-product feeds.

Greater increases in agricultural prices will occur when the by-product feeds can no longer substitute for soybean meal in

swine and poultry rations and have replaced all of the soybean meal in cattle rations. When substitution for soybean meal is no longer possible, the by-product feeds are valued solely for their feed energy in cattle rations and replace the feed from only one-third of an acre of corn.

The remaining acreage must come from traditional agricultural uses. Additional ethanol output requires substantially higher corn prices to entice farmers to shift land to corn (ethanol) production. And as land is shifted to corn from other crops, prices of other crops rise. Also as corn prices increase, livestock feed costs go up. Poultry, the most efficient grain converter, is the least affected.

The nation's largest ethanol producer, Archer Daniels Midland (ADM) Company, uses the wet-milling process to produce its ethanol. To improve the economics of processing corn into ethanol, ADM has developed fluid bed cogeneration (steam and electricity) boilers that burn high sulfur coal and meet EPA air quality standards. ADM is experimenting with mixing used tires and coal. Therefore ethanol processing could turn the nation's abundant coal supply and environmentally hard-to-dispose-of used tires into fuel for cars.

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under annual Federal acreage reduction programs with 10 million acres idled under the corn program. The acres idled under the corn program alone represent over 2.5 billion gallons of potential ethanol.

Future Ethanol Processing

Alternative ethanol agricultural feedstocks such as potatoes, sweet potatoes, Jerusalem artichokes, sugar beets, fodder beets, sweet sorghum, and grains other than corn may prove beneficial in the longer term. Use of these crops for ethanol does not present any particular technological hurdle. Should corn prices rise, some of these crops may prove to be cheaper feedstocks because they can be grown on a broader range of lands and in climates unsuited for corn production. Bioengineering and traditional plant breeding technologies that increase per acre yields or increase starch and sugar contents of corn and other crops also offer the potential for lower cost ethanol through reductions in feedstock costs. Any advances in crops that reduce production costs or increase starch yield would lower ethanol feedstock costs.

Processes to break down the various types of cellulosic biomass materials into sugars that can then be fermented are an active research area. Breakthroughs in biomass pretreatment and conversion would allow higher yields from grains because part of the grain crop is cellulose. Also, herbaceous plant matter could be used. For example, crops such as alfalfa, energy sorghum, and switchgrass, as well as cellulosic material such as corn stover or bagasse, could be fermented. These technologies could ultimately

allow ethanol production from woody plants and a broader range of organic wastes.

The Department of Energy (DOE) estimates potential ethanol production costs from cellulose feedstocks, such as grasses and fast growing trees, at \$1.00 to \$1.35 per gallon. This estimate includes carbon dioxide and the energy value of unconverted cellulose as by-product credits. DOE hopes to reduce ethanol production costs from cellulose to as little as \$0.60 per gallon by 1998.

Cellulose conversion and processing of renewable resources (biomass) into oxygenated fuels and chemicals is the next major development in agriculture. The timeframe over which this will occur depends on the level of research and development in the growth, harvesting, transportation, storage, processing, fermentation, and final product recovery related to cellulosic materials. Research on the biochemical, chemical, and microbial transformation of renewables into value-added by-products is critical. Some of the key developments will be: microorganisms which efficiently ferment a broad range of sugars in addition to glucose; technology to readily convert biomass materials into processed cellulose, lignin, hemicellulose, and by-product streams; chemical modification of cellulosic materials to products that supplant current materials derived from other sources such as petroleum; and development of an industrial infrastructure based on biomass resources.

Many potential benefits could result from an industrial infrastructure based on cellulosic biomass feedstocks. Rural communities could benefit from the processing of biomass feedstocks into industrial products through increased employment and tax base. Farmers could benefit

by having a wider selection of profitable crops. More crop choices make it easier to develop rotations that minimize chemical inputs. Some of the crop choices could be pasture grasses which would reduce farmers' incentive to plant row-crops on highly erodible land.

The focus of near- and long-term ethanol research and development differs to a degree. Much of the near-term research and development efforts have focused on the narrower context of the ethanol production facility itself. To examine the potential of the industry beyond a role as a user of surplus corn and other grains, research is being done by USDA on ethanol production technologies capable of using a broader set of feedstocks, and the development of markets for by-products from both new and existing technologies. ■

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Managing Solid By-products of Industrial Food Processing

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The food processing industry generates large amounts of solid by-products in the production of food items. Instead of treating these by-products as waste and landfilling them, many food firms are turning them into useful products. For example, in 1987 over 9 million tons of food and fiber by-products were further processed into animal feeds. Another 3 million tons were recycled for fuel. Currently, less than 3 percent of food processing by-products are landfilled.

Transportation costs to landfills and disposal fees are increasing and government regulations are becoming more stringent. As a result, food firms are finding that they can reduce costs and increase profits by transforming their by-products into useful items such as animal feeds, other human foods and additives, soil amendments, or fuel for energy production. Many are high-value products.

Hazardous By-products

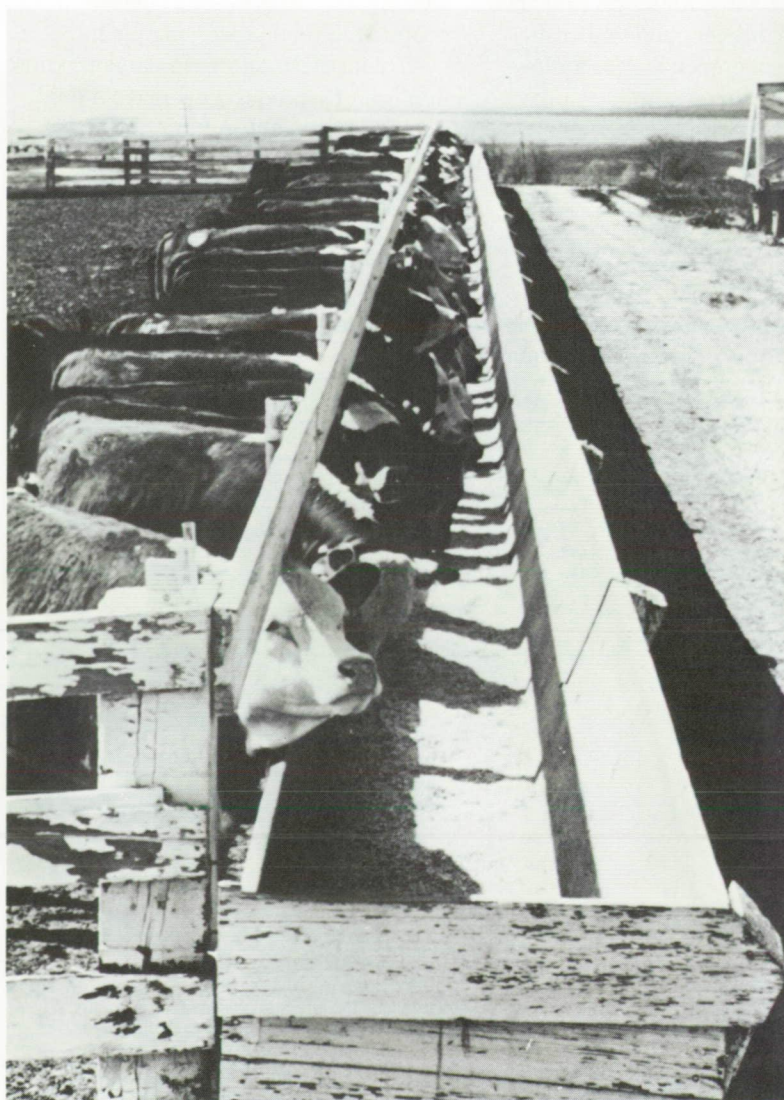
A certain percentage of solid by-products from food processing is considered hazardous. For example, residues from pesticides or fertilizers may be in peelings or other by-products from fresh produce. Chemicals used in food processing plants for treatment or cleaning of produce and meats may also create by-products with toxic wastes. In 1988, 10 percent of solid by-product processing capital costs and 5 percent of corresponding operating costs went toward by-product hazardous waste management in the food processing industry.

The U.S. Environmental Protection Agency (EPA) is particularly alert to the

potential for toxicity from concentrated chemical residues in by-products used for human foods and animal feeds. Toxicity is a concern for land disposal methods as well. Solid hazardous materials must be handled differently from other types of solid by-products, and are not included in the following discussion of by-product disposal.

By-product Disposal Costs

Currently, the costs to reduce or eliminate pollution from solid by-products in the food processing industry are low. They were estimated to total \$348.2 million in 1988—just 0.1 percent of the value of final product shipments. In part, these low costs are due to the industry's



The largest category of identified uses for food processing by-products is animal feeds.

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capacity to process and divert waste by-products to other uses.

Expenditures include processing, packaging, and other materials costs to transform by-products into usable inputs. The expenditures are divided into operating costs, capital costs, and payments to government agencies for collection and disposal. The largest share is operating costs (*table 1*). The amount depends on the quantity and form of by-products to be managed and the available methods for handling them. In 1988, operating costs were 80 percent of total disposal expenses.

Operating costs for disposal or redirection of solid wastes are rising (inflation-adjusted dollars). In 1983, these were \$140 million and, by 1988, \$278 million (*figure 1*). The increases were due mostly to environmental regulations that require more processing of by-products before disposal, limitations on types of materials acceptable for landfilling and land application, higher operating costs of new by-product processing technologies, and increases in raw products processed.

Conversely, recovered costs—revenues from by-product sales or process cost savings—declined in the early

1980's as saturated markets reduced by-product prices. Between 1985 and 1988, real recovered costs averaged \$14 million compared with an average of \$12 million for 1981 through 1984.

Payments to government agencies for collection and disposal of by-products in landfills increased throughout the 1980's. From a low of \$18 million in 1982, collection costs nearly tripled to \$51 million in 1988. Dramatic increases in disposal (tipping) fees accounted for most of the change.

Operating costs and government payments grew more rapidly than recovered costs. Average net by-product processing costs increased from \$150 million during 1981-84 to \$250 million in 1985-88.

Capital costs include the technology necessary to make alternative products from food processing firms' by-products. New technology increases marketability of processed by-products, but the associated capital and operating costs limit adoption in food processing plants.

Capital expenditures to prevent pollution from by-products averaged a relatively constant \$11 million from 1981 through 1985. In 1986, they rose to \$15 million and by 1988 they were \$19 million. New technologies for waste reduction and recycling of food by-products

are being adopted by a wide variety of firms. Most capital expenditures are for pollution abatement, not operating cost reductions. Such reductions are less costly to achieve by changes in processing management than with expensive capital additions.

By-product Uses and Disposal

A 1987 survey by the National Food Processors Association (NFPA) showed how raw agricultural commodities (RAC) are used in the food processing industry. The survey included several industry subsectors: preserved fruits and vegetables, grain mill products, sugar and confectionery products, fats and oils, dry beans, beverages, miscellaneous foods and kindred products (such as processed fish and seafood, and roasted coffee). The RAC tonnage reported in the survey represented 25 percent of the total for these subsectors in 1986.

Based on this survey, only 30 percent of RAC was used as food products; the rest were by-products. The by-products were processed into animal feed, human food, energy, and soil amendments, or were landfilled or dumped into the sewer.

As Animal Feeds

The largest category of identified uses for food processing by-products was animal feeds (*table 2*). Dry feeds accounted for 17 percent of by-products (6 million tons) and wet feeds for 9 percent (3 million tons). Wet- and dry-milling by-products are almost exclusively used as cattle feed, worth about 10 percent of the total value of the RAC. Culled fruits and vegetables, sugar beet pulp, molasses, and spent brewer's grains are also commonly used as animal feeds for beef, dairy cattle, and hogs.

The value and quality of by-products as feed are well known and, subject to market availability, they are easily sold. Characteristics of feeds vary with nutrient composition and moisture content. Sometimes it is necessary to remove moisture from the feeds by dehydration or to store the wet feeds in silos. Substitution of by-products for other feeds in animal diets must be done carefully to

Table 1. Operating Expenses Were the Biggest Share of Solid Waste Abatement Costs for the Food Processing Industry in 1988

Subsector	Solid waste abatement costs				Value of shipments
	Capital	Operating	Payments to Government	Total	
	<i>Million dollars</i>				
Meat products	3.8	27.9	8.0	39.7	74,168.4
Dairy products	3.1	22.4	8.2	33.7	41,289.1
Preserved fruits and vegetables	4.0	46.3	10.3	60.6	36,826.1
Grain mill products	0.7	17.9	2.9	21.5	37,493.4
Bakery products	1.2	17.2	3.5	21.9	20,956.3
Sugar and confectionary products	1.4	21.5	1.2	24.1	19,461.7
Fats and oils	1.1	13.6	3.0	17.7	19,955.1
Beverages	3.5	72.3	9.5	85.3	47,271.4
Miscellaneous foods and kindred products ¹	0.4	39.1	4.2	43.7	29,306.1
Total	19.2	278.2	50.8	348.2	326,727.6

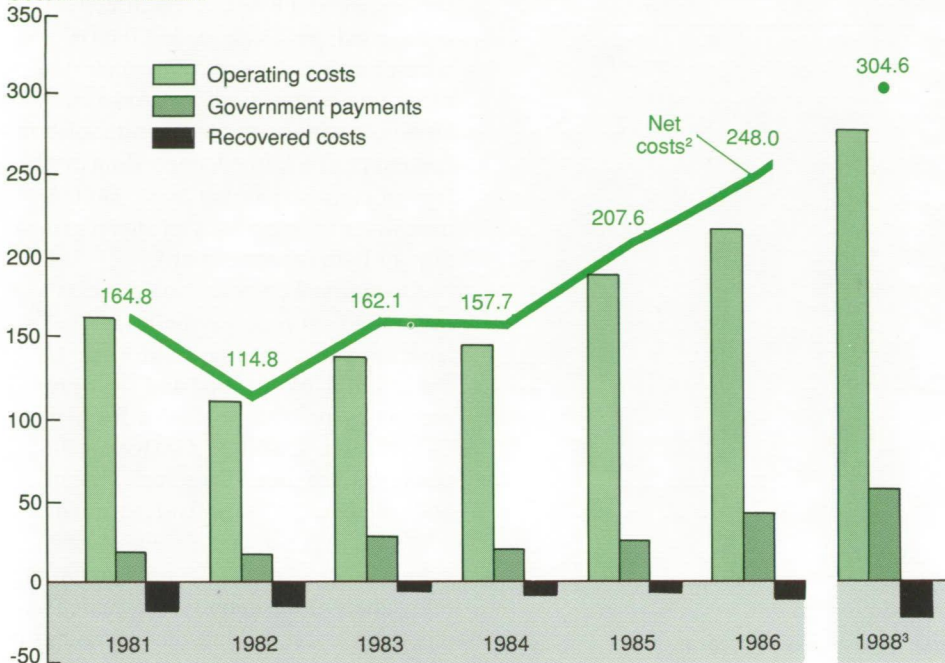
¹This category includes fresh, frozen, canned, and cured fish and seafood, and roasted coffee.

Sources: Bureau of the Census, Manufacturers' Pollution Abatement Capital Expenditures and Operating Costs, 1988 Current Industrial Reports.

Bureau of the Census, Value of Product Shipments, 1988 Annual Survey of Manufactures.

Figure 1. Net Operating By-product Disposal and Processing Costs Have Increased

Cost in million dollars¹



¹1988 dollars. ²Net equals operating costs, plus payments to government, minus recovered costs.

³Data for 1987 is not available.

Table 2. Animal Feeds Were the Top By-product Disposal Method for the Food Processing Industry in 1987

Food processing subsector	By-product volume	Utilization method						
		Wet feed	Dry feed	Land applied	Fuel	Land-filled	Other	Losses
	Tons	Percentage of by-product volume ¹						
Preserved fruits and vegetables	3,598,892	44.9	4.7	12.4	0.7	4.2	20.3	12.7
Grain mill products	2,573,236	23.3	44.2	0.1	1.7	0.3	25.7	4.8
Sugar and confectionary products	24,069,408	2.2	2.6	0.1	12.7	2.8	29.7	49.8
Fats and oils	4,334,838	2.6	92.5	0.0	0.1	0.3	4.1	0.4
Beverages	386,986	32.7	12.9	1.9	0.0	2.8	48.8	0.9
Miscellaneous foods and kindred products ²	329,065	34.4	2.8	1.1	0.0	1.0	62.2	NA
Dry beans	13,175	23.3	47.4	0.0	0.0	5.7	24.7	NA
Share (percentage)		8.8	17.0	1.4	8.9	2.5	25.8	35.6
Volume (millions of tons)		3.1	6.0	0.5	3.1	0.9	9.1	12.6

¹Percentages do not add to 100 due to rounding and recorded errors in materials balance for each subsector.

²This category includes fresh, frozen, canned, and cured fish and seafood, and roasted coffee.

Source: Rose, W. W., L. D. Pederson, H. Redsun, and R. Scott Butner, "Significance of Food Processing By-Products As Contributors to Animal Feeds," EPA/HED 8, October 1989.

prevent adverse effects on animal performance.

By-products for feed are used in concentrates, including energy feeds and protein products, and roughage. Energy concentrates have somewhat more protein (1 to 88 percent) than fiber (1 to 39 percent). Protein concentrates have 20 to 65 percent crude protein and at most 30 percent crude fiber, though a typical range is 3 to 15 percent. Roughage contains mostly fiber, ranging from 20 to 50 percent, but typically around 40 percent, with less than 10 percent protein (table 3).

Most feeds made from food processing by-products cannot completely replace other animal feeds, nor can all species equally utilize the same by-product feeds. For cattle, a typical rate of substitution for energy concentrates is 10 to 25 percent in the dairy ration, and 10 to 30 percent for beef in feedlots. By-product protein concentrate substitutes for 10 to 25 percent of the usual ration for dairy cows. Roughage is measured in weight fed, with acceptable substitution from 20 to 35 pounds per cow per day for most by-product roughage feeds listed.

Research on feeds in the food processing industry focuses on finding new uses for by-products and in refining existing uses to better meet animal nutritional needs. A promising area is the recovery of solids from effluents. Chemical precipitation, using a flocculating agent to separate suspended materials, can be applied to slaughterhouse effluents or fish processing wastewater.

Ultrafiltration, a pressure-driven membrane separation process, has been used to isolate proteins from whey, a by-product of cheesemaking, to concentrate and clarify fruit juices, and to recover edible oils and fats from wastewater. This process also separates proteins and enzymes from potato washwater, yeast from brewery waste, proteins and oils from fish brine, and red dye from beets. These by-products may be reused in the food processing system or used as feed or food additives.

Processes such as chemical precipitation and ultrafiltration not only recover more of the by-product solids for higher

Table 3. Animal Feeds Are Derived from Many Food Processing By-products

Sample by-products	Crude protein	Crude fiber ¹
	Percent	
Energy concentrate feeds		
Egg shells and liquids, hair and feathers, leather tannery meal, paunch contents, dried meat processing effluents	12 -75	2 - 33 (4 - 39)
Dried and liquid whey	1 -13	1 - 9
Citrus pulp and sludge, fruit and vegetable culls, fruit cannery sludges, dried tomato and fruit pomaces	7 -40	3 - 35
Grain screenings, hominy feed, wheat and rice brans	14 -18	9 - 32
Bakery wastes	10 -12	1
Wet and dry beet pulp, sugarcane and beet molasses, almond hulls, cacao shells	4 -16	5 - 20
Whole cottonseed	25	18
Dried winery pomaces, brewers' wet and dried grains	5 -26	16
Fish meal, oil, solubles	65 -70	NA
Protein concentrate feeds		
Corn gluten, meal and feed	25 -65	3 - 9
Meals from coconut, cottonseed, linseed, soybean, safflower and sunflower	20 -50	3 - 30
Distillers' dried grains	26 -30	13 - 16
Roughage feeds		
Corn and snap bean cannery waste, pineapple wastes	3 - 8	22 - 27
Barley, oat and wheat straws, rice hulls	3 - 5	40 - 44
Sugarcane bagasse and strippings	2 - 4	45 - 48
Cottonseed hulls, cotton gin trash	3	44

¹For animal products, ash rather than crude fiber is measured. The numbers in parenthesis represent the range of crude fiber percentages in paunch contents.

Sources: Bath, D. L. "Feed By-Products and Their Utilization by Ruminants." *Upgrading Residues and By-Products for Animals*. Boca Raton, FL: CRC Press, Inc. 1981. pp. 1-16.

National Research Council. *Underutilized Resources as Animal Feedstuffs*. Washington, DC: National Academy Press. 1983. pp. 5-45.

valued uses, but also produce cleaner effluent. These processes reduce pre-treatment costs for wastewater disposal and water reuse in the plant. Liquids such as recovered brines and syrups may also be reused.

The possibility of toxicity from pesticides on crops or heavy metals in meat products and fruit cannery sludges is of particular concern to food processors when they redirect their waste by-products into feed or food. Testing for chemical residues in by-products may be necessary because of the potential for concentration of toxins. Some by-products have naturally occurring chemicals that cause toxic results. For example, apple pomace with nonprotein nitrogen may lead to weight loss, birth defects, and reproductive problems when fed to cattle. Cacao shells (from the production of chocolate) contain theobromine and caffeine which adversely affect horses, pigs, poultry, and

calves. Familiarity with feed and by-product characteristics makes substitution safe and effective.

The grain mill product subsector includes pet foods, and prepared livestock and specialty feeds as final products. By-products from other food processing activities are added in making these final feed products. In 1988, pet foods and livestock feeds were valued at \$17 billion or 89 percent of the total value of shipments from the grain mill product subsector, which includes breakfast cereals and flours.

As Fuel

Another 9 percent, or 3 million tons, of food processing by-products were used as combustion fuel. Fruit and olive pits, nut shells, rice hulls, straw, and sugar cane bagasse (the dry pulp remaining from sugar cane after the juice has been extracted) make suitable fuels for burning

in boilers to produce steam and electricity.

Although the NFPA surveyed processors only about by-products directly combusted, gasification, distillation, and anaerobic digestion are other means of extracting energy from by-products. Materials with up to 50 percent moisture content can be burned, depending on the type of combustion unit used. Boilers heat water for electricity or steam generation, or both (cogeneration).

Operational cogeneration projects fueled by fruit pits, nut shells, and hulls have been successful in California. Of the 312,500 tons of food and fiber processing by-products available for fuel in California in 1986, 187,500 tons (60 percent) were used. As a fuel, almond hulls were valued at \$50.00 per ton in 1986, while peach and olive pits were valued at \$0.50 to \$10.00 per wet ton. In other areas of the country, the share is much lower due to inadequate amounts of by-products in single locations, transportation costs, and limited availability due to seasonal production.

Energy production from direct combustion of wet fuels (skins, peels, and culls with greater than 30 percent moisture content) is curtailed by the short processing season for fruits and vegetables. This causes the payback period for equipment investment to be unacceptably long. Reduction of moisture content is sometimes necessary to use these types of by-products in direct combustion. Moisture reduction, in turn, reduces fuel degradation, enabling energy generation beyond the processing season. With rising disposal fees, combustion of wet fuels such as apple pomace makes more economic sense.

In recent years, other energy conversion technologies for high-moisture by-products have been developed. One of these is the water-slurry gasification system, which uses high pressure to produce methane, carbon dioxide, and hydrogen from slurries containing up to 95 percent moisture. Eliminating the drying step usually needed before gasification can result in substantial cost savings. Using this process, 46,000 tons of potato by-products at 16 percent solids can be converted to 100 billion BTU's of methane (the main ingredient of natural gas). The methane replaces 25 to 40 percent of

the natural gas required by the potato processing plants.

Anaerobic digestion has been successfully applied to wet by-products such as beet pulp to produce methane. The biomethanation process, consisting of a two-stage anaerobic section followed by polishing steps, is used to convert 90 percent of organics in the pulp to methane. Not only does the fuel provide energy cost savings to the facility, but costs of drying and transporting pulps for animal feeds are eliminated. However, the effluent from biomethanation carries a heavy pollution load, which requires treatment of the effluent before discharge. About 10 percent of the initial dry material ends up as sludge and must be stored or spread. In one test, 286 tons of beet pulp generated 3.7 billion BTU's on a daily basis.

Ore-Ida Foods uses an anaerobic process known as Biothane to treat wastewater at its potato processing plant in Wisconsin. The process features a digester vessel of forced fluidization without mechanical agitation or a filter. Soluble solids removal is 90 percent, and methane purity is 75 percent. While the wastewater is clean enough to discharge, the anaerobic sludge must still be disposed of.

Another system, known as the anaerobic filter system, is used by Bacardi Corp. in Puerto Rico for wastewater treatment. The digester is a tank containing a plastic matrix resembling a filter. The anaerobic organisms, which are fixed in layers to the plastic matrix, ferment wastewater as it flows down through the system. Biogas is discharged through the top and burned as a boiler fuel, resulting in cost savings of \$600,000 to \$900,000 per year.

Ethanol fuel has received more attention as air pollution from automobiles is targeted by Federal regulations. (*See "Ethanol in Agriculture and the Environment" elsewhere in this issue.*) There are commercial processes for converting by-products such as cheese whey to ethanol. Cheese whey, which is about 90 percent of the original milk volume in cheese manufacturing, is a major pollutant when discharged into waterways. Although drying for animal feeds is one alternative, ethanol is a higher valued use for some processors.

The Carbery whey-ethanol process uses ultrafiltration to generate whey protein concentrate, which is then fermented and centrifuged to create ethanol. However, the effluent still requires treatment before discharge into surface waters. The output from the Carbery process is suitable for the production of vodka and may be used to fortify wine. These uses are of higher value than use as a fuel.

Much of the fuel and fuel-derived research was initiated as a response to wastewater problems. Combustion, anaerobic digestion, and gasification all generate solids to be disposed of. While the quantity of solids may be reduced, any toxic elements that are present before the treatment may become even more concentrated. Inert materials may be used as soil amendments or simply spread on the land surface. Disposal options may be limited by local environmental regulations.

The economics of using by-products for fuel depends on transportation distance to haul the material, costs of treatment and disposal of raw by-products, costs of alternative fuel inputs, and the availability of capital for installation. Payback curves for seasonal operations are longer than for those that process foods all year.

Other Uses

A category of specialized by-products, called "other" in the survey, was 26 percent or 9 million tons. This category includes essential oils, dyes, pits for fragrance and cosmetics manufacture, starch derivatives, pectin, fermentation by-products, biogas, and quantifiable solid losses from roasting, blanching, and cleaning. As the "catch-all" class of by-product uses, this category includes a number of high-valued niche markets, which may have potential for expansion.

There is substantial interest in recovering more human food products from materials that are currently disposed of. One method, counter-current extraction, uses a large screw which rotates continuously through the solids in a trough, intermittently changing directions of rotation. The liquid portion is squeezed out of the solid portion by this action. The process has been successfully used to extract apple juice, grape extract (containing aromatic compounds, tartarates

and color), citrus peel liquids (for liqueur production), poultry stock and fat for soups and flavorings, seafood components such as prawn and crayfish juices and chitinous residues, and fruit pectins high in fiber.

There is also interest in the commercialization of processes to produce single-cell proteins, which can be converted to animal feeds or human food. Microbiological agents, such as pure and mixed cultures of yeasts and fungi, produce protein during fermentation of by-products. Most single-cell proteins are derived from cane and beet molasses, but other materials such as meatpacking wastes, straw, and seed husks have been tested. Fermentation of cheese whey produces single-cell protein as a secondary output from ethanol production. Biotechnological processes may be necessary for widespread adoption.

Sewage Discharge

The survey showed that over a third of food processing by-products were lost as soluble solids in wastewater (especially with potatoes and wet milled corn), and as moisture through evaporation processes (particularly with citrus, sugar cane, sugar beets, tomatoes, malted products, potatoes, cottonseed, and apples). Such losses accounted for 13 million tons of by-product. New technologies may provide opportunities for increased recovery of materials, but economic viability depends on demand for materials and disposal costs.

Land Disposal

Land disposal methods (land application as soil amendments and landfilling) accounted for less than 5 percent of the by-products generated (*table 2*). Land applied and landfilled materials totaled less than 2 million tons of by-products in 1987. Wastes in the form of stems, leaves, dirt, small stones and other debris, most peelings and corings, some hard pits, and some solids screened from wastewater are either landfilled or land applied. Although food processors could be paid for by-product application to farming land, many firms view this as a disposal option rather than a revenue-generating alternative.

Land applied by-products often have economic value, but firms may have difficulty realizing returns. The Cooperative for Environmental Improvement, Inc. (CEI), started in 1969 by a group of California canners in Santa Clara County, uses spread-and-disc methods to return fruit and vegetable processing residues to agricultural lands at a cost of \$2.25 per ton. A full-time manager inspects loads and rejects nonprocessing and nonbiodegradable materials. Soil improvement on leased disposal land has been so dramatic that land has been returned to productive use and new disposal sites have been leased.

Land application involves obtaining permits from State and local environmental protection agencies. In turn, specialists may be needed to determine acceptable loading levels. Michigan State University researchers have assisted companies in finding application rates which minimize risk of nutrient overload and leaching on agricultural lands. One spice extracting company saves \$100,000 per year in landfilling costs by diverting by-products to land application and animal feeding. At a return of about \$5 per ton for feed, the company covers the associated handling and transportation costs.

One problem with wet food processing waste is its instability—decomposition is rapid. By-products sometimes need to be transformed to create greater stability. Composting, the controlled aerobic decomposition of organic materials, is one such process.

Compost is a humus-like material of crumbly texture and earthy odor, high in organic matter, and resembles rich topsoil. It makes a valuable soil amendment and, depending on the source material and added nutrients, may make a good fertilizer. Correctly composted material has no pathogens and is stable to further decomposition.

Composting reduces the volume of source material by more than 50 percent. It has been used successfully to reduce fish residues, potato trimmings, apple pomace, grape skins, fruit cannery wastes, and other by-products. An Ocean Spray plant in New Jersey composted cranberry and prune wastes, a process which required 25 to 30 weeks to complete. In Maine, composting has been

successful with potato waste and fish residues as base materials. The active composting period for potatoes was 4 weeks and for fish waste, 9 to 10 weeks.

Vermicomposting is a variant of the decomposition process. This system utilizes red manure worms or tiger worms in an aerobic environment with a shallow waste layer in a box with a moist bottom to break down materials. Depending on worm numbers, breakdown of materials may be from 2 to 4 weeks. The worms may be harvested and dried for animal protein feed and the composted material sold. Expenses include purchasing stock worms, and constructing or purchasing containers. A study on potato wastes determined that this process is feasible on a commercial scale.

Composted products may need to be tested for toxic elements and heavy metals before they can be sold. Careful attention to the by-product inputs should prevent toxicity. Odors and flies are not problems with correctly composted systems. Odors result from improper carbon to nitrogen ratios or inadequate aeration. Groundwater, surface water, and odor monitoring are required at some land application sites. In some cases, regulations designed for human waste sludges are enforced for food by-product applications.

Another alternative for management of solid by-products is landfilling. State and local regulations regarding acceptable materials for landfills have become much stricter in recent years. Moisture content restrictions are major barriers for many food processing materials that require significant moisture reduction before landfilling. Disposal fees range from \$10 to \$50 per ton. Along with high transportation costs, the fees are making some higher cost, alternative by-product processing feasible. ■

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Refrigerated Transportation: CFC's and the Environment

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Today's supermarket contains a wealth of fresh and frozen products. We have come to expect a wide variety of fruits, vegetables, meats, and dairy products in top-quality condition at all times of the year. These products have one thing in common—they depend on refrigerated transportation and storage.

Perishable products are often produced far from where they are consumed and must be shipped and stored under controlled temperature conditions to maintain quality. The chemicals used as refrigerants and to produce insulation in the trucks that haul perishable foods are chlorofluorocarbons (CFC's). Because CFC's can damage the environment, the U.S. Government has passed laws to phase out their production by the end of the decade. The refrigerated trucking industry is searching for safe, reliable chemicals to replace CFC's.

The Government is encouraging the phase-out by mandating reduced production levels and levying taxes on CFC production. In 1995, for example, production of new CFC's will be limited to 65 percent of 1986 production, and a tax of \$2.65 per pound will be imposed. By 1999, production will be down to 15 percent with a tax of \$4.90 per pound.

The refrigerated transportation industry uses about 4 percent of the total worldwide production of CFC's (*figure 1*). The major use of CFC's in refrigerated transportation is for insulation production—about 4,000 tons annually (*table 1*). Maintenance of refrigerated transportation equipment requires 930 tons annually, and charging new refrigerated equipment uses 765 tons. Charging

trucks and trailers uses 1,200 tons of CFC's annually.

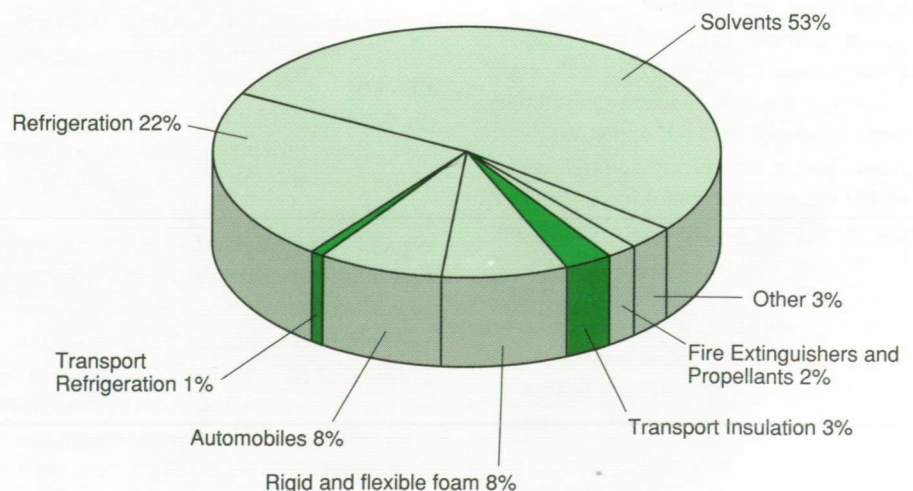
Impact of Phasing Out CFC's

Refrigerated transportation and storage are such efficient links in the food distribution chain that the average consumer pays little attention to them. These links are being brought to the forefront, however, as the industry struggles to replace CFC's as refrigerants and insulation production materials. CFC's are such an integral part of the industry that their replacement will affect every aspect of the food distribution chain from producer to consumer.

The most immediate effect on the consumer will be an increased cost for perishable products. As the industry changes over to new refrigerants and insulating materials, the costs will eventually be passed on to consumers of products carried and stored under refrigeration.

These costs include an estimated \$1 billion to restructure the refrigerant manufacturing industry in the United States and \$100 billion to retrofit or replace the refrigerated equipment which depends on CFC's. A major U.S. producer of refrigerants has recently released a new line of non-CFC refrigerants.

Figure 1. Refrigerated Transportation Is a Minor Use for CFC's



Source: Statt, T.G. "Uses of CFC's in Refrigeration, Insulation, and Mobile Air Conditioning," *Status of CFC's: Refrigeration Systems and Refrigerant Properties*. International Institute of Refrigeration, pp. 354-357, 1989.

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Table 1. Insulation Production Is the Major World Use of CFC's in the Refrigerated Transportation Industry

Refrigerated transportation mode	Annual use		Total
	New equipment	Maintenance	
		tons	
Cargo ships	200	50	250
Ocean containers	165	80	245
Trucks and trailers	400	800	1,200
Subtotal	765	930	1,695
Insulation production			4,000
Total			5,695

These new products, however, cost approximately twice as much as the chemicals they replace. Also, the new chemicals are not as efficient as the CFC's they are replacing, which will increase the cost of hauling perishable products even more.

Why CFC's Are Being Phased Out

CFC's are a family of chlorine- and fluorine-containing chemicals that have been used for 40 years as refrigerants and to produce foam insulation. Until the late 1970's, CFC's were regarded as ideal chemicals because of their stability. Chemical stability means that CFC's are safe, nontoxic, nonflammable, and nonreactive in refrigeration systems.

Unfortunately, the stability of CFC's has led to their down-fall. Since they are relatively nonreactive, once released they move unchanged into the upper atmosphere. There, the chlorine atoms react with the ozone layer, breaking it down. Since the CFC's are not destroyed by the reaction, they can persist in the upper atmosphere for up to 500 years. Because the ozone layer protects life on earth from damaging ultraviolet radiation, reducing or eliminating CFC production has become a matter of international concern.

In the early 1980's, researchers discovered a hole in the ozone layer above Antarctica. In the 7 years from 1981 to 1988, the ozone concentration in the upper atmosphere above Antarctica decreased 30 percent. Other parts of the world saw smaller but still significant decreases.

The discovery that the ozone layer was decreasing galvanized world opinion and led to an agreement called the Montreal Protocol, completed in 1987. This agreement, which was strengthened last year, mandates the phase-out of all CFC's by the year 2000. Another class of chemicals with less ozone depletion potential, called HCFC's (CFC's with some of the chlorine atoms replaced by hydrogen atoms), may also be phased out by the year 2020, although some countries, such as Germany, are moving more quickly.

Another potential problem with CFC's and some of their proposed replacements is the possibility that they contribute to global warming through the "greenhouse effect." The greenhouse effect is a theory that manmade gases, such as carbon dioxide, methane, and CFC's, allow sunlight to enter the earth's atmosphere but block heat from radiating away into space. Over time, the greenhouse effect could cause global temperatures to increase with serious consequences such as

widespread coastal flooding. The global warming potential of CFC's is a matter for concern, but so far there are no international agreements to regulate greenhouse gases. Debate continues on the best approach to take towards global warming.

Classes of CFC's

The term CFC is often used generically to refer to halogenated (chlorine- or fluorine-containing) carbon compounds. More precisely, these chlorine and fluorine carbon compounds can be divided into three groups, CFC's, HCFC's, and HFC's. Fully halogenated CFC's, such as CFC-11, 12, 113, 114, and 115, have the greatest ozone depletion potential (ODP) and greenhouse warming potential (GWP). HCFC's substitute some hydrogen for chlorine and thus have lower ODP and GWP. HFC's do not contain any chlorine and have a zero ODP and very low GWP. *Figures 2 and 3* show the ODP and GWP for the three classes of CFC's.

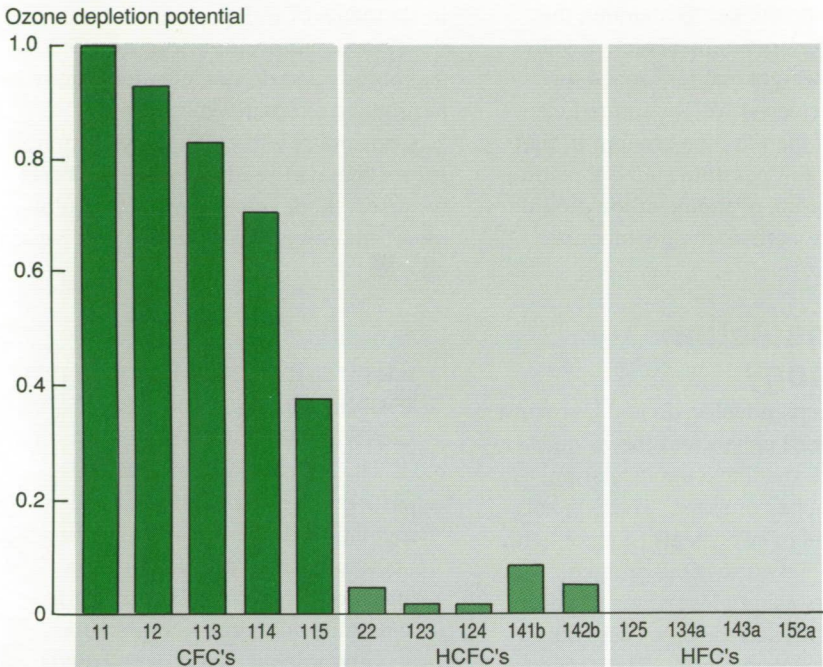
CFC's as Refrigerants

Currently, trailer refrigeration units use CFC-12 or a mixture of CFC-12 and other HCFC's or HFC's. All of these units will have to be retrofitted or replaced by the end of the decade.

For retrofitting, the industry is using two mixtures, one using HCFC-22 and HCFC-142b, or another mixture which combines HFC's and HCFC's. With both mixtures, all the rubber hoses in the refrigeration unit are changed to ensure compatibility. There are also potential flammability problems which don't exist with CFC's.

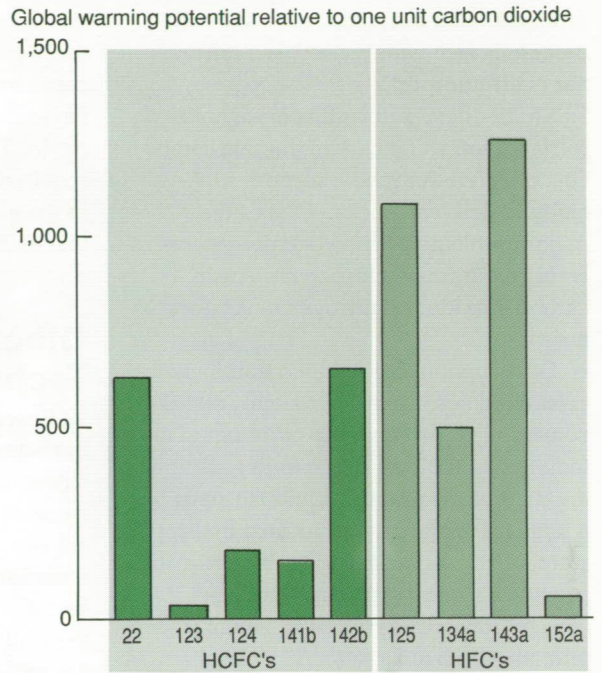
Plants will start to produce large quantities of these chemicals this year. However, the chemical industry is reluctant to invest too much in HCFC production since they have both GWP and ODP and may be targeted for phase-out in the future.

Figure 2. CFC's Have Greater Ozone Depletion Potential Than HCFC's and HFC's



Source: Fisch, Rick. "A World Without CFC's — Can the Industry Survive?" *Frozen Food Report*, July-August 1990.

Figure 3. HCFC's and HFC's Have Much Greater Global Warming Potential Per Unit Than Carbon Dioxide



Chlorofluorocarbons, used for refrigeration and insulation by trucks transporting perishable foods, are scheduled to be banned by Federal legislation by the end of the 1990's.

For new units, designers are focusing on HFC-134a. This compound has no ODP and a very low GWP. The downside is that HFC-134a has lower refrigerating capacity and efficiency than CFC-12, so units will have to be redesigned and possibly increased in size to achieve the same cooling power. Reduced efficiency also means that HFC-134a will probably not be suitable for refrigerated containers that operate in extremely harsh conditions. Finally, new lubrication compounds that are compatible with HFC-134a are still in the testing phase.

A major U.S. chemical company has just made HFC-134a available in large quantities at about twice the cost of CFC-12, the chemical it replaces. The price is expected to drop somewhat over the next few years.

Other Options for Refrigeration

The problems with CFC's may increase the use of other types of refrigeration such as cryogenics. In cryogenic refrigeration, liquid carbon dioxide or nitrogen is sprayed into the trailer where it becomes a gas and removes heat. The

gas is then vented out of the trailer. This method of refrigeration is gaining popularity for rail transport of deep frozen products, such as french fries. Carbon dioxide is also widely used as a refrigerant in air transport.

Studies have shown that cryogenic refrigeration using carbon dioxide can be cost effective for road transport, especially in delivery trucks. One of the major problems with cryogenic systems is that the infrastructure to replenish carbon dioxide and nitrogen tanks does not exist.

Other options for refrigeration include eutectic plates. In these systems, plates containing a low-freezing-point liquid are mounted in the roof of the trailer. Before the truck starts out, the liquid is frozen by a large refrigeration unit located in the warehouse. As the liquid melts, the load is cooled. Eutectic plates could work well for local delivery trucks where shipping distances are short.

CFC's as Blowing Agents for Insulating Foam

Today, most trailer insulation is made from polyurethane foam blown into place with CFC-11. The CFC's are lost to the atmosphere either during manufacture, during the life of the trailer, or when it is scrapped. Carbon dioxide is also used as a blowing agent, but carbon dioxide blown foam may lose its insulating value more quickly than CFC blown foam and is somewhat less efficient.

In the future, HCF-123, 141b, and 134a may be used as blowing agents, but toxicity tests will not be complete for 1 or 2 years. Also, 141b is somewhat flammable and all three compounds produce foam that has about 10 percent less insulation value than CFC blown foam.

Lower insulation value poses a serious problem for the refrigerated trucking industry because it means trailer walls will have to be thicker to maintain the same cargo temperature. Thicker walls mean more weight and less space for payload. Increased weight and reduced payload will increase the amount of fuel required per ton per mile and will result in the generation of more carbon dioxide that could exacerbate the greenhouse effect.

Other Insulation Technology

Researchers in Colorado and Germany have developed panels less than a quarter-inch thick that have the insulating value of 2 inches of foam. These panels are composed of two sheets of metal with a vacuum in between. One group of researchers is using glass beads to hold the walls apart, and the other uses a powder of diatomaceous earth. This technology shows promise. However, the technology to effectively mass produce the panels has not been developed and the insulation value drops to near zero at the wall joints and if the panels are punctured.

The Challenges Ahead

The industry must find viable substitutes for CFC's and make them available in sufficient quantity well before the end of the decade. HCFC's will be useful as "bridge" compounds, but they may also be phased out in the foreseeable future. Any solutions to the CFC problem cannot greatly reduce thermal efficiency because this would lead to increased costs and carbon dioxide emissions.

The countries that signed the Montreal Protocol (mostly developed nations) must convince the rest of the world to phase

out CFC use and not bring new CFC plants on line. This will be difficult since refrigeration brings important advances in standards of living, and most lesser developed nations are adopting CFC technology and do not have the resources to produce alternatives.

Consumers will end up paying more for refrigerated products since the costs for research, development, new equipment, and lower efficiency will be passed on. ■

Environmental Concerns Increase Intermodal Container Costs

The *Journal of Commerce* reports that stricter environmental regulations in Germany are adding \$600 to the cost of a 40-foot intermodal container, according to a German container manufacturer.

Government agencies and environmental groups are increasingly scrutinizing intermodal container construction. Container factories are often located in less developed countries in tropical regions. To construct the wooden floors, local lumber from rain forests is used. With 700,000 20-foot equivalent containers manufactured each year, the container industry is a contributor to rain forest depletion. Other types of flooring are available, but are more expensive. Also, refrigerated containers use CFC's as refrigerants. Environmentally safe refrigerants will cost about \$10 per pound while CFC's cost about \$3 per pound.

Food Packaging

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All segments of the packaging industry, including food packaging, face environmental issues. For example, fast-food chains are under pressure to reduce the amount of solid waste they generate and Maine has banned fruit drinks in aseptic packages (juice boxes).

Yet, packaging is integral to today's life style (see box, "A Country Without Food Packaging"). Nowhere would the loss of modern packaging be more quickly felt than in the food processing and distribution system. In underdeveloped countries where packaging is minimal or nonexistent, food losses of 30-50 percent are not uncommon. In the United States, packaged food losses are less than 3 percent, while fresh food losses are 10 to 15 percent. Reduced food losses lower food costs. Food packaging allows consumers to enjoy a variety of foods year-around, not just during local harvest seasons. Also, food packaging can decrease rather than increase solid waste generation.

These benefits of packaging come from a \$70-billion-a-year industry, of which approximately 70 percent is used for food and beverages. On average, food packaging costs about 9 percent of the retail price of food products.

What Does Packaging Do?

Aside from the obvious, providing a container for the product, the package affords protection against the harmful effects of bacteria, oxygen, light, and disease agents such as rodents and insects. Items are also now packaged to give consumers clues if tampering occurs.

With self-service supermarkets, packaging has taken on the role of providing information. The package is the manufacturers' link with the customer at the all important point of purchase. The package must attract the customer to make a purchase. It also, provides information on how to use and store the product and lists ingredient and nutrition facts.

Finally, utility-of-use has become a key element in many food packages. Microwaveable packages, single serving sizes, recloseable and resealable packages, squeezeable packages, and shelf-stable packages are all examples of pack-

aging that make products easier to use or provide more convenience for the consumer.

The Role of Food Packaging in Waste Reduction

Food packaging can reduce waste. For example, a pod of fresh peas is 62 percent inedible. In order to get a pound of fresh peas, about 2.6 pounds of peas and pods would have to be purchased, resulting in 1.6 pounds of discarded pods. However, buying 1 pound of frozen peas

A Country Without Food Packaging

What would the United States be like without food packaging? To envision this, one need only go back 200 years (20 years before the invention of canning, the first modern food preservation/packaging development). The shipping distances from production to cities and towns were often only a few miles. Chicken, pigs, and cattle were kept by homeowners in most cities and towns and many homeowners had their own gardens, root cellars, and smoke houses.

The system worked, up to a point. What made it work? Most people lived on farms and in small towns, and continued to do so up to the beginning of the 20th century. The population was smaller—only 4 million in 1790. Despite being located close to food production and availability, quality and safety remained a problem. Salted and dried meats, and wilted vegetables from the fruit cellar were the order of the day. Even the best inns served

meat that was tainted or "high" due to a lack of both adequate packaging and refrigeration.

Any attempt to go back to the days without food packaging would cause major problems. Today, the population demographics are reversed—about three-quarters of Americans now live in urban areas. There are more of us—250 million according to the latest census. Our food distribution lines are 3,000 miles long—California to New York or even longer—e.g., Chile to the United States.

Without food packaging most of us would have to revert back to growing most of our own food on small plots of land. Spoilage would reduce much of what is produced, forcing people to spend even more time in food production. With most people engaged in food production there would be little time to provide many of the goods and services we enjoy today. Thus, food packaging is an integral part of our modern society.



Aluminum cans are about 25 percent lighter today than when they were first introduced, saving natural resources and packaging costs.

leaves the customer with only a 1-ounce plastic pouch to dispose of. The pods of the frozen peas remain at the food processor where they are turned into recyclable by-products such as animal feed. (See *"Managing Solid By-products of Industrial Food Processing,"* elsewhere in this issue.) In New York City alone, consuming packaged vegetables annually eliminates the need to dispose of over 100,000 tons of fresh produce waste.

In a chicken processing plant, virtually all the waste—feathers, viscera, heads, and feet—is converted into by-products, often chicken feed. This is a true form of recycling. Processing 1,000 chickens produces about 1,650 pounds of recyclable waste products and requires the use of only 15 pounds of packaging. Compared to dressing chickens at home, this reduces the solid waste load from 1,000 chickens by a net of 1,635 pounds.

The U.S. Chamber of Commerce has developed estimates of waste reduction for some common food packaging materials. On average, every pound of paper packaging eliminates 1.4 pounds of food waste. Plastic is even more efficient. One pound of plastic packaging reduces food wastes by 1.7 pounds.

Environmental Concerns

Food packaging is not without its critics. With landfills filling up and citizens not wanting new ones in their community, municipal solid waste (MSW) has become a major environmental concern. Government agencies, elected officials, and national firms are under

pressure to greatly reduce or eliminate packaging. McDonald's decision to eliminate foam packaging was influenced greatly by pressure from environmental groups. Yet, packaging makes up less than one-third of the MSW being landfilled (figure 1).

Recycling

Traditional packaging materials, paper, metals and glass have been recycled in varying degrees for many years. In the

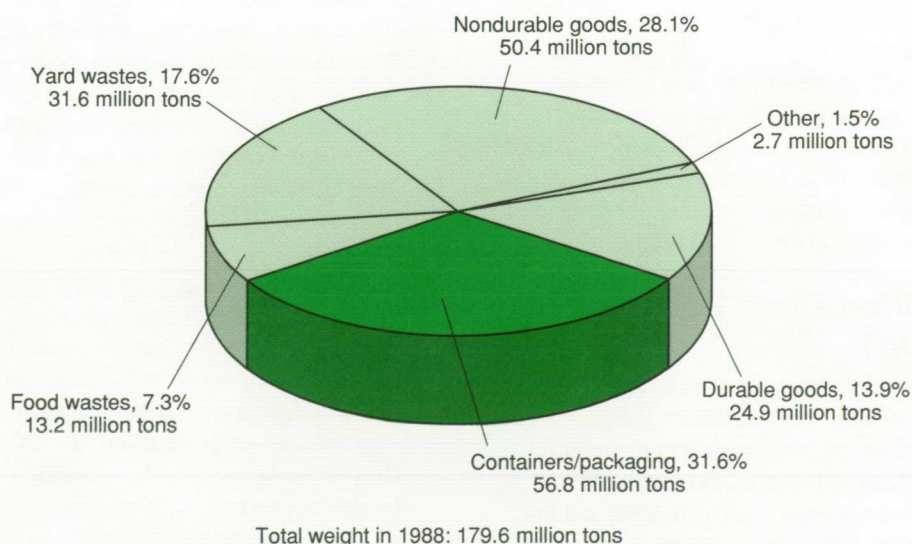
past, recycling has been emphasized during times of material shortages, such as the war years of 1918-19 and 1941-45.

Paper has had an established system of reuse for many years. A great many packages are made from recycled paper. About 30 percent of all paper and over 50 percent of corrugated boxes are recycled. Each time paper is recycled the fibers get shorter and eventually wash out of the system.

Another success story in packaging recycling is the aluminum beverage container. Unlike paper, aluminum can be recycled an unlimited number of times without degrading its physical properties. Today, more than 60 percent of aluminum beverage cans are recycled. (See *"Less Packaging and More Recycling Reduces Waste,"* elsewhere in this issue.)

A major roadblock to recycling is not technical ability, but financial feasibility. For example, technology has been developed that can process used aseptic juice boxes into plastic lumber. However, plastic lumber is more expensive than regular lumber, which limits its sales. The less expensive inputs from recycled sources relative to virgin sources or the greater the demand for final products

Figure 1. Less Than One-Third of Municipal Solid Waste Comes From Packaging



Source: U.S. Environmental Protection Agency. *Characterization of Municipal Solid Waste in the United States*, 1990 update, EPA 1530-SW-90-042, June 1990.



Fresh corn is often packaged to allow consumers to see the product and to protect kernels from bruising and dryness after the husks have been removed.

made from recycled materials, the more successful recycling will be in reducing packaging wastes. Thus, consumer willingness to bring discarded packages to central collection centers and their purchasing of final products made from recycled materials is a key to successful recycling.

Biodegradability

About 75 percent of MSW in the United States goes to sanitary landfills, the rest is either recycled or incinerated.

The modern sanitary landfill is designed to prevent degradation since it is a source of methane gas generation and potential groundwater pollution. William Rathje of the University of Arizona has shown that even a highly degradable item such as a newspaper is still readable after several decades in a modern landfill.

Even with today's technology, degradability does not alleviate the litter problem because degradation occurs too slowly. Only in remote areas where pickup is not possible or likely—e.g., wilderness areas or the oceans—can degradability be of some assistance.

Biodegradability in packaging materials could become more important as more solid wastes are composted. Today, however, composting accounts for only about 0.2 percent of the waste disposal in the United States. Highly compostable food and yard wastes are not being composted and end up as 25 percent of

the MSW supply. Thus, using biodegradable food packages would not reduce MSW unless the demand for compost greatly increased.

Overpackaging

Another criticism of packaging is that firms use more of it than necessary which raises the product price and contributes to solid waste disposal problems. Often what seems like overpackaging is actually part the package function.

A blister pack of small items may well be cost effective in terms of reducing pilferage or minimizing clerical help in handling and counting. Individually wrapped cheese slices prevent the cheese from drying out in the refrigerator once the package is opened. The empty space at the top of the box of many processed dry foods such as cereals is the natural settling that occurs during shipment from factory to consumer.

Once new packages are introduced, competition quickly forces continued reductions in the amount of materials used. For example, the aluminum can and plastic beverage containers are both about 25 percent lighter today than when they were first introduced, and the weight of the 16-ounce glass soft drink bottle has been reduced over 30 percent in the past 10 years. (See "Less Packaging and More Recycling Reduces Wastes," elsewhere in this issue.)

Designing Packages for Disposal and/or Recycling

From an environmental perspective, the ideal package would either weigh nothing or be reused or recycled an infinite number of times. Most packages can only approach these ideals. In the past, most packages were not designed with environmental acceptability in mind. This is changing. Packaging users and producers alike are beginning to look at design and purchasing decisions from an environmental perspective. These efforts may lead to redesign of not only packages, but product/package combinations pointed toward minimizing the package's environmental impact. Have you noticed how many packages now say "Made from Recycled Materials"? ■

Design Guidelines

To help manufacturers design packages with minimal environmental impacts, the Institute of Packaging Professionals has recently published package design guidelines. For more information, contact Institute of Packaging Professionals, 11800 Sunrise Valley Dr., Reston, VA 22091, (703) 620-9380.

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U.S. Flour Milling on the Rise

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American millers are grinding increasing amounts of wheat into flour to meet consumer demand. Flour consumption in the United States has grown almost steadily since 1970, with per capita intake rising by 24 pounds, or an average of over 1 pound each year. And American consumer spending on bakery products topped \$50 billion in 1990.

Growing interest in healthy eating and convenience has set the pace for this growth. Consumers have been boosting their consumption of fiber, bran, and whole grains. At the same time, they are buying more highly processed convenience foods—like sandwiches, pizzas,

and tortillas—which often contain large amounts of flour.

This situation reflects a turnaround in flour's fortunes. Per capita consumption of flour is estimated at 135 pounds in 1990—the highest level since the early 1950's and 10 pounds over 1985's mark (*figure 1*). This trend is in sharp contrast to the declining flour consumption levels recorded in the 1960's and early 1970's. It is also one of the first reversals in flour consumption in the developed world.

Types of Flour

Wheat flour is the primary grain product consumed in the United States. That's apparent in the wide variety of

food products prepared from flour: packaged flour for home baking, bakery mixes, breads, cakes, cookies, crackers, and pastas. Flour is also used in breakfast cereals, gravies, and soups. Overall, products classified in the bread and cake industry account for about 72 percent of total primary U.S. flour consumption (*figure 2*).

The flours used in the production of different food items are milled from various wheat classes. Hard wheats are used mainly in breads and rolls, and to a lesser extent, in sweet goods and all-purpose family flour. Soft wheats are used in sweet goods, cakes, cookies, crackers, and prepared mixes. Durum wheat is used almost solely in pastas.

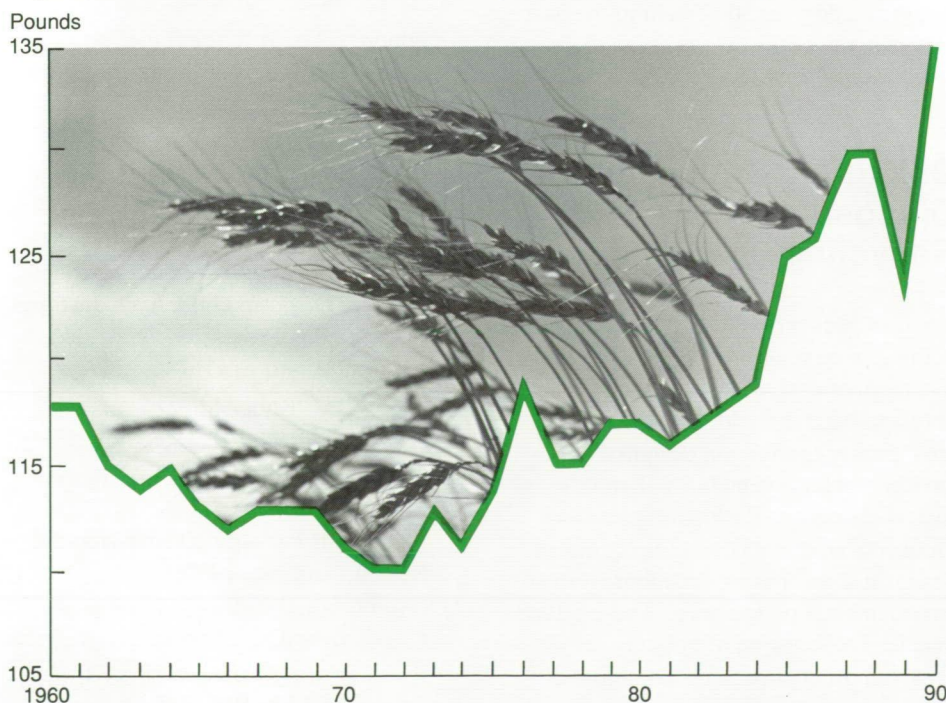
Small amounts of flour are also used for nonfood purposes. The main industrial uses include plywood adhesives, industrial starch (for laundries, textiles, pastes, and paper additives), and industrial alcohol. Minor uses include whiskey, beer, cosmetics, fertilizers, paving mixes, and polishes. Hard and durum wheats account for about 85 percent of the flour used for industrial purposes.

When milled, wheat also produces millfeeds. Millfeeds, pieces of bran and the wheat kernel, generally are used as livestock feeds. Millers exercise a great deal of discretion in determining the mix of flour and millfeeds produced by controlling the speed, pressure, and corrugation of the rollers used in the milling process.

New Mills Locate Near Population Centers

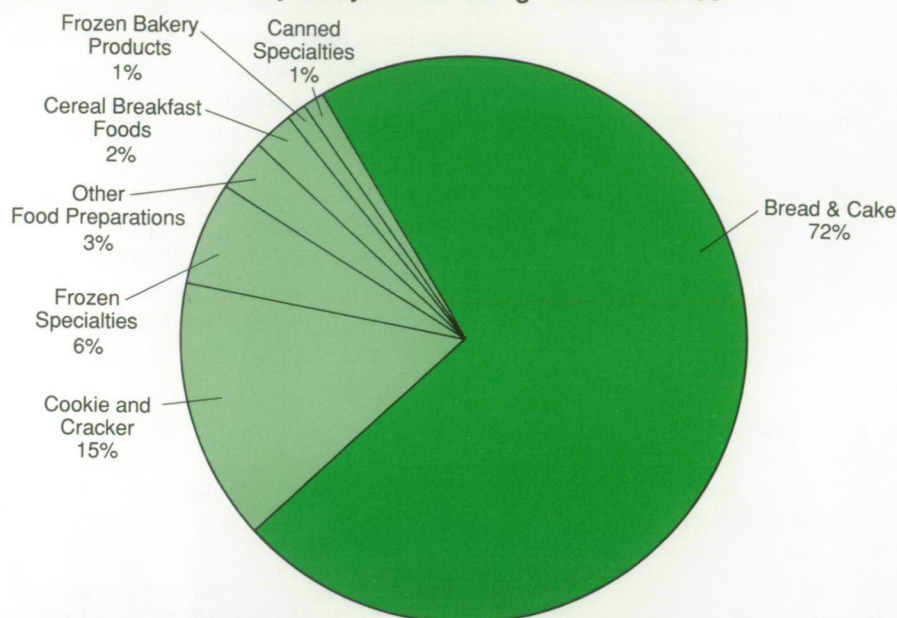
Individual flour mills often grind only one wheat class. Hard wheat mills are the most numerous and accounted for about 70 percent of total U.S. milling capacity in the late 1980's. Soft wheat mills accounted for 20 percent of the

Figure 1. Per Capita Wheat Flour Consumption Increased During the 1980's



Source: USDA, Economic Research Service. *Wheat Situation and Outlook*, WS-291, February 1991, p. 59.

The author is an agricultural economist in the Crops Branch, Commodity Economics Division.

Figure 2. Use of Flour By 7 Major Flour-Using Food Industries¹

¹Other industries that use flour include: prepared flour mix and dough, flour and other grain mill products, dog and cat food, and other prepared feeds. The pasta industry consumes large quantities of semolina and durum flour. The *Census* does not disclose flour consumption data for certain industries.
Source: *Census of Manufactures*, 1987, various industry series.

total. Durum accounted for 8 percent, and whole wheat mills, 2 percent.

These flour mills were scattered over nearly all States in 1990. States with the largest number of active mills include Pennsylvania, Kansas, New York, Minnesota, Ohio, and California. Milling activity is particularly large in the areas surrounding Lancaster, PA; Minneapolis, MN; Kansas City, MO; and Buffalo, NY.

Mill locations depend largely on the expected costs of shipping flour relative to wheat at the time the mills are built. Because major flour-consuming areas are often far from wheat-growing areas, rail rates are particularly important in determining mill location.

Until the 1950's, mills were often built near wheat-growing areas because rail rates for shipping wheat and flour were about equal. Rates for flour began to rise relative to wheat rates in the early 1960's. Since then, companies have been more likely to build their mills near population centers.

The introduction of covered hopper cars has likely been an important factor causing the change in rates. Hopper cars, developed in the early 1960's, reduced the costs of bulk wheat shipment. While flour can move in special hopper cars, bakers frequently appear to prefer smaller

shipments. Many small baking companies continue to receive flour in bags, and larger firms often do not want to incur the high inventory costs associated with storing large quantities of flour.

Other factors are also important. Box-cars that are used to deliver flour in bags

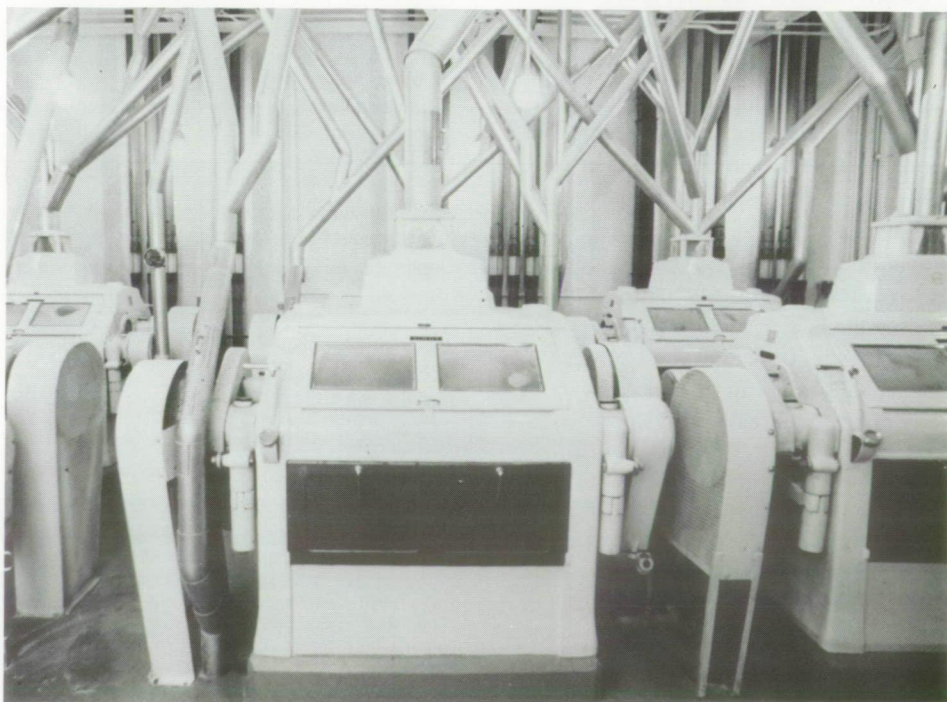
often have higher loss and damage claims and loading costs than covered hopper cars. In addition, sanitation requirements are higher for flour than for wheat.

Fewer Mills, Greater Capacity

Strong flour demand has meant growth for many firms in the milling industry. But even though new plants have been built, most of this industry growth is in plant sizes, not in mill numbers. Scale economies in processing and transportation are largely responsible for the drop in mill numbers and the large increase in capacity per plant.

The decline in mill numbers reflects a long-term trend toward consolidated production. Total wheat flour and durum mill numbers fell from 292 in 1973 to 219 in 1990. The closing of small mills has offset the escalating number of large-capacity mills (*table 1*). Small mills often either close or carve out niches in specialty markets.

As the number of mills has dropped, the average capacity per mill, as well as total industry capacity, has increased. Total industry capacity increased by 28 percent between 1973 and 1990, and average mill size rose by 70 percent. Mills in the largest size category (those



Rollers break wheat into coarse particles in the conversion of wheat to flour.

Photo credit: Millers' National Federation

Table 1. Wheat Flour Mills Were Fewer In Number in 1990 than in 1973

Daily capacity ¹	1973	1978	1983	1987	1990
<i>Number of mills</i>					
Under 200 cwt	54	46	34	21	18
200-399 cwt	35	34	30	22	17
400-999 cwt	36	26	20	18	14
1,000-4,999 cwt	82	71	67	65	66
5,000-9,999 cwt	60	64	58	59	58
10,000 cwt and over	25	33	42	44	46
Total	292	274	251	229	219

¹Includes hard, soft, whole wheat, and durum mills.

Source: Calculated from *Milling Directory/Buyers' Guide*. Various issues.

with over 10,000 hundredweight of daily capacity) accounted for 54 percent of total capacity in 1990, up from 35 percent in 1973.

Economies of scale are a major factor explaining these overall increases. Millers indicate that, within limits, plant capacity can be enlarged at a less-than-proportionate increase in energy and equipment costs. Per unit labor costs can drop sharply with larger output because the operating crew required for a larger plant is comparable to that for a smaller one. And unit transportation costs can fall if larger mills can negotiate lower rates on the basis of volume than their smaller counterparts.

Flour Mills Change Ownership

The ownership of many flour milling companies has changed in the past 20 years. Several of the largest milling companies more than doubled their mill numbers and daily capacities between the early 1970's and 1990 (table 2).

These transactions have realigned the relative size rankings of those companies holding the largest U.S. milling capacities. Pillsbury ranked as the world's largest flour miller in the late 1970's. The purchase of Peavey led ConAgra to first place in 1983. With the acquisition of International Multifoods in 1988, ConAgra reinforced its rank, and held 276,500 hundredweight of productive capacity in 1990.

Many of these acquisitions have been made by firms that have sizable agribusiness interests. Besides flour

milling, ConAgra, in 1990, was involved in oat and dry corn milling; barley processing; feed ingredient merchandising; commodity trading and brokerage; agricultural chemicals and fertilizer distribution; poultry, processed meat, and deli product marketing; financing and owning livestock on feed; producing and marketing prepared foods (Armour, Healthy Choice, Banquet, Patio, Morton, Taste O'Sea, and Chun King); and food processing and distribution in Australia, Europe, the Far East, and Latin America. Archer Daniels

Table 2. Large Flour Milling Firms Are Buying Out Small Firms¹

Company	1973	1978	1983	1987	1990
1,000 cwt					
ConAgra, Inc.	88.3	93.0	216.5	191.5	276.5
ADM Milling Co.	79.5	96.0	123.0 ²	167.7	193.7 ³
Cargill, Inc.	9.0	46.0	134.0	141.1	149.2
Pillsbury, Inc.	94.7	111.6	121.4	131.7 ²	119.7 ⁴
Seaboard Allied Milling Corp.	62.25	91.0	(-----Cargill-----)		
International Multifoods Corp.	71.7	71.9	78.1	80.3	(ConAgra)
Dixie-Portland Flour Mills	33.0	47.0	51.0	55.0	⁵
Peavey Co.	59.1	98.5	(-----ConAgra-----)		
General Mills, Inc.	55.1	55.1	55.1	62.25	66.7
Nabisco Brands, Inc.	40.0	44.5	43.0	28.0 ⁶	28.0
Ross Industries	33.0	(-----Cargill-----)			
Cereal Food Proc.,Inc.	17.0	21.9	31.3	68.3	68.3
Bay State Milling Co.	29.65	34.9	34.0	55.75	50.65
Colorado Milling and Elevator Co.	29.2	(Peavey)	(-----ConAgra-----)		
Mennel Milling Co.	15.0	17.0	21.0	21.0	22.7
Fisher Mills, Inc.	15.0	15.0	15.0	15.0	15.0
Bartlett Milling Co.	--	14.0	15.0	13.0	13.0
Tennant and Hoyt Co.	⁷	10.0	11.0	(----Pillsbury-----)	
Centennial Mills	19.0	24.0 ²	(-----ADM Milling Co.-----)		
Standard Milling	14.5	16.3	(Uhlmann)	(----ConAgra-----)	
Sunshine Biscuits	12.15	⁷	⁷	(----ConAgra-----)	
North Dakota Mill	10.0	10.0	18.0	18.0	18.0
Acme-Evans	⁷	⁷	10.0	12.0	(ADM)
Italgrani USA, Inc.	--	--	--	15.64	15.64
Amber Milling Co.	⁷	⁷	⁷	⁷	15.0
Midwest Grain Products	--	--	--	--	14.0

-- = Not listed in the *Milling Directory/Buyers' Guide*.

¹Acquiring milling companies are in parentheses. ²Includes alternating durum capacities. ³Does not include 31,000 cwt daily capacity held by ADM Holding Co. (formerly Dixie-Portland). ⁴Pillsbury announced on Jan. 28, 1991, that it had reached an agreement to sell 4 of its 8 flour mills to Cargill. This action would increase Cargill's total milling capacity by 51,700 cwt. ⁵Held by ADM Holding Co. ⁶All but 1 mill acquired by ADM. ⁷Less than 10,000 cwt daily capacity.

Source: *Milling Directory/Buyers' Guide*. Various issues.

Midland (ADM), Cargill, and Pillsbury also have substantial holdings.

The rationale behind these milling acquisitions is not always clear. By expanding their plant holdings and, in certain cases, integrating vertically, some companies may be able to improve their profitability over the long run through cost reduction. They may be able to negotiate lower transport rates; improve scheduling; and spread production, marketing, and financial risks over a larger volume of activity.

A greater number of plants held by a company, however, does not necessarily ensure lower costs and higher profits. Discussions with the trade suggest that less use of procurement economies occurs than might be expected. Different operations are commonly treated as competing profit centers, with profit maximization goals that may be incompatible. The operations of several agribusiness firms were sold off in the late 1980's, including all of the flour mills owned by International Multifoods Corp.

Fewer Firms Own Flour Mills

As the largest milling firms have expanded their holdings, concentration in the industry has increased substantially (table 3). In 1990, the top 12 companies owned about 80 percent of all milling capacity, up from 68 percent in 1973. They owned 108 wheat flour and durum mills. This total accounted for about 50

percent of all mills in the industry and all but 1 of the U.S. flour mills with 10,000 hundredweight or more of daily capacity.

The top four firms (ConAgra, ADM, Cargill, and Pillsbury) collectively increased their market share at a fast pace in the 1980's. As a group, they owned about 58 percent of all industry capacity in 1990, up from the 34 percent of capacity held by the top four firms in 1973 (table 3).

The economic downturn, if prolonged, will have an uncertain effect on acquisitions. The pace of acquisitions could slow from that of the mid-1980's if companies find themselves strapped for cash. However, some companies with large financial resources might eagerly purchase mills being offered for sale at recession-level prices.

Competition Appears To Remain Strong

Although concentration has increased rapidly, many in the milling industry agree that flour milling remains highly competitive. Millers often appear to treat flour as a very price-sensitive product, believing that the lowest-price, highest-volume operation gets the business. An example helps provide evidence:

- The milling margin, at \$2.05 in January 1991, was lower than most of the margins calculated in the 1980's, and more than 25 cents less than the margin in mid-1986. (The milling margin is the sum of bakery flour and millfeed prices per hundredweight of flour produced, less

the cost of the wheat needed to produce a hundredweight of flour.)

- At the same time, the cost of the wheat needed to produce a hundredweight of bakery flour (Kansas City standard patent) averaged \$6.45 for January 1991, about the same as the cost in mid-1986.
- The mid-month price of bakery flour in January 1991, at \$7.05 per hundredweight, was the lowest since the 1970's and about a third below prices in the early 1980's.

The milling industry historically has been quite competitive. For instance, one industry study stated that net income (after taxes) as a percent of sales ranged from -0.11 to 3.28 percent for major milling firms between 1977 and 1982. For diversified firms, the study found that the earnings of flour milling divisions were lower than the total companies' average earnings.

Millers in the late 1980's have often mentioned the importance of focusing on quick and accurate responses to bakers' needs, consistent product quality, and the development of market niches. Some observers have noted the importance of a heightened focus on innovation, segmentation of markets, and greater cost-effectiveness.

Performance Consistency a Pressing Concern

The 1990's will likely bring an increased focus on the performance consistency of flour. Some baking analysts contend that the baking performance of flour has dropped substantially in the past 25 years. This is one of the most pressing current issues in both the milling and baking industries.

Several factors substantiate the fact that flour performance has declined. For instance, one baking company executive reported that in 1975, more than 96 percent of the company's bake tests (which summarize grain, texture, feel, and color) yielded an acceptable bake score. By 1987, less than 50 percent of all flour met their requirements, and in 1989, the number was below 15 percent. Over this period, the company had used the same

Table 3. Concentration of Mills Increased at a Fast Pace in the 1980's

Size grouping	1973	1978	1983	1987	1990
<i>Cwt of capacity</i>					
4 largest	334,200	399,100	594,900	632,000	739,100
8 largest	550,650	664,100	822,100	898,600	952,750
12 largest	675,500	813,500	926,400	1,020,600	1,024,090
All firms	997,107	1,099,610	1,174,206	1,217,276	1,271,923
<i>Percent share of market</i>					
4 largest	33.5	36.3	50.7	51.9	58.1
8 largest	55.2	60.4	70.0	73.8	74.9
12 largest	67.7	74.0	78.9	83.8	80.5
All firms	100.0	100.0	100.0	100.0	100.0

Source: Calculated from *Milling Directory/Buyers' Guide*. Various issues.

equipment, the same method and formula, and the same individuals had performed the bake tests since 1973. (See box "Factors Affecting Flour Performance.")

However, the relationship between laboratory tests and flour performance is a complex issue. First, lab tests differ in importance to different types of bakers. Lab tests appear to be a special issue for soft wheat bakers who produce a wide variety of cookies, crackers, cakes, and pastries. Second, lab tests do not necessarily reflect conditions in the production plant. Two lots of flour with the same lab analysis rating can bake quite differently. At times, tests show virtually no correlation between lab analysis and baking performance.

Bakers have increasingly used additives to produce a commercially acceptable product. These additives include

Factors Affecting Flour Performance

Industry analysts suggest that several factors have likely contributed to the change in flour performance:

- Genetics—Producers encouraged breeders to produce higher yielding varieties that resisted disease. Breeders focused on higher yields, with less emphasis given to the end product performance of flour.
- Proliferation of wheat varieties—Wheat varieties that represented 85 percent of the acreage planted in Kansas in 1986 did not exist in 1977. The varieties planted in 1977 likely contained better baking characteristics.
- Agronomics—Increased irrigation and fertilization may have reduced flour performance.
- Milling efficiencies—Changes in milling practices may be a factor.
- Drop in protein content—The decline in flour performance in the 1980's has occurred in conjunction with a decline in the average protein content in the wheat crop. However, protein quality is as important as protein quantity.



After wheat is broken into coarse particles at the roller stage, it is run through box-like sifters where it is shaken through a series of screens to separate the larger from the smaller particles.
Photo Credit: Millers' National Federation

oxidants and vital wheat gluten that strengthen the protein and assist with gas retention. They were once used sparingly or not at all and today are often used at their legal limits.

Note: Most of the data reported in this article were obtained from the *Milling Directory/Buyers' Guide*, published annually by Sosland Publishing Company. This publication represents the most comprehensive source of information on mill locations and plant capacities. The milling industry regards these numbers as a benchmark. The tables presented here differ slightly from those presented in the *Milling Directory/Buyers' Guide*. Data reported in the Census of Manufactures are used sparingly in this article. Census data for SIC Code 2041 include not only flour mills, but also other establishments "primarily engaged in milling flour or meal from grain, except rice," including dry corn, buckwheat, and rye mills. ■

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U.S. Baking Industry Responds to Consumers

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Consumers' desire for convenience, service, and variety are helping to boost the demand for bakery products. Many consumers purchase freshly baked goods from in-store bakeries and retail outlets rather than use their scarce leisure time to prepare items from scratch. And the choice consumers have among bakery products is extremely large.

To meet the demand for greater food variety in the late 1970's and 1980's, manufacturers introduced many new bakery products, launching 1,155 new items in 1989 alone. Partly because of these efforts, items once considered strictly specialties—such as bagels and pita bread—have gained in popularity. Meanwhile, supermarkets accentuate sales from in-store bakeries, while retail bakers emphasize specialty goods and cookies. Restaurants cater to consumer demand for quick, inexpensive sandwiches. All industry segments have tapped into the trend of healthful eating, such as consumers' interest in whole wheat breads and oat bran muffins.

However, the increase in demand for bakery products differs among various segments of the industry and among product types. Per capita consumption of certain wholesale baked goods (such as prepackaged white breads and pies) on average, remained fairly level during the 1980's.

To broaden their markets, wholesalers have often aggressively developed new products and expanded their promotional base. Many industry analysts contend that fresh products from in-store bakeries (mainly located in supermarkets, department stores, and convenience stores) and

retail outlets (like Mrs. Fields and T.J. Cinnamons) pose a serious threat to prepackaged products. However, consumers often purchase goods on impulse at in-store and retail outlets. Impulse purchases may not, over time, erode the market share of wholesalers as some observers at one time thought.

Perishability Affects Structure

Wholesale bakers, who sell primarily to food retailers and food service companies, form the backbone of the baking industry. They generated about 56 percent of all bakery sales in 1990 (*figure 1*).

Wholesale baking plants typically are rather specialized. Most factories produce mainly bread and cake items (2,357

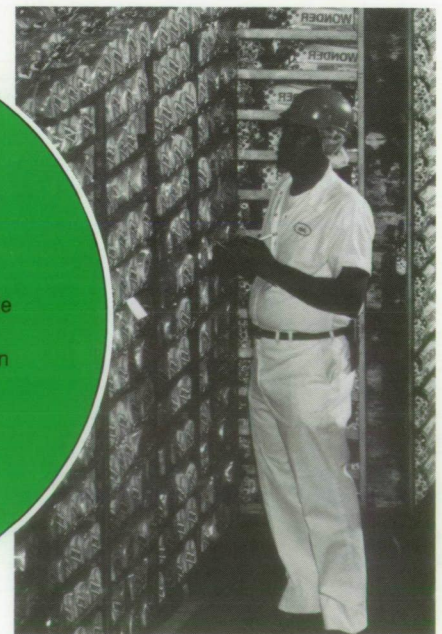
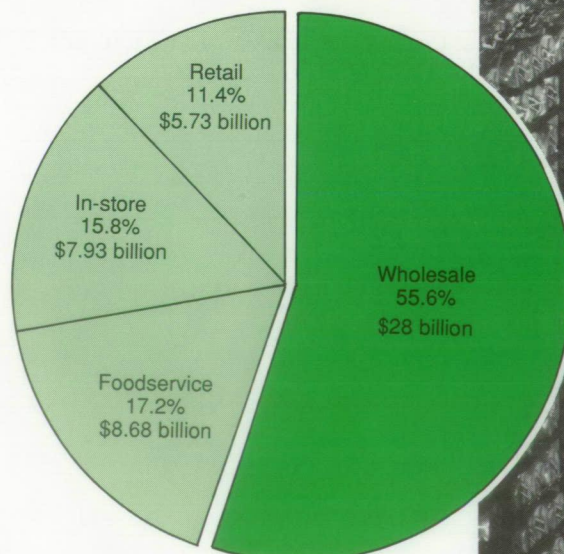
plants operating nationally in 1987) or cookie and cracker products (380 plants). Bread-type products have a shorter shelf life than cookies and crackers. Therefore, the bread and cake industry has more local plants close to population centers.

Within each industry segment, there are variations in the items produced. For instance, many plants in the bread and cake industry manufacture only a few distinct items, such as breads and rolls. A few plants make a wider variety of items. For example, one New York plant produces over 19 different items, ranging from bagels to pies and ice cream cones.

Many bread and cake bakeries remain single-plant, family-owned enterprises with fewer than 20 employees. Plants in

Figure 1. Wholesalers Dominate Estimated Baking Industry Sales

Total sales \$50.34 billion



The author is an agricultural economist in the Crops Branch, Commodity Economics Division.

Source: "Trends '91". *Bakery Production and Marketing*, June 24, 1990, pp. 44-78.

this size category accounted for 56.3 percent of all plants in the wholesale bread and cake industry in 1987, but only 2.3 percent of sales. With limited access to capital, many single-plant bakeries find that the costs of refrigerated shipments and the potential for spoilage outweigh the gains of geographic expansion.

This situation means that large, multi-plant wholesalers are important in the industry. Some of these operations, better able to bear the costs and risks of

large-scale enterprises, have developed into major businesses. For instance, Continental Baking, the largest bread and cake wholesaler in 1990, operates nationally. Several of the largest bread and cake wholesalers sell their products only in certain regions (*table 1*).

For cookie and cracker manufacturers, less constrained by product perishability, the economies of scale associated with long production runs surpass any advantages of plant dispersion. Plants with

fewer than 20 workers represented 49.7 percent of all plants in 1987, but barely 1.5 percent of total sales. As a result, the large cookie and cracker companies have fewer plants and a more national focus than the large bread and cake firms. For example, Nabisco, the largest cookie and cracker manufacturer in the United States, receives at least 15 percent of its annual sales from each geographic region (*table 2*).

Table 1. Continental Baking Is the Nation's Largest Bread and Cake Baker ¹

Company	1989 Sales	Area of operation					Share of business		
		North east	South east	Mid west	South west	West	Breads and cakes ²	Cookies and crackers	Others ³
	Million dollars	Percent							
Continental Baking Co.	1,836	13	12	45	5	25	100	0	0
Campbell Taggart, Inc.	1,400	0	45	15	25	15	90	0	10
Interstate Bakeries, Corp.	1,079	0	36	29	10	25	98	0	2
Flowers Industries, Inc.	782	0	100	0	0	0	100	0	0
Pepperidge Farm, Inc.	548	52	18	18	7	5	71	20	9
Best Foods Baking Group	530	60	20	20	0	0	100	0	0
Entenmann's, Inc.	502	40	8	14	4	34	90	10	0
Sara Lee Bakery	502	20	20	30	10	20	100	0	0

¹Sales of frozen items are included in the determination of the largest bread and cake companies. ²Includes pan breads, hearth breads/rolls, soft rolls/buns, sweet goods, cakes, donuts, pies, and English muffins. ³Includes frozen doughs.

Source: *Bakery Production and Marketing: Red Book 1990*, pp. 24-25. Gorman Publishing Co.

Table 2. Nabisco Is the Nation's Largest Cookie and Cracker Manufacturer ¹

Company	1989 Sales	Area of operation					Share of business		
		North east	South east	Mid west	South west	West	Breads and cakes ²	Cookies and crackers	Others ³
	Million dollars	Percent							
Nabisco Biscuit Co.	2,163	20	15	30	15	20	0	100	0
Keebler Co.	1,379	18	19	50	6	7	6	84	10
Sunshine Biscuits, Inc.	540	NA	NA	NA	NA	NA	0	100	0
Lance, Inc.	432	20	59	8	13	0	3	56	41
McKee Baking Co.	395	12	42	26	16	4	48	52	0

¹Sales of certain snack foods are included in the determination of the largest cookie and cracker companies. ²Includes pan breads, hearth breads/rolls, soft rolls/buns, sweet goods, cakes, donuts, pies, and English muffins. ³Includes frozen doughs.

Source: *Bakery Production and Marketing: Red Book 1990*, pp 24-25. Gorman Publishing Co.

Bakeries Have Changed Owners

Ownership of wholesale bakeries, whether the companies bake breads, cakes, cookies, or crackers, has evolved in the past 30 years as food processors have acquired baking companies. Within this period, control of every major wholesaler, except Flowers Industries, has changed.

As elsewhere in food manufacturing, many of the changes that occurred in the 1980's involved purchases by large, diversified companies. For instance, Kohlberg, Kravis, Roberts acquired RJR Nabisco Inc., parent of Nabisco Biscuit Company. During this period, Pepperidge Farm, Inc., became a division of Campbell Soup, Inc.; Entenmann's, Inc., a part of Kraft-General Foods; and Sunshine Biscuits, Inc., an operation of G.F. Industries, Inc., a California-based baking company. (Also see box "Single Transactions Affect Investment Flows.")

Large companies, already in the baking industry, often purchase other bakeries. An examination of these transactions suggests that the acquisition route has been the best way for many large baking firms to expand geographically. Baking firms have often found that buying distressed plants is cheaper than building new facilities.

At least two factors explain the preference for expansion by acquisition. First, the cost of building a new plant may be as much as twice the cost of buying and renovating an existing plant. Second, the buy-rather-than-build approach avoids adding capacity to a sector where excess capacity is a constant danger.

Acquisitions and mergers have enhanced the financial and marketing resources of the wholesale baking industry. Because many acquiring companies have substantial resources, they can channel large amounts of capital into product development and engage in the advertising necessary to establish and maintain brand loyalty. In addition, the packaging and product technologies of newly formed companies have likely accelerated the pace of new items entering the market.

Single Transactions Affect Investment Flows

Foreign Investment in the Baking Industry Increased During the 1980's

Year	U.S. direct investment abroad	Foreign direct investment in the U.S.
Million dollars		
1982	352	452
1983	391	485
1984	384	391
1985	647	461
1986	838	796
1987	1,202	702
1988	1,347	815
1989	13	1,030

Source: *Survey of Current Business*, August issues, 1987-90. U.S. Department of Commerce, Bureau of Economic Analysis.

Between 1982 and 1988, foreign direct investment in U.S. baking, as well as U.S. investment in baking abroad, showed a clear upward trend. In the mid-1980's, U.S. outflows exceeded inflows.

But in 1989, both domestic and overseas transactions substantially changed the investment balance.

Individual transactions often have a large impact on aggregate inflows and outflows. In 1989, Kohlberg, Kravis, and Roberts (KKR) sold 23 RJR Nabisco plants in Western Europe for \$2.5 billion to BSN, a French food conglomerate. This sale, along with smaller divestitures by other companies, prompted a near-disappearance in U.S. foreign baking investment. KKR's sale of these plants eased repayment of loans incurred by the leveraged buyout of RJR Nabisco. The sale was contrary to the recent trend of U.S. companies investing in Europe in anticipation of EC 1992.

In 1990, the Invus Group, the North American arm of R.T. Holding S.A. of Belgium, purchased General Biscuit of America, Inc., the U.S. biscuit division of BSN. While Invus already has major investments in U.S. bread and roll operations, this acquisition is its first into the U.S. cookie and cracker business. BSN divested its U.S. cookie and cracker operations to concentrate on markets in Europe and Asia.



Wrapped bread is inspected and prepared for shipping.

Photo credit: Continental Baking Company

In-store Bakeries Heighten Competition

Wholesalers, armed with their advertising and product innovation strengths, confronted new competition from a variety of outlets in the 1980's. These suppliers, which typically focus on convenience in service and location, include in-store bakeries, retail bakeries, and food service retailers (which bake goods on premise).

The rapid growth of supermarket in-store bakeries has caused wholesalers to re-examine their products and marketing methods. The number of in-store bakeries increased from 18,200 in 1986 to just over 23,000 in 1990. They generated almost \$8 billion in sales in 1990, up from \$4.9 billion in 1986. The top-ranked in-store bakery company—Winn-Dixie Stores, Inc.—operated 1,117 units in 1990 (see table 3).

Though in-store bakeries continue to be a dynamic segment of the grocery business, their rate of growth appears to be slowing. This trend is evident in both sales and in-store bakery numbers. For instance, the number of in-store bakeries expanded by about 7 percent annually from 1986 to 1989, but by only 3 percent from 1989 to 1990. Sales rose by about 15 percent per year between 1986 and 1989, but by only about 7 percent between 1989 and 1990 (figure 2).

Some observers stress the competition that in-store bakeries create for wholesalers. They claim that in-store baked goods are often perceived as being fresher and of higher quality. In-store bakeries, often positioned close to store entrances, frequently offer cakes and specialty breads not available elsewhere in the store. In addition, employees at in-store bakeries may be knowledgeable about baked foods, can take special orders, and distribute samples. Unlike their shelf or freezer case purchases of packaged goods, consumers may choose the desired number of items.

Other analysts disagree. These observers contend that in-store bakeries often charge premium prices that consumers will not likely pay on a regular basis. In addition, bake-shop purchases

Table 3. Winn-Dixie Ranked Number 1 in 1990 Among Supermarkets with In-store Bakeries

Rank	Supermarket company	Number of in-store bakeries
1	Winn-Dixie Stores, Inc.	1,117
2	Kroger Food Stores	946
3	Great A&P Food Stores	716
4	Safeway Stores, Inc.	575
5	American Stores Companies	513
6	Albertson's, Inc.	447
7	Publix Supermarkets, Inc.	336
8	Food Lion, Inc.	255
9	Grand Union, Inc.	155
10	Vons Companies, Inc.	154

Source: "In-store Top 50," *Bakery Production and Marketing*, March 24, 1991, p. 103.

are often made on impulse. Consumers who write "bread" on their shopping lists and buy premium in-store loaves will not typically do so every week. Finally, these analysts point out that some supermarkets have closed unprofitable in-store bakeries.

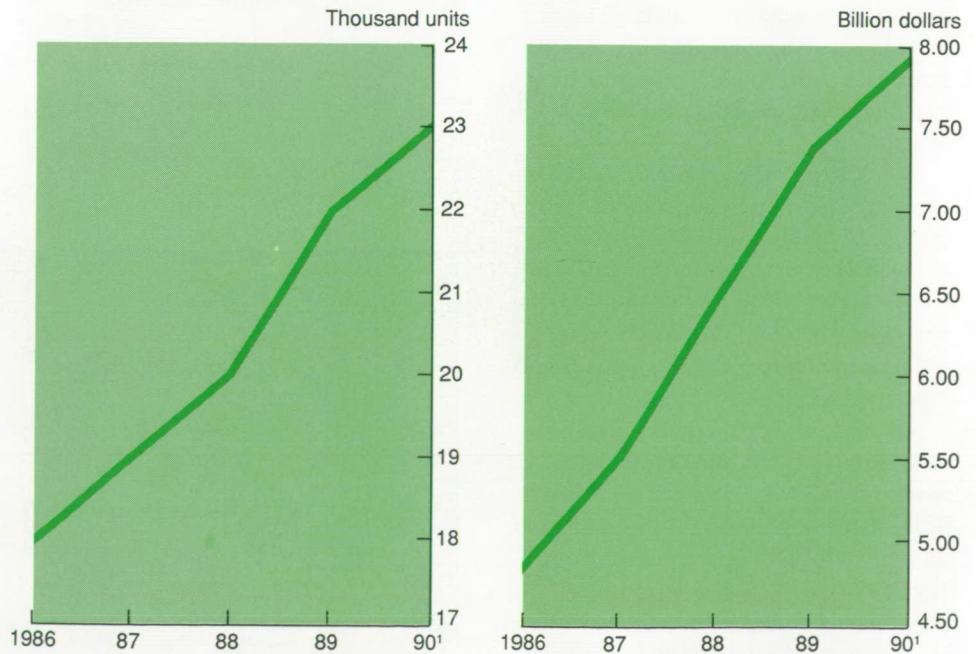
Regardless of the competition, wholesalers exploit the promotional efforts used by in-store bakeries. Items that have been successful at in-store bakeries, such as specialty items and single-serve units, are now being marketed in pre-packaged form by wholesalers.

Most importantly, wholesalers often supply in-store bakeries with frozen dough. Lacking experienced scratch bakers, many in-store bakery operators depend on the frozen dough provided by wholesalers that is later "baked off" and sold as fresh. Over three-quarters of all in-store bakeries in the late 1980's sold bake-off production, either solely or in combination with scratch-mix products.

Figure 2. In-Store Bakery Growth May Be Slowing

Total number of in-store units

... sales



¹Estimate.

Source: "Trends '90," *Bakery Production and Marketing*, June 24, 1990, p. 60.

New Product Introductions Are Costly

Intensifying competition in baking has disadvantaged many small, single-plant operations. These firms do not have the capital base to invest heavily in new product development and national advertising campaigns. Retailers often succumb to the "muscle" of major companies in introducing new products because their goods, backed by heavy advertising and name recognition, have a higher chance of selling than those of small bakers.

Growing product proliferation has heightened competition. In the late 1980's, over 12,000 new items in total were introduced each year, more than double the number of the early 1980's. The costs of new product introductions are large, and major companies are often better able to finance them.

Manufacturers and retailers have always negotiated the costs of introducing a new product. Manufacturers often use trade deals and allowances to encourage favorable treatment by supermarkets. As an example, manufacturers frequently pay supermarket chains an advertising allowance to guarantee inclusion of their product in the chain's newspaper ads.

With growing product proliferation, retailers appear to be increasing their

weight in the balance of power with manufacturers. "Slotting fees," a term defined in the late 1980's, take the notion of trade deals and allowances a step further. Some retailers have charged prices ranging from \$15,000 to \$40,000 per product per store to cover the costs of stocking selected new items. Manufacturers might pay \$2-3 million nationally in slotting fees to introduce a new product in stores across the country.

Slotting fees depend largely on the balance of power between the retailer and the manufacturer, the expected popularity of a new product, and the new product's uniqueness. In addition, slotting fees are likely higher in markets where a few retailers hold a large share of the market than in those that are less concentrated. If a retailer with a small market share tried to charge a large slotting fee for a popular new product, that retailer might find itself lacking an item that consumers are constantly requesting.

Because of the proliferation of new products and the incidence of failures, some retailers are also thinking about charging "failure fees." Failure fees insulate retailers from the costs of removing failed new products from the distribution system. With their sophisticated scanning equipment, retailers have thorough knowledge of item sales and how well new products perform.

Industry Task Force Study

Key costs for product introductions include research and development, market analysis, trade deals and allowances, and product advertising and promotion. A recent Joint Industry Task Force of the Food Marketing Institute and Grocery Manufacturers of America found that the cost per stock keeping unit (SKU) of introducing a new grocery product in 1988 ranged from \$378,000 to \$21.2 million, and averaged \$5.1 million.

Manufacturers who bear most of the costs of product introductions can save considerable expense by introducing more than one product at a time. For example, a manufacturer may spend \$3 million on advertising for a line of new products, rather than just for one item.

Many new products quickly become failures. For failed new products, key costs include product deletion throughout the store, warehouse, and distribution channels; disposal of raw materials and finished goods; and product markdowns. Retailers bear the primary costs of product failures. The Joint Industry Task Force reported that the average retailer cost per SKU per store for a product deletion was \$10.77, versus \$3.94 for manufacturers and \$1.60 for wholesalers. Because of these large costs, some retailers have thought about charging "failure fees."

Outlets Fill Market Niches

The growth in retail bakeries has also heightened competition. Retail bakers, often franchisees, tend to do well in shopping malls, near commuter stations, and in business districts. They vary from multi-unit enterprises to "mom and pop" stores, and from full-line bakeries to specialty cookie shops. Overall, the number of retail bakeries grew from about 16,000 in 1981 to 23,000 in 1990—a 44-percent increase in less than a decade. In 1990, retail bakeries did about \$5.7 billion in business, slightly higher than 1989.



Bread loaves, fresh out of the ovens, are checked for quality. Photo credit: Continental Baking Company

Foodservice outlets have also sharpened industry competition. These outlets sell large quantities of sandwiches, with breads, buns, and rolls a major component, and run the gamut from fast-food units to up-scale cafes. *Bakery Production and Marketing* magazine estimates that foodservice bakery sales (from those baking on-premise or receiving products from dedicated commissaries) were \$8.7 billion in 1990, an increase of 5 percent over the previous year.

Foodservice outlets pose a special challenge to other types of bakery merchandisers. Sandwich breads and rolls are a favorite of consumers at rapidly growing take-out restaurants. This is because sandwiches are easy to handle, quickly prepared, fairly inexpensive, and perceived as "light fare." As evidence of this market's growth, a National Restaurant Association survey of 50 menus found that the number of sandwiches listed jumped 55 percent between 1984 and 1989.

Competition from take-out restaurants has concerned many supermarket chains and bakery operators. One trade magazine reports that the turf battles over take-out have become so intense that "both supermarket and foodservice operators publicly complain that they perceive each other as threats."

In an industry shifting its focus from selling quantity to providing variety, small baking companies—whether wholesalers or retailers—must seek out narrow market niches. Providing distinctive products will probably enhance the profitability of both small operations and large national companies.

Innovative Strategies Expand Markets

With the growth of industry competition, bakery operators increasingly use new marketing approaches and production methods. Bakers are borrowing ideas from other industry segments, tailoring them to their own requirements. As a result, delineations between wholesalers and retailers have become much less rigid.



Cookie and cracker companies are not as constrained by product perishability as bread and cake firms, so they have fewer plants and a more national focus. Photo credit: Nabisco Brands, Inc.

Examples of innovative strategies abound. For instance, T.J. Cinnamons and Mrs. Fields, two large retail bakery chains, are selling their products at in-store supermarket bakeries. Eagle Food Centers, which operates 83 in-store bakeries, has been test-marketing dessert cakes from a Chicago-area retailer. Some specialty cookie bakers are offering the option of mail-order purchases.

Recently, an important growth strategy involves the "natural" food product area. In response to consumer demand for high-fiber products, bakers tapped into the "oat-bran craze." Scientific evidence has wavered about the health benefits of oats, but the latest studies offer evidence that oat products may indeed lower cholesterol. The focus is also on "lite" (low-calorie) breads and "low salt" crackers. New fat substitutes and formulas that eliminate fats have spawned a tide of "no-fat, no-cholesterol" products.

However, manufacturers recently have been made aware of the limits to "healthful" advertising. In early September 1990, the Food and Drug Administration (FDA) warned several companies about health claims for their products (including baked goods) that linked oat bran to cholesterol reduction. FDA stated that there was not enough fiber in the products to justify the claims that the companies had made at that time.

Challenges Ahead

Like other food industries, the baking industry currently faces recessionary pressures. If the recession is prolonged, consumers will likely focus more on the basics than on premium, up-scale items. This reaction translates into an emphasis on private label baked goods, rather than branded, high-ticket products. Brand loyalty could diminish as consumers search for bargains.

Baking companies are using different strategies to deal with the recession. Some are cutting routes and employees, delaying major capital expenditures and shortening work hours.

Those companies with low debts and marketing muscle may be better able to take advantage of the situation. These firms may look to weaker competitors as acquisition targets, hire talented personnel who were laid off by competitors, and make major capital purchases from anxious equipment vendors. Most enterprises will target better performance, and bakers may heavily discount their products to keep ovens busy.

Bakers also feel squeezed by environmental concerns. One recent target has been the smog-producing ethyl alcohol released during the leavening process. By unanimous vote on January 1991, Southern California's South Coast Air Quality Management District Board ordered 24 large commercial bakeries to install smog controls on their ovens. According to the *Washington Post*, the 72 ovens produced almost as much smog as a single oil refinery.

An image of excess packaging poses another potential environmental problem for bakers. Plastic or aluminum foil packaging prevents spoilage of baked goods (see box "Modified Atmosphere Packaging Extends Shelf Life"). To help combat consumer doubts about excess packaging, programs are emerging to recycle bakery wrappers. ■

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Modified Atmosphere Packaging Extends Shelf Life

Bakers are starting to use modified atmosphere packaging (MAP), a technology to extend shelf life up to 30 days and freezer life up to 6 months. MAP is a natural process. The technology replaces air by vacuum packing nitrogen or carbon dioxide inside the package and does not require the use of additives or preservatives to prevent spoilage.

MAP offers several advantages. Because it extends shelf life, MAP gives retailers a longer time to sell the product. It allows retailers to stock slower moving products that they might not offer otherwise. Bakers can also gain by mass producing slow-selling items or building inventories of fast-selling items.

Image and cost remain the two drawbacks to MAP bakery products. Retailers wonder if consumers will perceive a product with a 30-day shelf life as "fresh baked." Such goods could reflect negatively on the whole bakery department. Also, MAP items are sometimes more expensive. But if a bakery is already packaging a product, the cost of MAP can add as little as one-tenth of a cent per packaged item.

Recent Trends in Domestic Food Programs

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Participation and costs discussed in this article compare the fourth quarter (July-September) of fiscal year 1990 with the same period in 1989. Recent data from USDA's Food and Nutrition Service are reported as of January and are subject to revision.

The Federal Government spent \$5.69 billion on domestic food assistance benefits in the fourth quarter of fiscal year 1990, a 18 percent increase over the \$4.84 billion spent in the last quarter of 1989.

The continuing economic slowdown and increased unemployment rates were reflected in the growth of Food Stamp Program participation and costs which accounted for the bulk of the increase in total Federal costs (table 1). Child Nutrition programs and the Women, Infants, and Children (WIC) Program registered gains of over 10 percent over the previous year, while the numbers enrolled in Food Distribution programs continued to decline, a trend since 1987.

Food Stamp Program

Food stamps help low-income households purchase more nutritious diets. Monthly benefits are based on the income and size of the household and the cost of the Thrifty Food Plan (TFP). The plan is the least costly of four representative food plans developed by USDA's Human Nutrition Information Service. TFP specifies the quantities of the types of foods that households may use to provide nutritious diets for their members.

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The average number of food stamp participants rose 8 percent from 18.77 million in 1989 to 20.26 million in 1990. Average monthly benefits increased from \$51.42 to \$58.42 during the same period. Total benefits during the quarter rose from \$2.90 billion to \$3.55 billion, reflecting the increases in both participation and benefit levels.

Child Nutrition Programs

Average daily participation in the National School Lunch Program declined slightly from 23.70 million children in 1989 to 23.68 million in September 1990.

(Because the fourth quarter includes July and August when most school children are on summer vacation, figures for September are used to assess year-to-year changes in the School Lunch and Breakfast programs. Even September has its limitations due to changing school starting dates.) The National School Lunch Program provides approximately one-third of the recommended dietary allowance for school-age children. Eligibility for free and reduced price lunches is determined by family income and size. For example, children from a family of four with an income below \$16,510 are



USDA donates surplus commodities to charitable institutions under various food assistance programs.

Table 1. Benefit Costs of USDA Food Assistance Programs, Fiscal Years 1988-1990 ¹

Programs	1988	1989	1990	FY 1989 Quarters ²				FY 1990 Quarters ²			
				I	II	III	IV	I	II	III	IV
Million Dollars											
Family food											
Food stamps	11,149	11,676	14,100	2,902	2,954	2,925	2,895	3,488	3,529	3,542	3,550
Puerto Rico ³	883	912	940	228	228	228	228	235	235	235	235
Food distribution											
Indian reservations	47	51	50	12	13	13	13	12	13	13	13
Schools ⁴	830	771	611	273	297	120	81	191	247	92	82
Other ⁵	220	209	179	57	56	52	43	46	50	43	40
TEFAP ⁶	593	234	202	44	59	71	58	51	56	59	36
Cash-in-lieu of commodities ⁷	152	152	156	37	38	39	40	38	39	40	39
Child nutrition ⁸											
School lunch	2,908	3,005	3,210	903	931	772	398	958	1,045	773	434
School breakfast	474	505	594	149	153	130	73	173	190	147	84
Child care and summer food	648	744	866	148	157	187	252	171	187	217	291
Special milk	19	18	19	5	5	5	4	5	5	4	4
WIC ⁹	1,435	1,489	1,641	371	366	370	382	402	428	406	405
Total ¹⁰	19,358	19,766	22,568	5,129	5,257	4,912	4,467	5,770	6,024	5,571	5,213

¹Administrative costs are excluded unless noted. ²Preliminary. Quarterly data may not add to annual total due to rounding. ³Puerto Rico transferred from the Food Stamp Program to substitute nutrition assistance program on July 1, 1982--represents appropriated amounts. ⁴National School Lunch, Child Care Food, and Summer Food Service programs, and schools receiving only commodities. ⁵Commodity Supplemental Food Program and Elderly Feeding Pilot Projects, excluding bonus commodities, and donations to charitable institutions including summer camps. ⁶Temporary Emergency Food Assistance Program. ⁷Child nutrition programs and Nutrition Program for the Elderly. ⁸Cash expenditures. ⁹Special Supplemental Food Program for Women, Infants, and Children--includes administrative costs. ¹⁰May not add due to rounding.

Source: Food and Nutrition Service, Program Information Division.

currently eligible for free meals. Children from a family of four with an annual income between \$16,510 and \$23,495 are eligible for reduced-price lunches. These thresholds are changed annually to reflect changes in cost of living and poverty levels. Overall participation in the National School Lunch Program declined because the number of paid lunches fell from 13.0 million to 12.7 million participants, even though there were increases of 0.28 million in the number of free and reduced-price lunches served. Total costs for the program, including cash payments and entitlement commodities, were \$392 million in September 1990 compared with \$366 million in 1989. The increase reflects higher reimbursement rates and the relatively larger number of free and reduced-price lunches.

Schools also receive bonus commodities as part of the National School Lunch

Program. In 1990, they received \$27.0 million worth of bonus commodities during the months of August and September, nearly the same as the \$27.3 million distributed to schools in 1989.

The School Breakfast Program provides free and reduced-price meals to children whose families meet school lunch eligibility criteria. Approximately 42,600 schools participated in the program during the 1989-90 school year. In September 1990, 3.9 million children received breakfasts on an average school day, compared to 3.6 million the previous year. Of the 1990 participants, 85.8 percent received free or reduced-price breakfasts, nearly the same rate as the previous year, 85.9 percent. Federal expenditures for the program increased for September from \$55.9 million in 1989 to \$63.6 million in 1990.

Average daily attendance at facilities offering the Child Care Food Program

rose from 1.40 million in 1989 to 1.48 million in 1990 in the fourth quarter. Total meals served in the quarter increased 13 percent from 66.7 million to 75.6 million meals.

The adult care component of the program continues to grow rapidly. Average daily attendance at the adult centers increased from 13,800 thousand to 18,500 thousand persons, the number of sites increased from 462 to 665, and total costs for this part of the program increased from \$1.22 million to \$2.29 million. For the total program, including child and adult care components, costs increased from \$167.3 million to \$199.6 million in the fourth quarter of fiscal 1990.

The Summer Food Service Program, which is in operation only during June through September, served a daily average of 1.69 million children in 1990 compared with 1.65 million in 1989.

Total meals served in 1990 amounted to 91.2 million, a 6-percent increase from 86.0 million in 1989. Annual program costs increased from \$149.0 million in 1989 to \$164.1 million in 1990.

The number of half pints of milk served under the Special Milk Program increased slightly from 39.4 to 40.2 million in the last quarter of 1990. Program costs for the quarter rose from \$4.04 million to \$4.44 million in 1990.

Supplemental Food Programs

Participation in the Special Supplemental Food Program for Women, Infants, and Children (WIC) averaged 4.5 million per month in 1990, compared with 4.37 million the previous year. Of the 1990 participants, 23 percent were women, 32 percent were infants, and 45 percent were children. Average monthly benefits per person increased slightly from \$30.14 in 1989 to \$30.27 in 1990. Total food costs for the WIC program rose 6 percent from \$381.9 million in fourth quarter 1989 to \$404.6 million in the last quarter of 1990.

Monthly participation in the Commodity Supplemental Food Program (CSFP) declined slightly from 271,100 to 269,100. Cost of food issued rose from

\$11.55 million to \$14.0 million, a 21-percent increase. Bonus commodity donations for this program dropped from \$6.31 million in fourth quarter 1989 to \$2.76 million in fourth quarter 1990. Total food costs for the program declined from \$17.86 million in 1989 to \$16.76 million in 1990.

The basic target population of CSFP is similar to that for WIC, although CSFP has an additional elderly component. The two programs can operate at the same location but a person may not participate in both programs. WIC provides benefits in the form of vouchers for use in purchasing food at retail stores. CSFP distributes monthly commodity food parcels to participants in the program.

Food Distribution Programs

USDA provides food assistance to families that live on or near Indian reservations and to the Trust Territories of the Pacific Islands through the Needy Family Program. The average number of participants in the Food Distribution Program on Indian reservations declined 6 percent from 145,000 to 136,300 persons. Entitlement commodities totaled \$10.15 million in 1989 and \$10.49 million in 1990. The value of bonus commodities for this program, unlike other programs,

fell slightly from \$2.35 million to \$2.21 million.

An average of 931,300 meals per day was served under the Nutrition Program for the Elderly compared with 925,400 a year earlier. USDA provides cash and commodities to this program, which is administered by the Department of Health and Human Services. USDA expenditures for food and cash in lieu of commodities totaled \$34.9 million in 1990, down 4 percent from \$36.2 million in 1989. The value of bonus commodities donated to this program fell from \$750,700 to \$313,200.

In the fourth quarter of 1990, USDA donated \$17.9 million worth of commodities to charitable institutions compared with \$23.2 million the previous year, a 23-percent decline. The Temporary Emergency Food Assistance Program (TEFAP) distributed \$45.5 million worth of commodities to needy persons in 1990, which is 21 percent less than the \$57.6 million distributed in 1989. Very few surplus government commodities were made available to this program. However, under the Hunger Prevention Act of 1988, canned meat, peanut butter, egg mix, canned beans and raisins were purchased and distributed to needy households under this program. ■

Food and Nutrition Legislation

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The 102nd Congress convened in January 1991. Several food and nutrition bills have been introduced in the House and the Senate. A few are described below.

Nutrition

H.R. 82—Rep. Mervyn Dymally (CA)

This bill would establish a United States Commission on Obesity which would: (1) conduct research regarding the causes and treatment of obesity; (2) study the fast-food industry's influence on obesity and diet habits; and (3) engage in public education programs regarding the health and social effects of obesity and promote exercise and diet as a means of prevention and control. The Commission would also make grants to public or private research institutions and universities to research the metabolic differences between obese and nonobese individuals and among ethnic groups. Grants would also be committed to research healthy diet habits and attitudes in young people for use in developing educational programs.

H.R. 817—Rep. Charles Rangel (NY)

The Federal Food, Drug, and Cosmetic Act would be amended to require that the label or labeling of a food product state the specific common or usual name of any fat or oil. The label would also have to contain, by serving portions, the number of ounces or grams of fat, and the number of calories derived from saturated, polyunsaturated, and monounsaturated fats. In addition, the total amount of cholesterol, sodium, and

potassium contained in each serving would be required on the label. The Secretary of Health and Human Services could exempt a food from these regulations if the labeling imposes an unreasonable burden or if the public would be adequately informed respecting the sodium or potassium content of the food by notices placed close to the food on display in retail outlets. The Secretary would also be permitted to exempt manufacturers or processors whose annual total sales were less than \$500,000.

H.C.R. 64—Rep. Andrew Jacobs (IN)

This resolution calls for federally funded school lunches to provide optional meatless meals. Currently, federally funded school lunch programs seldom provide meatless meals, but an increasing number of school youths are rejecting meat diets.

The next three bills would amend the National School Lunch Act to extend eligibility to certain programs to receive refunds from the Child Care Food Program (CCFP). The CCFP currently may reimburse approved child care facilities for afternoon snacks.

H.R. 375—Rep. Alan Mollohan (WV)

This bill would extend eligibility for the CCFP to children receiving day care services pursuant to parents' participation in State job opportunities and basic skills training programs.

S. 223—Sen. Mitch McConnell (KY)

This bill would extend eligibility for reimbursement under CCFP for meal supplements for children in afterschool care at schools.

S. 224—Sen. Mitch McConnell (KY)

This bill would modify the criteria for determining whether a private organization providing nonresidential day care services is considered an institution under CCFP. The bill would start basing eligibility for child care food benefits on the number of children who qualify for free or reduced-price meals under the National School Lunch Act.

H.R. 544—Rep. Major Owens (NY)

This bill also would amend the National School Lunch Act to restore eligibility for food supplement benefits under the dependent care food program to adolescent youth 18 years of age or under. It would also make children with disabilities eligible for such benefits at any age.

Food Safety and Quality

H.R. 222—Rep. Neal Smith (IA)

This bill would amend the Poultry Products Inspection Act to reestablish minimum inspection and processing standards. All poultry and poultry products would have to be slaughtered and processed under standards which would have complied with the rules and regulations and all inspection and reinspection standards in effect July 1, 1977.

H.R. 509—Rep. Joe Kolter (PA)

This bill would amend the Federal Food, Drug, and Cosmetic Act to require food and drug manufacturers to maintain a toll-free telephone line for inquiries about food containing added vitamins or minerals, herbal foods, foods for special uses, over-the-counter drugs and any

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A United States Commission on Obesity would study American dietary patterns and habits.

other food which makes a health or nutrition claim. It would also require that the labels and advertising of these products contain a reference to the toll-free line.

S. 35—Sen. Daniel Moynihan (NY)

This bill would establish a system to regulate bottled water. It would require the bottler to clearly identify the water source. It would also establish criteria concerning minimum well construction standards, distance separation from upstream wastewater discharge, or minimum distance separations from a variety of potential contamination sources such as abandoned wells, septic tanks, waste impoundments, and landfills. The standards for public drinking water would be applied to bottled water. The bill would require simple labeling procedures and expand the monitoring, testing and reporting procedures for bottled water. It would require standard definitions for drinking water, natural water, spring water, well water, distilled water, purified

water, soda water, seltzer water, and mineral water.

Other

H.R. 156—Rep. Stephen Neal (NC)

All foodservice operations would receive instructions for removing food which has become lodged in a person's throat. The instructional material would be distributed by the Department of Commerce. The foodservice operation could post instructions on the premises so employees would become familiar with techniques and could consult the instructions if a person were choking. If a foodservice operator were to act in accordance with the instructions in trying to assist the removal of food lodged in someone's throat, no U.S. court could enter a judgment for ensuing damages against the operator.

H.R. 228—Rep. Neal Smith (IA)

This bill would clarify the eligibility of certain small businesses for loans under the Small Business Act. The bill

would also aid, protect, and preserve small businesses in meat production and marketing by restricting the number of cattle, swine, or sheep that a meatpacker or a person owning more than 5 percent of the stock, voting power, or control of a meatpacker may slaughter in any one location per week. It also would restrict the number of cattle, swine, or sheep that a meatpacker or meat marketer may offer for sale or may offer to purchase in a week.

H.R. 278—Rep. Cardiss Collins (IL)

This bill would make it an unfair practice for a retailer to increase the price of any food, drug, device, or cosmetic product once the retailer marks the price on it. The Federal Trade Commission (FTC) would require retailers to establish a system of audit so that FTC could enforce prohibition on price increases. The FTC would be permitted to order a retailer who violated the prohibition to refund any amounts of money the retailer obtained by increasing the price. ■

USDA Actions

Lori Lynch
(202) 219-0689

USDA regularly implements operational and regulatory changes that affect the status of food and nutrition in the United States. Here are some recent actions.

Inspection and Certification of Peanuts Required

USDA now requires that all peanuts sold for human consumption be inspected and certified.

According to USDA's Agricultural Marketing Service (AMS), approximately 95 percent of the peanuts sold for human consumption are already inspected and certified under marketing orders for size, quality, and condition. Enacted in December, Public Law 101-220 requires that the remaining 5 percent of the peanut crop be inspected, certified, and tested.

AMS offers inspection and certification services for a fee to peanut handlers. Most handlers now operate under a "Peanut Marketing Agreement" authorized by the Agricultural Marketing Agreement Act of 1937. Under this arrangement, peanut handlers who have signed the marketing agreement are compensated when tested peanuts are found unsuitable for human consumption because of aflatoxin contamination.

Handlers who have not signed the agreement and whose peanuts must now be tested due to the new law may wish to sign the agreement to take advantage of the indemnification program. Interested handlers may contact the Peanut Administrative Committee, P.O. Box 18856, Lenox Square Station, Atlanta, GA, 30326.

The author is an agricultural economist in the U.S. Agricultural Policy Branch, Agriculture and Trade Analysis Division.

Cheese Replaces Peanut Butter

Due to an increase in the cost of peanuts and a decrease in the cost of cheese, the USDA is substituting cheese for peanut butter on a limited basis in its food assistance programs.

A drought reduced the size of the 1990 peanut crop, meaning fewer peanuts are available for peanut butter. The cost of peanuts increased from less than a dollar per pound last year to approximately \$1.70 per pound. On the other hand, the average price of processed cheese has dropped from approximately \$1.65 to \$1.20 per pound.

According to USDA's Food and Nutrition Service, which oversees the food assistance programs, the replacement makes economic sense because USDA will get the best nutritional value it can for its money.

Cheese was readily available for Federal assistance programs in the early 1980's after high production led to large surpluses. Changes in the dairy price-support programs brought production more in line with demand, and generous donation policies greatly reduced Government-held inventories of cheese. Cheese prices rose sharply. As a result, very little cheese was purchased for Federal programs in fiscal year 1990. In many cases, peanut butter was substituted as an alternative source of protein.

The Nutrition Programs, which include the National School Lunch Program and the Nutrition Program for the Elderly, began receiving cheese in December 1990. The Emergency Food Assistance Program (TEFAP) planned to replace peanut butter with cheese in February 1991. TEFAP gives foods donated by USDA for household use to eligible Americans, including low-income and unemployed persons.

New Food Safety Publication

Many of the approximately 7 million cases of foodborne illness reported each year in the United States result from consumers mishandling food after purchase. Therefore, USDA's Food Safety and Inspection Service is offering a new publication to inform consumers about safe food handling practices. According to statistics from the U.S. Centers for Disease Control, approximately 85 percent of foodborne illness incidents could be avoided by following safe methods for food handling.

The publication, *A Quick Consumer Guide to Safe Food Handling*, was developed after food scientists analyzed consumer handling of food in the home using a scientific method called the Hazard Analysis and Critical Control Point (HACCP) approach. This system identifies the critical points in everyday food handling where experts say the wrong move could result in foodborne illness.

The publication provides do's and don'ts of safe food handling, emphasizing meat and poultry products. It covers the food safety aspects of food shopping, storage, meal preparation, cooking, microwaving, serving, and handling leftovers.

The guide includes cold storage and cooking temperature charts which list recommended temperatures for meat and poultry products. The cold storage chart details how long a wide variety of perishable foods will last at freezer and refrigerator temperatures. It also offers tips on handling refrigerated and frozen foods during an electrical power outage. Specific information on how to report a case of foodborne illness is given.

For a free copy of *A Quick Consumer Guide to Safe Food Handling*, write to: Consumer Information Center, 574-X, Pueblo, CO 81009.

Consumers with questions about safe food handling can also call the USDA Meat and Poultry Hotline at 1-800-535-4555, from 10 a.m. to 4 p.m. ET. Residents of the Washington, DC, area can call (202) 447-3333.

Sharwil Avocados Can Move Interstate from Hawaii

Sharwil avocados may now be shipped to the continental United States from Hawaii without treatment, providing they meet certain harvesting and handling requirements.

The shipping of avocados from Hawaii to the continental United States is regulated to prevent the spread of three insects, the Mediterranean, melon, and Oriental fruit flies. These flies are found in Hawaii but not in other parts of the United States. However, if the Sharwil variety of avocado is picked in compliance with USDA regulations and packed within 24 hours, it is not a host to these fruit flies.

Currently, untreated Sharwil avocados can be shipped to Alaska because of Alaska's colder climate. Since host fruits are not grown in Alaska, there is little risk of fruit-fly infestation. All avocados grown in Hawaii and shipped to States other than Alaska previously had to be treated prior to movement.

James W. Glosser, administrator of USDA's Animal and Plant Health Inspection Service, said that USDA has carefully monitored the movement of Sharwil avocados from Hawaii to Alaska and discovered no violations of the picking and packing requirements. No eggs, larvae, or flies were discovered after the avocados arrived in Alaska. Therefore, USDA now allows untreated Sharwil avocados to be shipped to any State as long as they are harvested and handled under the specified conditions.

Mangoes From Central and South America Allowed Again

USDA has reopened the United States to treated mango imports from Central and South America.

Mango imports from these areas were banned in 1987 because a suitable treatment for fruit flies was no longer avail-



USDA now requires that all peanuts sold for human consumption be inspected and certified.

able. At that time, the Environmental Protection Agency prohibited fumigation with ethylene dibromide, the traditional treatment for killing exotic pests such as fruit flies on mangoes.

USDA's Agricultural Research Service has demonstrated that a procedure for dipping South American mango varieties in hot water kills the larvae and eggs of fruit flies, including the Mediterranean fruit fly.

U.S. markets are now open to all varieties of mangoes from Mexico, Central America, South America, and the West Indies. A hot-water treatment similar to the one now allowed for South American mango varieties had been approved previously for certain other mango varieties imported from the West Indies and Mexico.

Import Restrictions on Chilean Meat and Livestock Eased

USDA has declared Chile free of foot-and-mouth disease and rinderpest, two major cattle diseases, and has issued regulations making the importing of Chilean meat and livestock easier.

Some of the U.S. prohibitions and restrictions on importing meat from Chilean cattle, sheep, and goats have been removed. However, there will still be a number of special restrictions on imports of these meat products, and the current restrictions on swine and pork products will continue.

James W. Glosser, administrator of USDA's Animal and Plant Health Inspec-

tion Service, expects Chile to export few if any traditional farm animals or meat products. He does foresee the possibility of a new flow of llamas and alpacas coming to the United States. Special health certification, testing, and quarantine requirements have been developed to deal with these animals.

Quarantined animals will undergo laboratory tests for foot-and-mouth disease. Exporters also have to arrange a 60-day pre-embarkation quarantine in Chile. Quarantines in the United States will be reduced from 90 to 40 days, making the quarantine requirements less costly.

Rinderpest and foot-and-mouth disease are viral infections that strike cloven-hoofed animals but neither is a threat to human health. The diseases cause a variety of symptoms leading to reduced productivity, weakness, and often death. Outbreaks of these diseases could have disastrous effects on cattle herds and could raise meat prices in the United States. In addition, if an outbreak were to occur in the United States, we would no longer be considered "free" of these diseases and could lose markets.

In order to be declared free of rinderpest and foot-and-mouth disease, a country must have an effective eradication, control, and surveillance program for these diseases. It also must be free of these diseases for at least 1 year. Chile meets these standards. However, because Chile's neighboring countries are still infected with foot-and-mouth disease, USDA will continue to impose some import restrictions.

Rinderpest has never been known to exist in Chile and constitutes no appreciable risk. The last outbreak of foot-and-mouth disease in Chile was in August 1987, and Chilean officials have taken precautions against a recurrence of this disease.

Standards for Dried Whey Revised

USDA now permits salty whey, the moisture removed from cheese curd as a result of salting, to be covered by U.S. whey standards. The standards will apply to the whey after its salt has been removed.

Dried and condensed whey are significant sources of vitamins and protein in

human nutrition, and are also used to some extent in animal feed.

Only whey originating as saltless was eligible for U.S. grading. This type of whey results from the initial coagulation of milk protein into cheese curd at the start of cheesemaking. This is the major source of whey for processing.

In the past, the salty whey was discarded because it was too salty. Improved whey prices and increased whey disposal costs have improved the economics of removing the salt. Membrane technology, using a process of osmosis, can economically remove salt from whey. The desalinated whey can be sold as sweet whey.

The Agricultural Marketing Service is authorized to approve desalination methods for handlers seeking USDA approval of the whey-handling facilities. Collection of this whey must meet certain sanitary requirements.

Low-Fat Patties in the School Lunch Program

USDA plans to purchase new low-fat beef patties for use in the National School Lunch Program.

Meat industry research projects have developed palatable beef patties containing just 10 percent fat. USDA is attempting to move this technology from the laboratory into the packing plant to provide a leaner beef product to school children. Beef patties that are served in the school lunch programs average approximately 20 to 22 percent fat. The fat content of these products is already lower than in many commercial products, but the development of low-fat patties would be a substantial improvement.

USDA conducts a trial purchase in a two-step bidding procedure. First, USDA solicits and evaluates proposals and samples from interested suppliers. Second, producers of the product that USDA finds acceptable are invited to submit sealed bids to sell up to 79,200 pounds of their product for distribution to pre-selected schools.

Imported Fruits From Chile

USDA has amended its regulations to allow stonefruit (apricots, nectarines,

peaches, and plums) to be imported from Chile based on pre-clearance inspections, as long as certain precautions are taken. Previously, imports had to be fumigated. Fumigated imports will continue to be allowed.

Precautions include inspecting the fruit in Chile, and covering all shipments completely with tarpaulins or enclosing them in containers or sealed trucks during movement from the inspection facility to the vessel or aircraft.

Activities to determine the eligibility of fruit shipments to the United States are called "pre-clearance" to distinguish them from similar inspections, treatments, and other procedures performed by Animal and Plant Health Inspection Service (APHIS) inspectors at U.S. ports of arrival. Inspections conducted in Chile are comparable in effectiveness to inspections at the U.S. ports of entry.

These pre-clearance inspections are performed under the direction of USDA APHIS inspectors in Chile and are carried out either by APHIS inspectors or by inspectors of the national plant protection service of Chile in the presence of APHIS inspectors. In most cases, fruit pre-cleared in Chile does not require reinspection at U.S. ports.

Ohio and Idaho Free of Cattle Tuberculosis

USDA declared Ohio and Idaho free of cattle tuberculosis, making cattle from these States more marketable domestically and internationally.

A State must be free of bovine tuberculosis for 5 years in order to be accredited. Ohio's last infected herd was slaughtered in 1985, Idaho's last, in 1984.

Both States have maintained active programs to identify cattle so that any infected animal can be traced back to its herd of origin. The surveillance programs were supported by the livestock industry, State officials, the veterinary profession, and many other organizations.

Kansas and Oklahoma Not Free of Cattle Tuberculosis

USDA has removed cattle tuberculosis-free status from Kansas and Oklahoma. Both States had been declared "free" in 1984.

The bovine tuberculosis accredited-free status of both States was rescinded when several infected herds were found. The source of one of the Kansas infections is unknown of yet. The other cases originated from a single infected Oklahoma herd that was dispersed in 1988.

Officials in both States say that they are arranging to have all infected and exposed herds slaughtered. If a State has previously been declared "free" it can regain free status once it remains free of infection for 2 years after the last infected herd is slaughtered.

With the addition of Ohio and Idaho and the loss of Kansas and Oklahoma, 41 States plus the Virgin Islands are considered "free" of cattle tuberculosis.

Idaho Declared Free of Cattle Brucellosis

USDA declared Idaho free of cattle brucellosis. Idaho is considered free of brucellosis because no cattle herds were found to be infected with the disease for 12 consecutive months and the State met all other program requirements.

Cattle owners in "free" States benefit by no longer having to test their animals for brucellosis before they are sold. Savings will amount to more than \$300,000 per year in Idaho.

Brucellosis causes abortion, reduced fertility, and lower milk yields in cattle. Nationwide, cattle producers still incur annual production losses of more than \$12 million from brucellosis. Humans can be infected by drinking unpasteurized milk from infected animals or by handling aborted fetuses from brucellosis-infected animals.

With the addition of Idaho, 30 States and the U.S. Virgin Islands are now free of this costly disease of cattle.

Fewer than 1,000 herds are still under quarantine for brucellosis in the United States. In the early 1930's when the eradication efforts first started, 5 percent of the Nation's cattle herds were estimated to be infected with brucellosis. This dropped to 124,000 herds in the late 1950's, and down to 7,074 herds in 1980.

USDA Research

Food Poisoning Detection Tests Patented

Saumya Bhaduri, USDA molecular microbiologist, has developed and patented a test that detects quickly (within 5 minutes) a relatively unknown food-poisoning bacterium.

The test uses a crystal violet dye which binds to disease-causing strains of the bacterium *Yersinia enterocolitica*, but not to harmless strains. The crystal dye method does not allow for further testing, however, because the bacterium is killed by the test. A newer test also being patented uses Congo red dye. The Congo red dye test is especially useful in field laboratories of food processing plants, hospitals, and sewage treatment facilities where it is essential to isolate the organism live for detailed study.

Y. enterocolitica can grow in dairy, beef, and other meat products at temperatures as low as 32 degrees F. The bacterium can reach infectious levels at refrigerated temperatures in 4 days. Once the organism is eaten in contaminated food, it grows in the human intestine and produces toxins, causing abdominal pains, diarrhea, and vomiting. Ingestion of contaminated foods or bottled water, contact with sick pets, and the transfusion of contaminated blood have been implicated as ways of transmitting *Y. enterocolitica*.

The new tests will make it easier for industry and regulatory agencies to safeguard food by pinpointing the *Y. enterocolitica* strains that are harmful. They are simpler, quicker, and more reliable than current tests, which are often inconclusive and can take days to complete.

The National Centers for Disease Control have received several reports of food poisoning from the bacterium in recent years. An outbreak last year in Fulton County, GA, was caused by children coming into contact with adults who were cleaning chitterlings. The bacterium has also become a major cause of food poisoning in the Netherlands, Belgium, Finland, Sweden, Germany, Italy, Ireland, Australia, Canada, and Japan.

Saumya Bhaduri, who works for USDA's Agricultural Research Service (ARS), explains that the tests rely on the dyes to bind to an unidentified substance produced in *Y. enterocolitica* strains containing a plasmid. A plasmid is a small piece of DNA that can be used to carry genetic messages. In this case, the presence of the plasmid converts a harmless strain to a disease-causing organism.

For more information, contact Saumya Bhaduri, Eastern Regional Research Center, Philadelphia, PA, (215) 233-6620.

Foreign Biocontrol Agents Fight Weed Pests

Increasing numbers of helpful weed-fighting insects and microorganisms are being imported into the United States.

ARS scientists based in Rome, Italy, shipped 33 times more weed enemies in 1990 than in 1980. Insects, mites, and pathogens are tested overseas and in this country, and then released to devour or otherwise control alien weeds.

ARS has stepped up the hunt for natural enemies as alternatives to chemical herbicides, says Lloyd Knutson, director of the ARS Biological Control of Weeds Laboratory in Rome. Some herbicides can injure subsequent crops or move into

ground water, he says. Also, weeds in some areas are showing resistance to the chemicals.

Since the Rome lab opened in 1959, 17 species have been identified that attack 15 different weeds.

For more information, contact Richard Soper, Biological Control, Beltsville, MD, (301) 344-3930.

Herbicides Help Weeds Self-Destruct

A class of herbicides has been discovered that causes weeds to overdose on their own natural chemicals.

Diphenyl ether herbicides, which are used on soybeans, cotton, and many other crops, disrupt weeds' production of chlorophyll. Consequently, a natural compound normally used by weeds to make chlorophyll builds up. This compound produces a form of toxic oxygen that destroys weeds' cell membranes.

This discovery helps scientists learn how chlorophyll synthesis is regulated in plants, and how to control how plants respond to stress, ARS researcher Stephen O. Duke says. He also hopes to make herbicides control a broader spectrum of weeds or reduce the amount needed.

For more information, contact Stephen O. Duke, Southern Weed Science Laboratory, Stoneville, MS, (601) 686-2311.

Forecasting Ground water Contamination

A team of ARS scientists is working out computer forecasts to tell if fertilizer applied to farmland will reach underground water sources.



Two new tests make it easier for industry and regulatory agencies to safeguard food by pinpointing *Y. enterocolitica*, a harmful bacteria that grows in dairy, beef, and other meat products.

Research on a computer model called GLEAMS is part of a national initiative to protect ground water from fertilizer and pesticide contamination, says team leader Ralph A. Leonard, an ARS soil scientist. GLEAMS tracks pesticides only, but scientists hope to expand it to include nitrates and phosphorus from commercial fertilizers and manure.

Reducing the loss of agricultural chemicals to ground water is a top priority of the research.

For more information, contact Ralph A. Leonard, Southeastern Watershed Research Laboratory, Tifton, GA, (912) 386-3462.

Flax for the Health Conscious

A new flax variety called Omega may please the cholesterol conscious.

Developed by ARS plant geneticist Jerry Miller in cooperation with North

Dakota State University, Omega's seeds contain omega-3, a family of fatty acids. Studies suggest that consuming moderate amounts of omega-3 and avoiding high-fat diets may help reduce the risk of cardiovascular disease.

In the United States, flax is typically sold for its oils, although some flax seed is sold in health food stores and bread made with flax is sold in some bakeries.

Omega may be in full production by 1992. A limited debut in commercial markets is scheduled for the early fall harvest this year.

For more information, contact Jerry Miller, Oilseeds Research, Northern Crop Science Laboratory, Fargo, ND, (701) 239-1381.

Oriental Persimmons—High in Vitamin C

Orange-red Oriental persimmons have about three times as much vitamin C as citrus.

Certain varieties provided 218 milligrams of ascorbic acid per 100 grams of fruit, or up to 363 percent of the recommended daily intake of vitamin C, says ARS scientist Jerry A. Payne.

The fruit is also high in fiber and a good source of potassium and vitamin A, Payne says. It can be grown as far north as central Georgia.

Persimmons can be eaten fresh and used in desserts, pies, jellies, and other products. They can be dried and eaten like candy or frozen and eaten like popsicles.

For more information, contact Jerry A. Payne, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA, (912) 956-5656. ■

Reports of Interest

The Economic Research Service recently issued the following reports of interest to the food industry. To order copies, call toll free 1-800-999-6779 (8:30-5:00 ET).

Effects of Declining Ground Water

Most States have water supply problems, and several are seeing ground water levels fall significantly. The increasing cost of pumping irrigation water caused by the declining ground water levels is putting pressure on irrigators to adopt new irrigation systems and production practices and to make changes in cropping programs to use irrigation water more efficiently.

This report examines the changes irrigators are likely to make as the cost of pumping water rises. A case study in a declining groundwater area of Kansas illustrates the economic feasibility of alternative irrigation systems and related irrigation technology.

Economic and Technical Adjustments in Irrigation Due to Declining Ground Water. AGES-9018. William Crosswhite, Clif Dickason, and Robert Pfeiffer. February 1990. \$8.00.

Advertising Boosts Cheese Sales

As a result of increased advertising, natural cheese sales shot up about 21 million pounds and processed cheese

sales were up about 193 million pounds from September 1984 to June 1989. These sales were for cheese consumed at home.

Generic advertising influences households that normally do not purchase natural cheese, whereas households that normally purchase processed cheese are the most influenced by advertising.

Government donations of cheese tend to dampen sales of both processed and natural cheese.

This report uses estimated econometric demand models to simulate the results. The models can measure the effects of both generic and branded advertising.

Effects of Advertising on the Demand for Cheese, January 1982-June 1989.



The increasing costs of pumping low levels of ground water are pressuring irrigators to use water more effectively.

Photo credit: Mary Ahearn

AGES-9055. James R. Blaylock and W. Noel Blisard. August 1990. \$8.00.

New Approach to Wetland Protection

Current Federal wetland protection efforts, such as the Swampbuster provision of the 1985 farm act, may be insufficient to attain the administration's goal of "no net loss" in wetland acreage. One option is to establish a permanent wetland reserve program.

This report reviews why wetlands are important, looks at past and present Federal wetland policies, and examines the dimensions of a reserve under three sizes.

Both the likely geographic distribution of the reserve and the likely crop rotations affected are analyzed, and potential easement and restoration costs are estimated. Key questions about how a reserve would be implemented are highlighted.

A Permanent Wetland Reserve: Analysis of a New Approach to Wetland Protection. AIB-610. Marc Carey, Ralph Heimlich, and Richard Brazee. August 1990. \$4.00.

U.S. Policy and World Food Security

Domestic agricultural policies have a tremendous impact on world food security, particularly in terms of how they affect the level of food stocks held by the Government and commodity prices. Domestic policies will indirectly affect U.S. food aid programs through the same mechanisms, which should generate debate among groups that support food aid. The 1990 farm bill and the GATT negotiations offer opportunities and challenges to strengthen world food security.

This report looks at how elements of U.S. farm policy affect world food security, the impact of changing domestic policies, and what's ahead for world food security.

World Food Security: The Effect of U.S. Farm Policy. AIB-600. Mark E. Smith. April 1990. \$4.00.

Measuring U.S. Food Spending and Income

Food spending in the United States has risen almost every year since the end of the Great Depression. Income has risen faster, however, chiefly because of the increasing number of families with more than one wage earner, so food spending as a percentage of income has declined. Higher income households spend more money on food but use a smaller share of income than lower income households. Measures of food expenditures and income vary according to how income is measured, what expenses are counted, and who is paying for the food.

This report analyzes changes in U.S. food spending and income from 1929 to 1989. The author uses many tables and graphs to illustrate the data.

U.S. Food Spending and Income: Changes Through the Years. AIB-618. Alden Manchester. January 1991. \$4.00.

Uses of Alternative Crops/Products

Developing new crops or products could raise farm income and reduce government subsidies, the trade deficit, and potentially adverse environmental effects of farm production. Alternative opportunities for new crops or products exist in agriculture-based industry, aquaculture, and floriculture and environmental horticulture.

Examples of the many alternative crops or products and their uses that the report discusses include: rapeseed for feed, cosmetics, and pharmaceuticals; corn for ethanol fermentation and degradable plastics; crawfish as a substitute for shrimp; and essential oils for flavoring and fragrances for food and beverage manufacturing or cosmetics and toiletries.

Alternative Opportunities in Agriculture: Expanding Output Through Diversification. AER-633. Michael R. Dicks and Katharine C. Buckley, editors. May 1990. \$8.00.

Pesticide Use Trends

Pesticides used on major crops increased from 225 million pounds of active ingredient (the material in a pesticide

product that controls pests) in 1964 to 558 million pounds in 1982. Rapid growth in the use of herbicides led that dramatic increase. Farmers increased their use of pesticides on corn and soybeans to a greater extent than on other crops during that period. Insecticide use on cotton fell.

Since 1980, pesticide use has stabilized or declined. Regulatory decisions that removed pesticides from the market if health or environmental risks outweighed the economic benefits may have reduced the variety of pesticides available to farmers. But those decisions apparently have not slowed the growth of pesticide use.

This report illustrates pesticide use trends using data from USDA and the Environmental Protection Agency, discusses factors affecting those trends, and presents major policy issues. Twenty-five tables are appended.

Agricultural Pesticide Use Trends and Policy Issues. AER-622. Craig D. Osteen and Philip I. Szmedra. September 1989. \$8.00.

Impact of Energy/Pesticide Inputs on Farming

Seven input industries that had an impact on U.S. farming in the period 1966-86 are described in this report. The industries include pesticides, energy, fertilizer, feed, credit, farm machinery, and hired labor.

Both pesticide sales to farmers and farmer use of pesticides rose significantly during the 20 years surveyed. The share of major crop acreage treated with insecticides and herbicides doubled. U.S. pesticide output was dominated by about 28 large firms. Many new pesticides were developed.

The food and fiber sector accounts for 10 to 15 percent of all U.S. energy consumption but has little influence on energy prices. Food processors use more electricity and natural gas than oil. Ethanol remains a high-cost fuel relative to oil and depends on Government subsidies.

Seven Farm Input Industries. AER-635. Joseph R. Barse. September 1990. \$11.00. ■

Less Packaging and More Recycling Reduces Waste

Minimizing the amount of packaging is one way to reduce the quantity of waste landfilled. Prior to the 1980's, virtually no package designer would have made a packaging choice with the sole intention of lessening the amount of packaging waste.

Traditionally, food manufacturers made packaging choices between cost and consumer convenience, or between package volume and consumer convenience. Often the decision favored consumer convenience in order to increase or maintain sales. But firms also kept an eye on costs and looked for ways to reduce packaging costs.

One way to lower costs is to reduce the quantity of materials used in manufacturing the package. While such reduction may seem negligible and lower the cost by only 1/10 of a cent on each package, total cost savings can amount to millions of dollars on products sold across the nation.

An example of a series of incremental, almost imperceptible changes in packaging is the 12-ounce aluminum beverage can. Since 1972, the thickness of the aluminum can body has been diminished primarily by the use of new designs that retain strength while reducing the metal required. In another innovation, the top of the can was necked in—first one, then two, three, and four times. Each successive necking down of the end lowered the weight of the can. By 1989 the average weight per can had been reduced by 26 percent.

A similar progression of incremental changes—lowering the amounts of material—has occurred in the packages that compete with the 12-ounce beverage can. (The production and sale of packaging is a highly competitive business.) Manufacturers of the 2-liter plastic soft drink bottle have reduced material weight by 25 percent over the past 14 years, and 16-ounce glass bottles have been reduced by 30 percent over a period of 10 years.

Recycling, the reuse of a packaging material, either to form new packages or to manufacture other useful materials, is another way to reduce sending packaging wastes to the landfill. Aluminum and glass can be remelted over and over again without degrading their properties. In the late 1960's, intensive efforts began to encourage people to recycle their aluminum cans. Sixty percent of aluminum cans are now recycled.

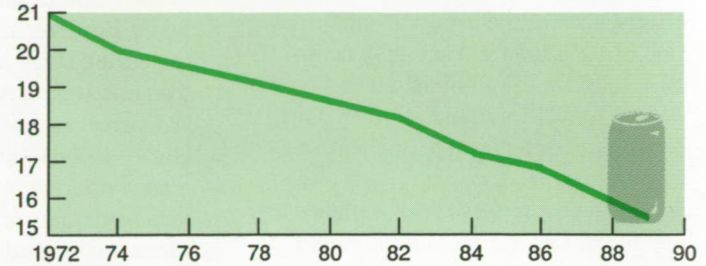
Other packaging materials are being recycled as well. Over 50 percent of paper corrugated boxes are recycled, limited only by lack of mills to handle waste paper recycling.

Potentially the greatest technical challenge to recycling is plastic because many different types of resins are used. Despite this drawback 20 percent of the plastic beverage bottles are being recycled. Coca-Cola has introduced soft drink bottles with recycled plastic resins, and Pepsi-Cola is waiting for government approval for their recycled plastic bottles.

—Robert F. Testin (803) 656-2229
and Peter J. Vergano (803) 656-5684

Aluminum Beverage Cans Keep Getting Lighter

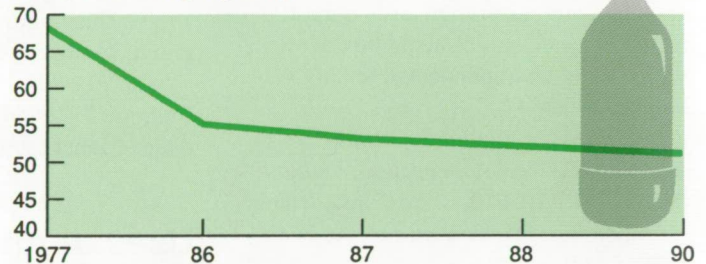
Average weight per can (grams)



Source: Aluminum Association. *The All-American Can: The Advantage Stock Up*, Washington, DC.

So Are 2-Liter Plastic Beverage Bottles. . .

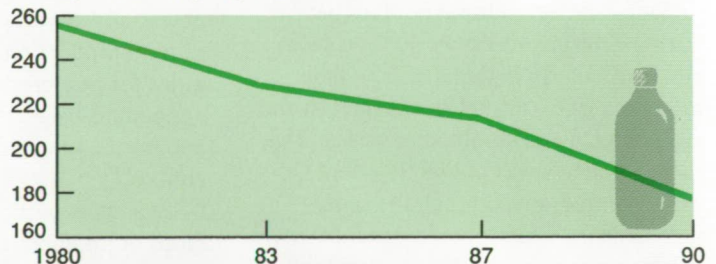
Average bottle weight (grams)



Source: F. Voight, Eastman Chemical, Kingsport, TN

. . . And 16-Ounce Glass Beverage Bottles

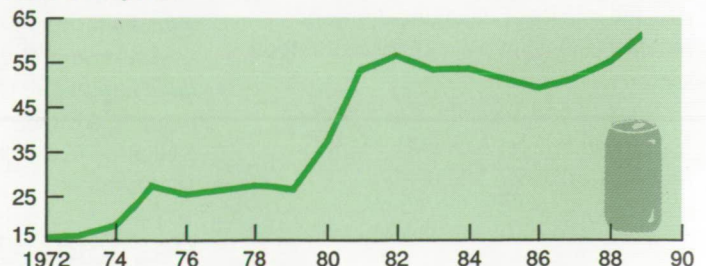
Average bottle weight (grams)



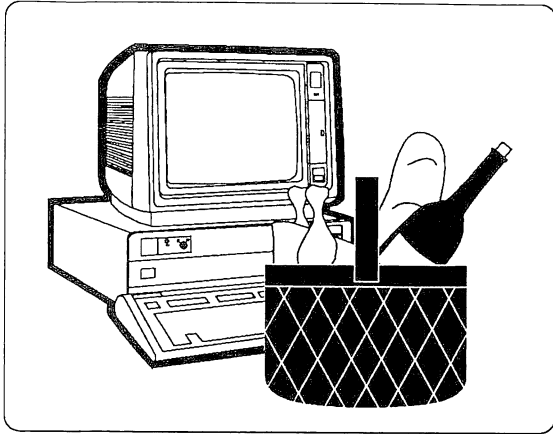
Source: K. Schlesselman, Manager, Container Design, Foster-Fobes, Marion, OH.

Over One-Half of Aluminum Cans Are Now Recycled

Percent Recycled



Source: Aluminum Association. *Aluminum Recycling, America's Environmental Success Story*, Washington, DC.



Test your knowledge of . . .

Americans and Food

Do you know America's #1 food import or how many new food and grocery products were introduced in 1989? What food showed the largest percentage gain in consumption over the past 20 years? These are just a few of the challenging questions you will find in a new computer quiz developed by USDA's Economic Research Service.

The quiz is available on a 5.25-inch disk and requires MS/PC-DOS Version 3.2 or 3.3 and 640 KB of memory. The program contains 54 questions and answers with important details on a wide variety of topics, ranging from fish consumption and trade to the fast food market. The easy-to-understand questions and answers make the quiz an excellent teaching tool and presentation aid. *Single copies are \$25 (Order #91002A), but bulk orders to one address allow a quantity discount: 10 copies for \$40 (order #91002B) or 50 copies for \$75 (order #91002C)!*

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Now, here's your chance to test your knowledge of "Americans and Food" with a sample of questions from the quiz. The answers are below.

1. How many new food and grocery products were introduced in 1989?

- | | |
|-----------|------------|
| (a) 989 | (c) 8,971 |
| (b) 3,787 | (d) 12,055 |

2. Which group dines out most often?

- | | |
|---------------------|----------------------------|
| (a) 14-24 year olds | (c) 45-64 year olds |
| (b) 25-44 year olds | (d) 65 years old and older |

3. Do you know the largest market for U.S. exports of processed food?

- | | |
|------------|---------------------|
| (a) Canada | (c) The Netherlands |
| (b) Japan | (d) Mexico |

4. Let's check your knowledge of the many "new" foods available these days. Do you know what *surimi* is?

- | | |
|-----------------------|-----------------------------|
| (a) A type of cabbage | (c) A fat substitute |
| (b) A fish product | (d) An artificial sweetener |

Ready to tally your score?

1. The correct answer is (d) 12,055, but an estimated 90 to 99 percent of new food products fail.
 2. The correct answer is (b) 25-44 year olds.
 3. Exports of processed food to (b) Japan totaled \$5.4 billion in 1989, followed by \$1.5 billion to Canada.
 4. Surimi is a minced (b) fish product used in products that simulate crab, shrimp, and other popular seafoods.

Note: Data products are not returnable.

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