THE ROLE OF IRRADIATION IN FOOD PROCESSING:

CAN IT BENEFIT ALASKA?

by

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Circular 64

March 1988

INTRODUCTION

Processing food to preserve it for later use is a familiar technique. Canning, freezing, drying, pasteurization, sterilization, and chemical treatment of foods are commonly used and accepted processes. Methods of food processing are continuously being improved through research and development to bring high-quality, wholesome products into the marketplace.

Another preservation process, food ionization or irradiation, has been the subject of research and development for over 40 years. Although not as well known to consumers in the United States, it is used to preserve many different food products throughout the world. For example, potatoes are treated in Japan to inhibit sprouting, frozen fishery products are treated in the Netherlands to extend shelf life, and mangoes are treated in South Africa for insect disinfestation (Van Koij 1986).

The American consumer is not as likely to encounter food that has been irradiated as are consumers in other parts of the world. The United States Food and Drug Administration (FDA) is known internationally for its strict food safety program. Extensive testing is required before FDA will approve the preservation of food products using new methods. Once approved, newer methods often replace existing ones. Currently, there is speculation that the ionizing radiation technique may, in the future, replace chemical use in the processing of many foods, particularly fresh fruit (Loaharanu and Urbain 1982, USDA 1987), because it eliminates any possible chemical residue from post-harvest treatments. In food-related surveys, consumers have indicated that they prefer irradiated foods over foods preserved with chemicals (Sloan 1985). Use of irradiation to replace chemical treatment in food processing would parallel its adoption for the sterilization of medical products during the past 20 years. Indeed, the United States consumer is more likely to use irradiated food-packaging, pharmaceutical, and cosmetic products than irradiated food products (Markovic 1985).

Treatment of Alaska-produced food products by ionizing radiation may benefit the seafood and agricultural industries and the Alaskan consumer. A feasibility study to evaluate the potential social and economic benefits and risks as well as the costs of using the process in Alaska on Alaskan products is being coordinated by the Institute of Northern Engineering. A research and development project to determine effects on the quality of Alaskan products could be the next phase in the introduction of a new food-preservation technique to Alaska.

FOOD IRRADIATION PROCESS

Irradiation is used primarily to extend shelf life of food. The shelf life of perishable foods such as fresh fish, poultry, and meats can be extended two to three times. It may be used with other conventional processes or used alone as a single process replacing other techniques. Products are exposed to an ionizing radiation source that produces charged particles or ions. Because of this, the technique also is called ionizing energy preservation. Doses of radiation vary depending on the product, and the levels which can be used are regulated (Lecos 1986).

Irradiation can be used to preserve food (fig. 1) because ions passing through the food break chemical bonds in the microorganisms destroying them. Insects can be killed or sterilized. Further ripening and sprouting of fruits and vegetables also can be slowed as seen in Figure 2. The food does not become radioactive during the ionizing process any more than one's teeth become radioactive after a dental X ray. The irradiation process produces little, if any, change in the appearance of the food because the temperature of the food is raised only a few degrees (IFT 1983). There are small changes in the structural bonds that may alter the product slightly. For example, irradiated dried peas and beans cook faster than the conventionally dried product, and irradiated meat is tenderized. Potatoes do not turn green after exposure to light, indicating that solanin, a naturally occurring toxin, is not formed (Loaharanu and Urbain 1982).

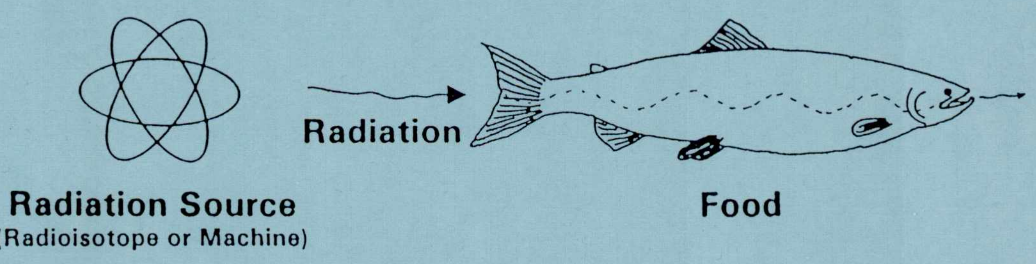

Figure 1. How food irradiation works.

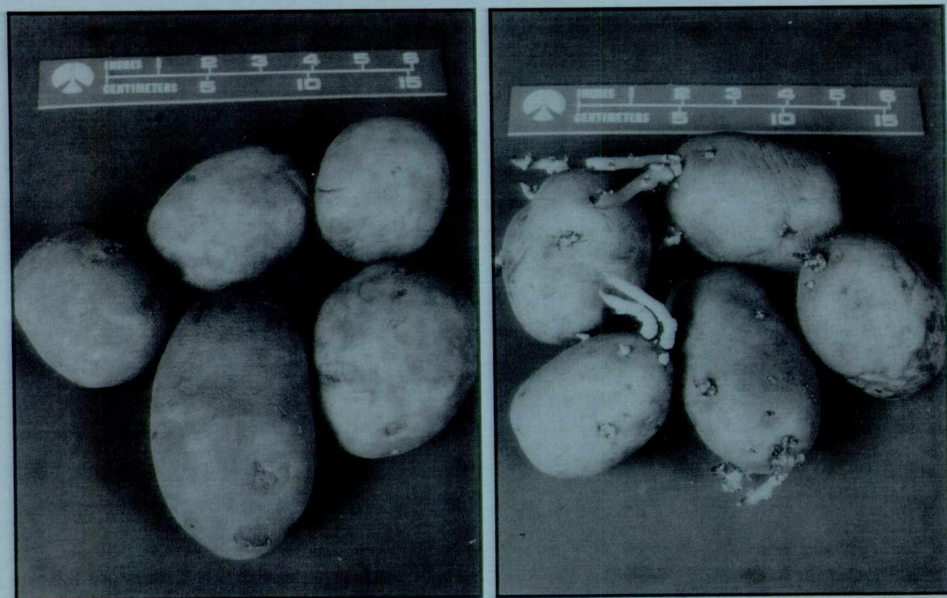

Figure 2. Sprout inhibition of supermarket potatoes stored at room temperature for one month. Control samples that received no additional treatment have sprouted after the one month storage period. Treated samples have not sprouted (Photographs courtesy of H. Farrar, IV, and G. Subbaraman).

LABELING

Foods treated with irradiation look like, or in some cases look better (Bruhn and Noell 1987) than, traditionally handled foods. Unlike foods preserved by some other processes, labeling is required in the United States so that the primary purchaser is aware that the food has been processed by ionization (FDA 1986). The logo in Figure 3 is the international radura (irradiation) symbol used for labeling.

There are labeling guidelines for all irradiated foods sold directly to consumers. At the present time, one of the following statements must accompany the radura logo: 1) "treated with radiation," or 2) "treated by irradiation." Such unpackaged products as potatoes or papayas must either be labeled individually, on the bin, or with a counter sign or card at the point of purchase (FDA 1986). When combination food products like cake mixes and salad dressings contain irradiated ingredients, such as spices, the package does not have to be labeled. Small quantities are involved, and it is considered obvious that the product has been processed in some way (FDA 1986).

Any product that is irradiated prior to wholesale distribution must also be labeled. This regulation is to prevent the reirradiation of foods during processing. The FDA allows a product to be irradiated only once, no matter how small the total dose would be. The statement "treated with radiation, do not irradiate again" or the statement "treated by irradiation, do not irradiate again" is required (FDA 1986).

Figure 3. Radura logo required for labeling (FDA 1986).

CURRENT USES OF IRRADIATED FOODS IN THE UNITED STATES

The FDA determines what food products can be treated with ionization and at what levels and for what purposes in the United States. The agency has approved ionization treatment of the food products in Table 1. Poultry and fish are not presently on the approved list. Because of the presence of Salmonella, a common source of food-borne illness (food poisoning), and increased awareness of the high levels of this and other disease-carrying bacteria present in products reaching retailers' shelves (Kampelmacher 1985), a petition has been filed to allow irradiation of poultry (Josephson and Brynjolfsson 1987, USDA-FSIS 1986). A petition to allow irradiation of fish for commercial sale is expected in the near future.

The FDA's approval for some food products dates from the 1960s, although the average American consumes little irradiated food. This is not true for American astronauts who began eating irradiated food in outer space during the Apollo missions (IFT 1983). In at least one United States hospital, patients who cannot tolerate disease-carrying organisms, consume irradiated foods. Foods eaten by these patients range from pastry and bread products to beverages and are preferred over the alternatives because they have normal appearance, taste, and texture (Aker 1984).

Table 1. Foods approved for irradiation in United States.

Food	Year Approved	Purpose
Wheat, wheat flour	1963	Insect control
White potatoes	1964	Sprout inhibition
Pork	1985	Trichinella spiralis control; parasite causes trichinosis
Dehydrated herbs, spices, seeds teas, vegetable seasonings	1986	Kill insects and control microorganisms
Fresh fruit and vegetables	1986	Insect control; Maturation inhibition

(Lecos, C.W. 1986, FDA 1986.)

Irradiated spices and dehydrated vegetables are the only food items that are likely to be consumed by the general public. There is some speculation that irradiated fresh fruits and vegetables may reach supermarket shelves in the near future. In test markets, southern California consumers purchased 13 pounds of conventionally processed papayas versus 150 pounds of labeled, irradiated papayas during a one-day sale period (Bruhn and Noell 1987). The papayas were displayed side by side in supermarkets, and consumers were encouraged to ask questions about the process and to taste the papayas. Labeled, irradiated mangoes also sold well in Florida (Puzo 1986). Appearance and quality of these tropical fruits encouraged consumer purchases in these markets. Although response was positive in these market tests, extensive market testing of irradiated food products has not been done in the United States. Despite its limited use with food products, many products that American consumer s use every day are irradiated. A few representative examples are listed in Table 2.

Table 2. Commonly used items that are irradiated in the United States.[1]

Baby bottle nipples	Nonstick cookware
Tampons	Baby Powder
Water	Food packaging materials
Food containers	Cosmetics
First aid packs	Burn ointments

[1] 40 irradiators are operating in the United States (Markovic 1985).

FOOD WHOLESOMENESS

Food safety, or wholesomeness, is a major concern for the consumer and the food industry alike. For that reason, a major emphasis of food irradiation research and development during the last 40 years has been the safety issue. Foods treated with irradiation are considered safe to eat if: 1) no significant toxic effects or radioactivity are produced in the food product by processing, 2) nutritional quality is not significantly decreased when the irradiated food is compared to the fresh product or the same food processed using traditional methods, and 3) harmful microorganisms and microbial toxins are not present.

Toxicological Safety

Consumers frequently confuse irradiation with radiation and radioactivity, and fear that irradiated food is radioactive. However, exposing foods to low-dose ionizing energy will not make the food radioactive, and the consumer is never exposed to radiation (Josephson and Brynjolfsson 1987).

When foods are treated with ionizing energy to kill microorganisms or delay sprouting, a few (6 out of 10-million) chemical bonds are broken in the foods, producing new compounds. These compounds produced from the food's natural components are known as radiolytic products. Low doses of ionizing energy create very small amounts of these compounds. Some consumers fear that these compounds are unnatural or hazardous (Josephson and Brynjolfsson 1987). In fact, most of these radiolytic products, including free radicals, have been found in the same or other foods. Some of these products are produced when foods are cooked or processed using traditional methods. Trace amounts of other radiolytic products that are chemically similar to natural food compounds also may be formed (FDA 1986). Recent studies in which humans consumed irradiated foods revealed no need for concern (Brynjolfsson 1987). Similarly, no ill effects have been reported among individuals who have eaten irradiated foods as part of a daily diet.

Nutritional Quality

Under today's processing conditions, low-dose ionizing energy preservation has little effect on the overall nutritive value of the food. Carbohydrates and proteins retain their nutritional quality. Fats also are relatively stable, although a slight loss of unsaturated fatty acids may occur with storage. This loss is similar to that found after wheat is ground, and its effect on nutritional quality is insignificant. Nutritional quality of iron, calcium, and other minerals is not affected by irradiation. Some vitamins such as riboflavin, niacin, and vitamin D also are very stable. However, levels of others, including thiamin, vitamin E, and vitamin A, may be reduced, but not any more so than by other commercial processing methods (IFT 1986, Josephson et al. 1978). In some cases, nutrient retention may be enhanced when ionizing energy preservation is used instead of other commercial processes (IFT 1986).

Microbiological Safety

Spoilage and disease-carrying microorganisms are reduced by ionizing energy preservation. Shelf-life is extended, lowering food losses when spoilage microorganisms are reduced (Loaharanu and Urbain 1982). Levels of disease-carrying microorganisms, such as *Salmonella, Campylobacter jejuni,* and *Clostridium perfringens* also are lowered, reducing potential health hazards and monetary losses due to illness (Josephson and Brynjolfsson 1987, Kampelmacher 1985, USDA-FSIS 1986). However, foods treated with low-dose ionizing energy are not sterile, so proper handling and storage continue to be very important to prevent multiplication of surviving microorganisms. The USDA is developing guidelines to ensure that irradiated meats and poultry are handled safely and properly during processing (Engel 1987). Other foods must be handled according to FDA's good manufacturing guidelines (FDA 1986).

International Opinions

The United States Congress, like many consumers, expressed concern about the safety of irradiated foods as interest in this process has been renewed in the last several years. As a result, that body requested a scientific review of research, both pro and con, conducted on food irradiation. Four years later, a report was issued which concluded that:

> from all the available scientific evidence foods exposed to ionizing energy under the conditions proposed for commercial application are wholesome, that is, safe to eat. Their nutritional adequacy compares favorably with that of fresh foods or with that of foods processed by well established conventional methods. (CAST 1986).

In addition, the FDA completed an extensive review prior to the recent approvals of additional foods for irradiation processing (FDA 1984, 1986). The American Medical Association has also endorsed the process for foods (AMA 1985).

Similar studies have been conducted worldwide. British scientists concluded that irradiated foods were safe, wholesome, and nutritious (ACINF 1986) in a study requested by the Ministry of Health. The Canadian government (1987) also concluded that "food irradiation is effective and does not pose a hazard to health." Earlier, the World Health Organization of the United Nations issued a report stating that food irradiation was safe at approved levels (WHO 1981).

The current international standards and a code for operation of food irradiation facilities were adopted in 1983 by the Codex Alimentarius Commission (CAC) (CAC 1984). The CAC is a United Nations body that sets international standards to protect consumers, facilitate international trade, and aid developing countries.

THE IRRADIATION FACILITY

The construction of a facility or facilities in Alaska to irradiate food products is a potential new use of a radiation source in the state. However, the use of radiation sources in Alaska is not new. There are numerous sources located at various sites throughout the state (Heidersdorf 1987). All facilities utilizing X rays whether in dentist offices or airport security stations employ radiation. This radiation energy is generated electromechanically. Gamma radiation sources are used by Providence Hospital in Anchorage to provide radiation therapy services and are also used for research and industrial purposes at various locations in-state. Many of the questions and concerns expressed about the location of a food-irradiation facility in Alaska center on the type of source that will be used, design of the facility, regulations regarding transportation of the radiation source, and geologic elements influencing location of a facility.

Ionization Source

Ionizing energy used in the irradiation of food can be generated by machine sources or gamma radiation sources. Machine sources include high-energy electron beams and X ray photons. Cobalt 60 and cesium 137 are potential gamma radiation sources. The technology using both types of sources is not really new, although more recently, gamma sources have been preferred for food irradiation. Only limited amounts of cesium 137 are available, and the production of more is unlikely. Adequate supplies of cobalt 60 are anticipated in the future (Sloan 1987). However, machine sources also are currently used in food irradiation facilities in several foreign countries. Electron beam accelerators and X ray photon machines also are routinely used for sterilization of medical products and food containers; crosslinking of plastic and rubber materials; and the curing of inks, coatings, and adhesives on a wide range of packaging materials, including those used for food.

There are both positive and negative aspects associated with each type of source. High-energy (10 MeV) electron beams do not have the penetrating capability of X rays or gamma sources, which may be a problem if conventional handling and packaging procedures are used. This problem may be overcome by using X rays rather than high energy electron beams. The penetration capability of X rays at levels used for food irradiation is slightly higher than that produced by the gamma source, cobalt 60. An in-line X ray converter may be used to increase the penetration of electron beams. However, the conversion to X rays can drop the efficiency of high-energy electron beams by as much as 92 percent (Rodrigues 1985). The advantage of machine sources is their relative safety. Transportation concerns are moot because there is no isotope source to be transported and locational concerns such as geologic factors are minimized (Rodrigues 1985). If the safety of the machine is compromised it is turned off.

Photon emissions from a gamma radiation source are shielded by lowering the source into a pool of water or into a lead cask that acts as a shield (United Fresh Fruit and Vegetable Association 1986).

Transportation and Security of the Source

If machine-generated ionizing energy is used for food preservation, transportation safety is not a concern. However, consumers frequently express concern about transportation of gamma radiation sources. Regulations and procedures for transporting gamma sources in Alaska are in place (18 AAC 85.320) because these sources are currently used for medical, industrial, and research purposes in the state. The regulations regarding intrastate movement and storage must be as stringent as those for interstate transport (U.S. NRC 1984). Interstate transportation of all radioisotopes is governed by the United States Department of Transportation (DOT) as well as by the Nuclear Regulatory Commission (NRC).

Both cobalt 60 and cesium 137, the gamma radiation sources commonly used in food irradiation facilities, are transported to and from facilities in specially designed casks which have been rigorously field tested. Films of these tests show the cask intact after being dropped 2000 feet on its most vulnerable point. There were no leaks in the cask after a freight train that was transporting it was rammed against a barrier, nor after the truck trailer on which the cask had been placed melted in a fire.

Irradiation Facility Design

A typical design of a commodity irradiation facility is shown in Figure 4. This design is similar to a commercial potato irradiator that has been operating in Shihoro, Japan, since 1974 (Kameyama 1985). It uses cobalt 60 as a radiation source, although the basic design would not change if a machine source had been used. Among the 133 irradiation facilities operating worldwide, 71 use cobalt 60 as a source. Plants are operating in 41 countries ((Markovic 1985).

At the center of the irradiation chamber is the source (1). The source chamber is completely shielded by concrete walls, ceiling, and floor (2). Commodities to be irradiated are placed in containers and loaded onto the entrance conveyor (3) that carries them into the irradiation chamber, past by the source (4), and out of the chamber (5). This process irradiates one side of the commodities. A turntable (6) rotates the containers 180 degrees and the process is repeated. The containers are then removed at the exit point (7). All functions are performed by an operator from the control room (8) outside the irradiation chamber and can be viewed through a window (9).

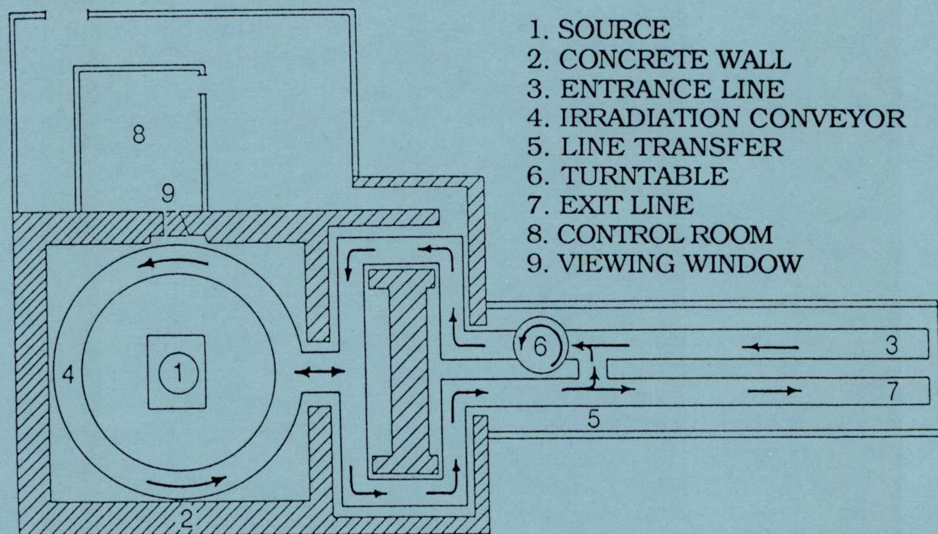

Figure 4. A typical food irradiation facility (Adapted from: Kameyama 1985).

Facility Safety

There are three safety components within an irradiation facility: shielding, ventilation, and interlocking. Shielding must fully surround all ionizing areas. The amount of shielding (e.g., concrete or earth) necessary in a facility using a machine source is less than that necessary in a facility using a gamma radiation source. This is because the auxiliary equipment used to generate the radiation can be housed in a minimally shielded area outside the fully shielded irradiation chamber (Ramler 1982, Rodrigues 1985). Ventilation of the irradiation chamber disperses trace amounts of ozone and nitrogen oxides that are produced during the irradiation process. Personnel entry is delayed until the dispersal is complete (Martin 1982, Ramler 1982). Interlocking is a key design factor in facility safety. Mechanical, electrical, and remote-radiation monitor interlocks are combined with complex mazes and visual/auditory warning signals to sense any mechanical or human violations. If violations occur, machine sources are automatically and immediately deactivated (Ramler 1982), and gamma radiation sources are lowered into the storage water pool or cask (Martin 1982).

When machine-generated X rays are used, the state of Alaska is responsible for the radiation facility. All radiation facilities in state that are not licensed by the NRC must be registered with the Alaska Department of Health and Social Services (Heidersdorf 1987). The NRC is the lead agency for the licensing of facilities using gamma sources. Rigid standards, regardless of source, are set for leak testing, radiation detection, personnel dose monitoring, waste disposal, operational procedures, training, emergency procedures, and a radiation safety program (Jarrett 1985).

Solid or liquid waste disposal is not a routine function in the irradiation process, regardless of source type. Spent gamma sources are returned to the seller for disposal (Martin 1982). If the cooling water in a plant using a gamma radiation source was accidently contaminated, it would first be contained and then cleaned up at the site or transferred to an authorized agent for cleanup and/or disposal after containment (U.S. NRC 1984).

Regardless of design, the safety of a facility depends on the human factor. Because of this, trained "health physicists" are in charge of on-site safety. These professionals have applied to and been examined by a national certification board that evaluates the candidate's training and qualifications (Martin 1982). Health physicists supervise and monitor all aspects of a facility, including personnel. Alaskan regulations covering general radiation safety and allowable exposure to workers and the public have been established (Heidersdorf 1987).

Environmental Factors Determining Plant Location

Many factors such as commodity production and harvesting areas, transportation networks, potential impact on local communities, and the projected major use of the facility will determine possible locations for an Alaskan irradiation facility. Final site selection and eventual construction will be influenced by environmental concerns. Seismic and volcanic activity, potential for groundwater contamination, and the presence of permafrost are considerations in the location of a facility employing a radiation source in Alaska. A detailed geotechnical exploration program would be conducted at a proposed site before final site approval.

Earthquakes are an important consideration because the state's southern coastline is part of the circum-Pacific seismic belt. The damage caused by the 1964 earthquake in Alaska has been widely documented (Eckel 1970, Hansen et al. 1966). Alaskan seismic shock zones are identified in the Uniform Building Code, the continually updated engineering criteria for safe building construction (International Conference of Building Officials 1976), and stringent design standards have been developed for facilities that employ radiation sources (ANSI 1984).

Most of Alaska's volcanoes are located along the Aleutian Chain and on the Alaska Peninsula, the location of many of the state's coastal fishing ports. This poses an obvious local hazard, but volcanoes can also have a distant effect because of falling ash, dispersion of gases, and the potential for tsunamis. Potential sites should be outside of potential distant hazard zones if possible (Davies 1987).

Although some tsunamis are generated by volcanic eruptions (Swanson and Kienle, in press), most are created along Alaskan coastlines by earthquakes. The Alaska State Division of Emergency Services has published a series of hazard maps outlining possible tsunami run-up for many coastal communities (Davies, 1987).

Groundwater maps have been developed for several Alaskan locales. The depth to the aquifer as well as soil conditions are factors in determining potential sites for an irradiation facility. Permafrost, or perennially frozen ground, is found in most parts of Alaska. It is continuous in the northern region, becoming discontinuous in interior Alaska and fragmented toward the southern boundary of the state. The coastal regions along the Gulf of Alaska are free from permafrost (Hartman and Johnson 1984). Although successful facility designs have been developed to erect structures on permafrost terrain (Permafrost, 1983), the best alternative is to avoid a site with permafrost.

Table 3. Some Alaskan commodities that may benefit from irradiation processing.

Food industry	Commodity
Seafood	Halibut
	Other groundfish
	Salmon
	Crab
	Shrimp
	Defatted fish meal
Agriculture	Reindeer
	Domestic red meats
	Meat processing by-products
	Potatoes
	Cole crops
	Carrots
	Cut flowers
	Animal feeds

Seafood Industry

Alaska's seafood industry, the state's largest private industry employer, produces 25 percent of the entire value of fish and other seafood landed in the United States. Kodiak and Dutch Harbor are among the ten largest fishing ports in the country. Alaska's fishing industry continues to grow, pioneering new fishing grounds and developing new fisheries and product forms (Johnson increasing and maintaining fishing stocks, ensuring that a viable renewable-resource industry continues to flourish. However, these programs have also been responsible for establishing very short fishing seasons for some species. Halibut season, for example, typically lasts several hours to several days (Johnson 1986). Unlike most other Alaskan fish, about 50 percent of the halibut harvested is sold fresh (Babbitt 1987). These short harvesting seasons have resulted in gluts on the market, reducing price and quality of the product sold (Johnson 1986).

Much of the seafood processing is now done through joint ventures. In joint venture operations, United States fishermen harvesting fish in Alaskan waters supply foreign processors with their catch (Johnson 1986). The incomes accruing to Alaskans are limited to the ex-vessel value of the fish. A further reduction in the value of total fish products occurs in many Alaskan fishing communities, because the seafood processing "waste" is dumped into the ocean (Monsen 1987). This also creates potential environmental hazards and potentially reduces the value of the total fish landings (Lewis and Lewis 1982). These post-processing fish by-products can be important food sources in the animal feed (Brundage 1986) and animal health products industries (Tsuji 1983).

Agricultural Industry

Agricultural producers in Alaska market their products largely within the state. Milk, potatoes, cole crops, reindeer meat, and cut flowers are among them. The surface transportation system in Alaska has never been tailored to movement of agricultural products within the state or to markets outside the state (Lewis and Thomas 1982). Furthermore, the only land transportation network is in the central area of the state and primarily serves Fairbanks and Anchorage, the largest population centers (Lewis et al. 1987). Shipment of fresh food to areas outside this network is always by air. Nonperishable, bulk items are transported to central collection points by coastal barges that operate seasonally. Freight is then shipped from these coastal ports inland on the river system (Lewis and Lewis 1982). The short production season for fresh-marketed crops limits the time for sales and the share of the annual market held by Alaskan products. (Lewis and Lewis 1980).

Products of the agricultural industry in Alaska that are not currently marketed are slaughter plant by-products. These by-products are presently discarded, thereby reducing the total value of slaughter plant output. In plants outside Alaska, by-products are used extensively in the pharmaceutical, cosmetic, and animal feed industries (AECL 1987). An exception is animal hides. Presently, small lots of cow hides are salt-cured and sold out of state. This practice is more common for reindeer hides but only because of their high value as a novelty item.

Benefits to Food Industries and Consumers

There are a number of potential benefits that could accrue to both the seafood and agricultural industries and to Alaskan consumers by extending the shelf-life of higher-valued products and increasing the value of currently discarded by-products. Products could be in transit to markets for longer periods of time, allowing known markets that cannot now be served economically to be reached. This could benefit the seafood industry specifically by increasing Alaska's share of the premium fresh-fish market outside of the state and by increasing the availability of fresh fish in Alaskan markets. It may also allow fresh Alaskan reindeer products to enter the growing national and international game meat markets.

Cost of transporting products to existing markets could be reduced if fresh products could be shipped over longer distances using surface rather than air transportation. This is a potential benefit to the seafood industry because of Alaska's remote location. The agricultural industry also could benefit because of the limited surface transportation system within the state. The Alaskan consumer, who currently pays high prices in the grocery store (University of Alaska Coop. Ext. Service 1987), should ultimately benefit from the lower transportation costs.

The quality and availability of foods in rural Alaska could be improved. Selection in these areas is frequently limited and costly (Nowak 1975, University of Alaska Coop. Ext. Service n.d.). Products shipped fresh, particularly vegetables, are handled at multiple points and are sometimes held for lengthy periods, thus reducing product quality and increasing costs, even when air transport is used. Other products are frozen prior to shipment and, unless care is taken, thawing and refreezing can occur (Lewis and Lewis 1980). Availability in rural markets with limited access also may be improved if less perishable products could be locally stored for longer periods of time. Lengthening the shelf-life of fresh products could thus benefit rural Alaskan consumers by improving product quality and providing an alternative to freezing as a preservation method.

Product safety for all Alaskan consumers may be improved. Ionization increases the shelf-life of foods by decreasing the numbers of spoilage microorganisms present. Simultaneously, levels of naturally occurring disease-carrying microorganisms are reduced. Reduction of these pathogenic microorganisms of public health concern would allow Alaskan consumers to enjoy a safer food supply.

Vegetable producers would be able to increase their acreage in production and their share of the fresh market if it were possible to hold products for longer periods of time. Similarly, increasing the storage period for fresh seafood could aid the seafood harvester by reducing market gluts, controlling price fluctuations, providing more consistent supplies, and reducing spoilage due to oversupplied markets. Market potential of underutilized but desirable fish species with a shelf-life too short to allow transporting to market may also be improved.

Marketing of underutilized or discarded by-products could increase the value of the product line now marketed by Alaskan food production industries, while improving environmental quality control. Irradiation of seafood and animal slaughter by-products would reduce naturally occurring disease-carrying organisms, potentially increasing the value of these products. When these by-products are used in in-state production of animal feeds (Brundage 1986), the Alaskan consumer may directly benefit from a safer (Van der Schaaf and Mossel 1963) and less costly food supply (Husby 1987, Husby and Wooding 1985). Alternatively, locally produced or imported animal feeds used in Alaska could be irradiated, reducing potential pathogens (Mossel et al. 1968). Animal hides other than reindeer could be marketed on a more frequent basis if quantities sufficient for economical shipment outside the state or for in-state use could be stockpiled. This cannot now be done because of the erratic nature and wide dispersion of the supply.

Process Cost

One important consideration is the cost of the irradiation process. How this cost compares to the cost of conventional preservation processes is an important factor determining its eventual use. In the case of fresh products, the cost will obviously be higher than doing nothing to the product. However, most commodities, even when marketed fresh, have been processed to some extent. Thus, improved product quality may warrant a price increase that would be acceptable to the consumer. It is possible that this potential processing cost increase may be offset by lower transportation costs. For example, if surface rather than air transportation can be used to reach markets that are currently only accessible by air, a substantial savings may result.

SUMMARY

Treatment of Alaska-produced food products by irradiation may benefit the seafood and agricultural industries by opening new markets both in Alaska and worldwide. One major use of this technology is to extend shelf-life so that products can be shipped greater distances as fresh products without degradation of product quality. Thus, food irradiation may allow Alaska to capitalize on existing strengths and overcome existing limitations. The Alaskan consumer's quality of life also may be improved if availability, safety, and quality of food products is improved by the irradiation process. In addition to extending shelf-life, ionization will also decrease microorganisms of public health concern, providing a direct benefit to the consumer.

This process has been reported by national and international organizations to be effective and safe. Regulations regarding its use have been established. Required labeling of irradiated food products will allow individual consumers to make informed choices among available products. Consumers in many countries are already eating irradiated foods and using irradiated medical, cosmetic, and household products everyday.

Can the food irradiation process benefit Alaska? Although there are potential benefits, much is unknown about the applicability of the process to Alaskan commodities and its acceptability by the Alaskan consumer. Potential social and economic benefits and risks as well as the costs of using the process in Alaska on Alaskan products will determine if this process is adopted.

FURTHER READING

For more detailed information about specific topics addressed in this publication, please consult the reference list. To aid the interested reader in finding this information, the references cited under major topics are listed below.

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