TEN PER CENT MORE GRAIN

At a low estimate, ten per cent of stored grain is lost every year to insect pests. In this article, based on a lecture given earlier this year in Switzerland, Dr. Harry E.Goresline, Food Radiation Specialist of the Food and Agriculture Organisation, now assisting the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, explains how use of radiation can help to prevent losses and the research which has taken place to ensure its safety.

The problem of insects attacking his storages of food has been with man from his earliest times. Many elaborate and devious methods were devised and practiced over the years but heavy losses of foods to his insect enemies remained until very recently. The development of chemical insecticides seemed to make it possible to exercise a high degree of mastery over the situation. However, it later came as a great shock to find that through some loop holes in nature's processes some insects were able to develop a high degree of resistance to most of the "safe" chemicals that could be devised. This situation set off a new search and that is how ionizing radiation happened to come into the picture.

As long as there was plenty of food available for the family and the population man seemed content to allow insects to claim a certain portion of his food supply. Even in populations which can afford chemical insecticides there are still losses, mostly because of indifference to the situation. It has been conservatively estimated that on a world basis, after harvest, 10% of the food grains stored by man are destroyed or fouled by insects. This could in many cases mean the disappearance of thousands of tons of cereal grains with the result of lowering the supply available to nourish the populations in many countries.

Recently it has become increasingly evident that we have entered on a collision course between the population explosion and man's ability to produce food by conventional means. It is likewise evident that we can no longer tolerate insect destruction of our food supplies. It is a drain upon the food resources and the economy that must not continue. It saps the fertility of the land, causes land to be used for no useful return, wastes the labour of the farmers and causes nutritious food to disappear before the outstretched hands of starving people.

During the 1950's it became increasingly apparent that ionizing radiation might play a role in solving certain problems of food infestation. Early work involved the effect of radiation on different groups of insects and on the different stages in the life cycle. During the early 1960's P.B.Cornwall and co-workers at the Wantage Research Laboratories in the United Kingdom worked out the basis for effective control of insect populations in grain by the use of low doses of Gamma radiation. It was found that doses as low as 16,000 rads (a rad is a unit of radiation dose) caused death and sterility in most of the insects of importance in stored grain. By exposing a variety of insects to radiation treatment they showed that (1) adult insects could be killed, (2) adult insects could be made sterile, (3) insect eggs present in grain could be prevented from hatching, (4) insect larvae would not complete the life cycle, and (5) insect pupae would not emerge as adults and if some were ready for emergence at the time of radiation they were made sterile. These and many studies by other workers paved the way for practicable demonstrations of how such a method might be applied to the conservation of stored food products. At the present time grain and other edible seeds is receiving the most attention but there is also considerable potential for handling insect problems in dried fruits and vegetables, dried fish, prepared cereals, mixes, and many packaged goods that are classed as staple items.

It must be made clear that radiation treatment is not a panacea for all the problems of controlling insects and that it is complementary to present practices and the use of insecticides. It can take its place in the treatment of certain products where it offers something useful and can be competitive in cost, convenience and effectiveness or offers something no other method supplies.

SAFETY QUESTIONS AND ANSWERS

The question of induced radioactivity in irradiated products is often raised. It can be said unequivocally that no radioactivity is induced in food products produced by officially approved methods. Radioactivity can be induced in chemical elements only by certain radiation energies. The methods approved for radiation treatment have, therefore, been restricted to low energies.

Questions are also frequently asked about the wholesomeness or safety for consumption of irradiated foods by man. Research over a 15 year period conducted by standardized animal feeding techniques employed in nutrition research, and by feeding to human volunteers, have to date shown a clear record of no toxicity or tumor production, no alteration in longevity, reproduction or physical characteristics. Such tests have been made on more than 20 representative foods of the human diet, and at levels of radiation treatment beyond that to be expected in normal treatment of food, and in no case has a statistically valid adverse effect been demonstrated. Most of these tests have been on products treated with radiation at a level more than 100 times that needed for insect disinfestation.

So far there has been no demonstrated increase in resistance of insects to radiation treatment. It is conceivable that resistance could be developed in insects that through several generations were exposed to sub-lethal doses of radiation. However, the treatment advised is one that will kill the insect, or render it sterile. Under these circumstances no new generation will develop to transmit resistance. With some chemical sub-lethal application results in increased resistance, and changes in types of insecticides must frequently be made in order to maintain control of the insects.

Research has not indicated cases of physical, organoleptic or functional changes in food products given doses of radiation that would be used for insect control. Colour, flavour and functional changes do take place in wheat flour but at doses far beyond that to be used for insect control. The destruction of vitamins, proteins and amino acids by radiation are roughly equivalent to those losses by other conventional processing methods, but only at radiation values far above the dose levels we are discussing.

One very interesting facet of the radiation treatment of insects is the secondary bonus of producing sterile insects. A partial protection against reinfestation is obtained by the fact that fertile females coming in from the outside would be inseminated with sterilized sperm by the sterile males in the treated product. Likewise, males from the outside mating with the sterilized females would produce no young. Chemical insecticides do not offer similar protection from reinfestation.

There is growing concern among public health authorities regarding the increasing amount of chemical residues being added to the human diet. Chemical treatment of grain and other products adds a certain amount to that burden. Already limits are being set by Governments for the application of chemical insecticides to food products and more drastic action can be expected to follow. One of the attractive values that irradiation treatment has to offer is that no residues remain as a result of the application of radiation to food products.

Some of the desirable features of radiation treatment are unique and unattainable by other means. For example sealed packages of dried fruit or vegetables, packaged products or flour packed in paper, plastic or tin can be disinfested by irradiation. This cannot be accomplished by the conventional means such as dry heat, chemicals, gas or steam, because these would ruin the package or the product or could not penetrate the sealed package. In wet foods radiation treatment can be carried out even in the frozen state, and parasites in raw meat can be controlled by treating the dressed carcase. Packages or boxes of dried fish, tobacco, wool, silk or other products that are commonly attacked by insects can be treated by radiation. As with any other treatment there must be adequate protection against reinfestation, either by the container or the method of storage.

ECONOMICS OF RADIATION TREATMENT

Radiation treatment is at this time expensive and will remain so until application to industry and experience brings certain costs down. The development of more economical equipment and sources of radiation will play an important role. At present the cost of application is high because every unit must be designed for its specific job and the sources of radiation are new and fabricated by hand. Until many units can be made from the same design and by assembly line methods the prices will come down only gradually.

The cost of treatment of a product like grain for disinfestation has been calculated by many technologists but is based upon best judgment. The exact cost will not be known until a commercial plant has come into operation. Costs that have been suggested indicate that for operation at 30 tons of grain per hour, for 20 hours a day, for 300 days per year, 180,000 tons could be treated at approximately 20 to 25 US cents per ton. If the throughput per hour is increased the cost per ton goes down; if the hours of use during the year go down the cost per ton treated goes up. The suggested figures indicate that at the present time radiation disinfestation can be competitive with chemical treatment.

For small lots of grain on the farm or in local warehouses or where mechanical handling is not employed the treatment of choice is by the use of chemical insecticides. Radiation treatment can only be recommended at present for installations equipped for mechanical handling of bulk grain at 30 tons per hour or greater. For other types of application it can be recommended only where sufficient grain can be assembled to make for efficient operation. In areas where insect damage is high (40% has been reported) then the 100% reduction of the insect population in an infested product becomes very attractive because of the savings involved.

POSITIVE RESULTS

There are ample research results to show that insects can be killed or controlled in many food products and that the results are 100% effective unless reinfestation is permitted. These results on the radiation treatment of foods are so positive that at the present time there are pilot plants, in being, under construction or in the late planning stage, in more than 10 countries. Each country wishes to determine the exact results to be expected in its particular circumstances. In most of the pilot plants research will involve studies on insect disinfestation, which indicates that opinions exist at many locations that the method has an expected potential.

Several designs have been prepared by competent engineers indicating in detail and cost how radiation disinfestation of grain can be integrated into

industry. One of the prerequisites for integration is that the treatment must not interfere in any way with the normal handling procedures in a grain terminal. The radiation operation is, therefore, conceived as being a separate unit through which grain is passed for treatment and may be cut in or out at will. This must be done in order to give the grain terminal the flexibility needed to adjust to different rates of intake or outlet and for making separation of different lots or qualities of grain. If the intake of grain all comes in 8 hours of the day the grain can be diverted to storage from which the irradiation unit may be fed for a total of 20 hours.

To integrate radiation treatment into an existing grain terminal requires that the radiation plant be built as a separate unit. This is because of the heavy concrete shielding required and the special handling needed for the radiation source material. It would be easier and more economical to design such a unit as a part of a new installation in which the radiation portion would be an integral part of the construction. Such an installation would be able to treat a ton of grain at less cost.

HUMAN CONSUMPTION

In nearly all countries there is legislation that forbids the sale for human consumption of any processed food commodity unless it is wholesome, safe for consumption and does not consist of inferior material. The processor of any food must, therefore, prove that products he manufactures meet the requirement of such laws. Irradiated food comes under this requirement and since the process is new it has been subjected to studies far beyond those imposed upon older conventional methods of food preservation.

Extensive animal feeding tests have been carried out on foods, including irradiated wheat, at levels of radiation treatment at and far above those expected for insect disinfestation. Three years of feeding tests on irradiated wheat, through 4 generations of animals, were carried out in the United Kingdom and the United States of America. Thousands of rats and mice were used in these tests. Similar work has been done in other countries. None of these tests have revealed any adverse effect due to the consumption of irradiated grain in the diet.

It was on the basis of such results that the Food and Drug Administration in the United States gave clearance for human consumption of irradiated wheat treated at doses between 20,000 and 50,000 rads by either Cobalt 60, Cesium 137 or accelerated electrons up to 5 MeV.

INTERNATIONAL TRADE

Many of the food items that would be treated by radiation treatment are items in which there is extensive international trade. This is particularly true of food grains in which enormous quantities of wheat are exported by such countries as Argentina, Australia, Canada and the United States. There is also a large trade in rice in the Orient. If irradiation is going to play any part in the preservation of items such as these in international trade it will be necessary for the importing countries to give clearance for consumption and to allow such irradiated items to enter into their channels of trade. This calls for legislation. Such legislation should have similar characteristics and requirements an all countries, to encourage international trade. To tailor-make one shipment to a specific requirement and the next shipment to another country according to a different requirement would cause confusion, and add to the cost of doing business.

It was to assist in the procedure of making legislation that the Food and Agriculture Organization, the Agency and the World Health Organization jointly convened an Expert Panel in Rome in 1964 to study the matter. The report of this panel, entitled The Technical Basis for Legislation on Irradiated Food, was forwarded to Member Governments for voluntary use in promulgating legislation. The idea behind this was to promote, if possible, legislation in the various countries with enough similarities in the requirements to make it easier for international trade to flourish when the time came that irradiation took its place as one of the recognized methods of food preservation.