Ag and Food Interprets

- **Liquid fertilizer men eye liquid feeds**
- **Nematocide business and research hustling**
- **Chemicals sought to aid control of wheat stem rust**
- **Defoliant demand grows with mechanization**
- **Radiopasteurization may be first use of food irradiation**

Liquid Feeds

Liquid fertilizer men are among those eyeing possibilities of promising but commercially unproved new products

THE POSSIBILITY of making liquid animal feeds and liquid fertilizer in the same plant intrigues some manufacturers in both these industries. Little liquid feed is on the market now, but at least a half dozen experiment stations and a number of feed companies are investigating them. Urea and phosphoric acid can be used in both, so feeds could be mixed in liquid fertilizer plant, and double use made of raw material storage tanks. In some areas peak demands for fertilizer and feed might occur at opposite seasons and help level off plant output through the year.

Urea Accepted

Urea is already an accepted feed ingredient (AG AND FOOD, October 1955, page 817), and a number of companies are marketing molasses-urea mixtures. But phosphoric acid is quite new in feed applications. D. Richardson and his coworkers at Kansas State, working under a Westvaco Mineral Products Division fellowship, recently announced encouraging results using phosphoric acid instead of dicalcium phosphate, defluorinated phosphate rock, and steamed bone meal as a supplemental phosphorus source in beef cattle rations. Some work has also been done with lambs.

Phosphoric acid can be used in either dry or liquid feed formulations, but so far the biggest outlet has been for liquid feeds. This has been due largely to the pioneering efforts of Frank Rawlins of Amalgamated Sugar Co., Ogden, Utah, who found phosphoric fitted in well with molasses feeds. National Molasses Co. of California makes a liquid feed for cattle and sheep containing 80% molasses with the balance made up of phosphoric acid, vitamins, and trace minerals.

Feed Service

Feed Service Corp. at Crete, Neb., has a 50 to 60 ton per day semiworks liquid feed plant at Crete, and a larger commercial plant at Lockport, La.

The company will manufacture a patented cattle feed pre-mix solution of urea, phosphoric acid, minerals, and ethyl alcohol. Pre-mix will be distributed to molasses terminals where it will be combined with molasses in various ratios—usually so final product contains 60 to 70% molasses. The ethyl alcohol speeds up metabolic rate of rumen microorganisms so that they grow faster and convert nutrients into usable forms more efficiently. Ruminants can then consume more feed and make better gains at lower cost.

Feed Service Corp.'s product is not a complete feed, since grains or other roughage must also be fed, but, like the other feeds mentioned, it can be free fed as a liquid and does not have to be mixed before feeding.

It has been fed to at least 100,000 animals, chiefly in Texas, Nebraska, and Iowa. Feed Service is concentrating on liquid cattle feeds now, but swine and poultry feeds may come later. These require a different approach because swine and poultry cannot utilize urea.

It would seem that countries such as Great Britain which now import large quantities of cottonseed meal and other protein materials would find liquid feeds containing urea especially attractive. However, there is apparently little or no interest in liquid feeds in Great Britain now.

Liquids Have Advantages

Liquid feeds—like liquid fertilizers—can be handled in bulk cheaper than solids can. Of course, handling on the farm requires an initial investment in special equipment. An advantage of liquids is that vitamins and trace minerals, which are added in very small quantities, can be more thoroughly mixed than they can in solids. Corrosion of handling equipment by phosphoric acid in liquid feeds could be a problem, but it can be overcome. If formulated improperly, fermentation of molasses could also occur. A low pH offers protection against this. Liquid feeds sometimes attract flies, but phosphoric acid tends to control them.

Mixing Equipment May Be Used

Mixing equipment in liquid fertilizer plants can be used for most liquid feed materials, but if molasses is used a different type mixer is needed. Because a variety of raw materials and finished products must be stored for a fertilizer plant, and only two or three

Nematocide Business Is Hustling

Shell's Nemagon (1, 2-dibromo-3-chloropropane) will reach full scale commercial marketing stage this year. Company officials say it can be used on some growing plants.

Carbide's Crag 974 (3,- 5-dimethyl-tetrahydro- 1, 3, 5, 2H-thiadiazine-2-thione) and Stauffer's N-521 have moved into the experimental stage on tobacco plant beds and in the field.

Stauffer's Vapam (sodium *N*-methyl dithiocarbamate dihydride) is being used commercially in the nursery and floriculture industries. Vapam shows promise for tobacco, orchard replant beds, and row crops.

Virginia-Carolina's VC-13 Nematocide (*O*-2, 4-dichlorophenyl-*O, O*-diethyl phosphorothioate), Goodrich's Nemacryl and Stauffer's N-244 (3-*p*-chlorophenyl-5-rhodanine) have reached the experimental stage.

raw materials, and usually only one finished product, are involved in liquid feed formulation, only part of a fertilizer plant would be used for feed operations.

Adding a feed product to its fertilizer line is a chancy proposition for a liquid fertilizer plant operator. Liquid feeds are very new, and the course their commercial development will take is still uncertain. In the early days of liquid fertilizer development, some formulators rushed into the new field without adequate knowledge of the chemistry or chemical engineering involved, and some operated with what is now recognized as poor financial management. "Liquid" proponents, therefore, hope liquid feeds can advance more slowly but more carefully in these areas.

"Feed Grade" Phosphoric?

Grade of phosphoric acid used may become a problem. It may be necessary to market a new "feed-grade" material with specifications intermediate between present food and fertilizer grades.

Like liquid fertilizers, liquid feeds will probably be more favored at first by the smaller, newer companies than the older, larger firms. This does not mean the larger feed manufacturers are not interested—some of them definitely are. There is just more incentive for a small outfit to try to break into a big market with something new than there is for an established company already maufacturing a successful line on a large scale.

Nematode Control

Nematologists wage war against worms that may be taking a tenth of the farmer's crop

MAN IS PITTING his brain against the lowly worm in a desperate struggle to control nematodes. And at times it looks like the worms may be winning! For only in recent years have nematodes been recognized for what they are—destroyers of more than several hundred million dollars worth of crops annually.

Considerable sums of money are being poured into the fray. USDA spends more than half a million dollars annually; it maintains a special laboratory studying golden nematode control. Florida, over a two-year period, is throwing almost $2 million into the fight against burrowing nematode. Growers and state departments of agriculture—encouraged by industry, state experiment stations, and the USDA—are joining hands to turn back the worms:

Long Island potato prowers agreed among themselves that all potatoes shipped out after July 1955 would be packed in paper bags (AG AND FOOD, March 1955, page 202–05). They're hoping to prevent export of golden nematode in soil adhering to burlap bags.

The Texas Department of Agriculture issued a quarantine proclamation against the burrowing nematode (*Randopholus similis*) in August, restricting movement into Texas of plants from Florida that might carry the pest.

California's Department of Agriculture held a hearing in December on its proposed quarantine to restrict movement of soil, plants with roots, and underground parts of plants into California from Florida, Puerto Rico, and Hawaii. Growers in California are also afraid of the burrowing nematode.

Damage to 5000 Acres of Citrus

And the fear is understandable. Burrowing nematode causes "spreading decline" of citrus; the pest has damaged about 5000 to 6000 acres of citrus orchards in Florida. Although burrowing nematode is not known to exist in Texas and California, its entry could wreck many groves. The pest also causes serious root rot in avocado trees. Without control measures or natural barriers, the burrowing nematode could infest more than 40,000 acres in Florida during the next decade. By the 10th year annual losses would jump from almost $4 million to more than $35 million. Accumulated losses would top $195 million!

Nematocide Research is Hustling

USDA workers in Florida have found that AAventa, an organic mercurial product made in The Netherlands, can be used for many bare-rooted ornamentals, although it kills citrus nursery stock. A distributor has been appointed to handle AAventa in Florida.

Another organic mercurial compound from Holland, Asbulba, has given good experimental results for control of endoparasitic nematodes in roots of ornamentals.

There is a trend towards using solid carriers (vermiculite and attapulgite) for nematocides such as D-D and Nemagon.

Researchers report that some fatty acids (in water preparations) have outstanding nematode-killing properties. These compounds are relatively safe to humans, easy to apply, and do not possess obnoxious odors.

But burrowing nematode is not the only nematode causing growers difficulty. Growers have to contend with a host of other plant parasitic nematodes, each with its own food preferences and feeding habits. Each year, new noxious nematodes are discovered.

Some problems that have remained unanswered for years, and even troubles heretofore unsuspected, are turning out to be due to nematodes. At least two cases occurred during 1954: researchers found that meadow nematode (*Phatylenchus coffeae*) causes "black root" in strawberries in Arkansas; others discovered the soybean cyst nematode in North Carolina, previously known only in Japan and Manchuria.

What Chemicals Are Doing

Growers have tried all sorts of methods to fight nematodes: cultural practices, therapeutic treatment, selection and planting of resistant crop varieties, crop rotation, inspection of planting stock, and chemical treatment. And scientists are even watching cannibal nematodes to see if they can find some way of encouraging them to feast on man's enemies.

Soil fumigants hit the market in 1945, after chemical companies had tested hundreds of compounds for their effectiveness. Three leaders emerged from the scramble: Shell Chemical's D-D mixture (dichloropropene-dichloropropane), Dow Chemical's methyl bromide, and Dow's EDB (ethylene dibromide). D-D and EDB have been sensational successes in row crops on sandy loam soils, but both have a common fault—they kill roots and murder an orchard or vineyard. Methyl bromide is deadly to humans and must be applied to the soil under a plastic cover. Until recently, the grower has had to take the bad effects along with the good.

$10 Million for Chemicals a Year

Other products are coming out on the market since specificity of nematocides has been demonstrated. Some maufacturers claim improvements in their new products; researchers have learned more about methods of applying the older nematocides. Chemical companies guard their sales figures, but experts estimate the annual volume of business at $10 million or more. About 60% of the tobacco land in South Carolina alone is now treated with more than $200,000 worth of chemicals. Sales this year are expected to exceed 1955; lower prices are being quoted in some areas. D-D, for example, dropped three cents a pound recently in California. Row treatments were more widely used in 1955 than previously; and consumption is up because of the lower per-acre cost of this type of treatment.

Many unsolved mysteries about nematodes still exist, but research is picking up at a fast pace. One point, however, is hardly disputed anymore: the farmer's bankroll gets fatter when he controls nematodes.

Wheat Stem Rust

New weapons sought to back up traditional genetic approach

In the decade ending in 1950 only four of some 230 known races of wheat stem rust were widespread in North America. Some races had subsided because of natural processes, resistant wheats had been developed for others, and wheat stem rust was essentially under control. But in 1950 a new race, 15B, began suddenly to spread. By 1952 it was the most prevalent wheat stem rust in North America and by 1954 some older races had become threatening. These events have stimulated interest in new weapons against wheat stem rust, notably irradiation and chemicals.

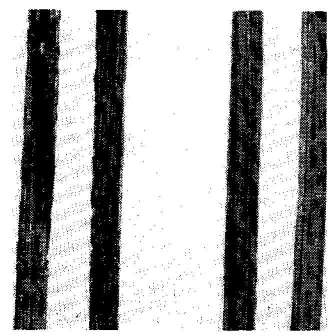
Wheat stem rust is caused by a fungus that lives part of its life on wheat and grasses and part on certain types of barberry bushes. On the barberry bush, which supports the sexual part of its life cycle, the rust can hybridize to produce new races—like 15B—whose spores can then travel long distances on the wind. The barberry bush, therefore, has been or is being eradicated in the major grain growing areas. It has been impossible, however, to eradicate it in the eastern U. S. where new rust races can still develop.

Breeding new varieties, the traditional answer to wheat stem rust, has been outstandingly successful. It yields a "painless" out for the farmer troubled by rust, and its produces progressively better wheats as well as a great deal of genetic knowledge applicable to other problems. It does take time. A new wheat must not only resist stem rust, but other rusts, smuts, and blights as well. And it must be quality wheat—in fact, breeding for quality may take more time than breeding for rust resistance.

Breeding Time Cut

Today, plant pathologists in Canada, the U. S., and elsewhere make annual surveys to detect new races of rust. If one (or more) turns up, and development of a resistant wheat is indicated, plant geneticists have a large number of variously resistant wheats to start with. (USDA alone has a collection of some 15,000 varieties from all over the world.) Greater knowledge of plant genetics, use of greenhouses, growth chambers in which five crops a year can be raised, wintertime breeding nurseries in Mexico, and winter increase of new varieties in Arizona and California—all have helped to shorten the time needed to get a new variety of wheat to the grower. During the past decade, this time has dropped on the average from 12 years to 6 years.

Since a new race of wheat stem rust takes from 5 to 10 years to spread widely, new varieties of wheat, under present conditions, should be ready by the time the rust becomes threatening. Nevertheless, although race 15B began to spread in 1950, resistant wheat was not available commercially until the winter of 1953–54 when Canadian farmers got 160,000 bushels of Selkirk seed developed by the Canada Department of Agriculture.



There are chemicals that control wheat stem rusts, but at present all are impractical because of cost, toxicity to wheat, and other factors. Marquis wheat (right) has been sprayed twice with a carbamate. Unsprayed control (left) has been attacked by rust

(Perhaps 1.5 to 2 million bushels of Selkirk seed are now available in the U. S.) And in recent months, the North Dakota Experiment Station and others have released varieties somewhat more suitable than Selkirk for U. S. wheat growing conditions.

There is some feeling, therefore, that breeding new varieties, as now practiced, is not the ultimate answer to wheat stem rust. The search for new techniques has turned to ionizing radiation among other things. At Brookhaven National Laboratory plant geneticists are using radiation to produce new varieties by including mutations in wheat. A different approach is taken at the State College of Washington where the Institute of Agricultural Sciences is attemping to use radiation to induce the excellent stem rust (and leaf rust and smut) resistance of tall wheatgrass to become part of the germ plasm of common wheat. Others are working with irradiation too, but the technique is new and practical results probably cannot be expected for some years.

Among chemicals, the nongenetic approach, sulfur (which was first used years ago) controls wheat stem rust but it must be applied repeatedly in relatively large amounts. About the same holds true for the Dithanes (dithiocarbamates), and other carbamates, although some Canadian experts believe Dithane D-14 (nabam, disodium ethylene bisdithiocarbamate) plus zinc sulfate has shown enough promise to warrant its use to some extent.

Twenty field tests in North Dakota and Manitoba, some with state experiment stations and some on large private farms, by Rohm and Haas last year, gave yield increases up to 10 bushels an acre and nine pounds per bushel test increase. This resulted where two to four applications were used at the level of two quarts Dithane D-14 plus three-fourths pound of zinc sulfate and a half ounce of spreader sticker, or two pounds of Dithane Z-78 (zinc ethylene bisdithiocarbamate) alone in 25 gallons of water per acre. With Dithanes, the manufacturer recommends application at 10-day intervals from the boot stage to the soft dough stage. Dithanes are protective chemicals and it is important to get the entire plant covered before rust infection sets in. They do not affect germination or milling and baking qualities of wheat.

Calcium sulfamate is an excellent preventative and eradicator for wheat stem rust, but it is toxic—seed from treated wheat germinates very poorly. Actidione and some other chemicals also show more or less promise but at present there is no chemical that can be considered entirely satisfactory.

A Good Chemical for Wheat Stem Rust—

1. **Should probably be systemic—able to give season-long protection with one application.**
2. **Should, if not a systemic, be usable with a good "sticker"—not yet available—that would withstand considerable rainfall without washing off.**
3. **Should, in either case, have long enough life to remain effective through the season or during prolonged storage if stem rust does not materialize.**
4. **Should not alter the wheat grain physically or chemically, leave toxic residues in it, nor affect subsequent germination of seed.**
5. **Should be applicable as dust or mist so aerial application could be used to lower cost.**

Chemicals Face Problems

Chemicals face difficult problems. A wheat stem rust epidemic cannot be predicted with any certainty more than a few weeks in advance. A chemical would have to be stock-piled in or near the growing area and would have to be rather long-lived in storage. A systemic fungicide that would give season-long protection with one application would be ideal, but it should neither affect the quality of the grain nor render it toxic. And perhaps the biggest problem is the receding price of grain, in the face of which it is difficult to promote the development of satisfactory chemicals and more difficult to sell them to the grower except in extreme emergencies. On the positive side, a good chemical for wheat stem rust might be used against

others of the eight distinct species or subspecies of rust that attack oats, barley, and rye, as well as wheat. Some of these are of major importance.

To date, then, the only weapon against wheat stem rust—and a very good one—is to breed resistant wheats. Ionizing radiation as an aid to breeding is in its infancy. Although good progress has been made with chemicals, none are available yet that could replace the genetic approach (which replacement is probably not desirable anyway) or that could be used practically during the infrequent time lag between the widespread advent of a new race of rust and commercial availability of a resistant wheat. Says one experienced man, however, "The intensive search by investigators with chemical companies and experiment stations is sure to give results in time."

Defoliation and Desiccation

Harvest-aid chemicals grow in popularity and demand with mechanization

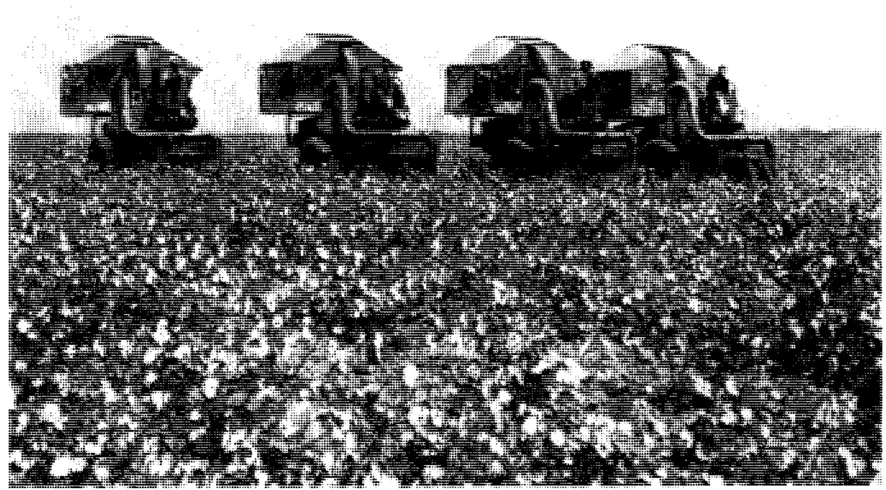
Mechanization on the farm, as in other places, has created a need for auxiliary developments to yield best results. One of the aids to farm machinery is the group of chemicals for defoliation and desiccation of crops before harvesting. Their use has caught on particularly with cotton and is spreading. Most of the products in wide use are relatively simple chemicals adapted from older uses. But during the past five years, research has been turning up some promising new materials that are beginning to appear in commercial use.

The coming of mechanical pickers made chemical defoliants a necessity to cotton planters. Success with cotton led to trials with many other crops whose harvesting would be easier if leaves and vines were eliminated. Variables such as weather and the crop itself have produced good to disappointing results with harvest-aid chemicals on alfalfa and clover seed crops, beans of all kinds, potatoes, rice, and other crops threshed or combined dry.

For most crops other than cotton (and cotton in some areas) the process is really chemical drying or desiccation. There is an important difference between defoliation and desiccation, say agricultural experts, although the same contact herbicides may be used for both purposes. When a plant is defoliated with chemicals, the process essentially is that of hastening a natural plant function—removal of leaves. When the objective is desiccation, chemicals are applied (usually in higher concentrations) to dry leaves and other plant parts rapidly.

Cotton Defoliation

By far the largest use of defoliant chemicals in the United States is on cotton and most research in the field is done on cotton. Defoliants must prepare field cotton for pickers to get the maximum quantity in one pass, and must minimize leaves going through a picker which may cause lowered grade due to stains on the lint caused by the picker's "grinding" action.



Defoliants prepare cotton for mechanical picking and open bolls to air and light

Oldest and still most used cotton defoliant in the South is calcium cyanamide, with magnesium chlorate and sodium chlorate—combined with one or more sodium borates for fire retardancy—next in importance. Since calcium cyanamide needs moisture (dew) to work, its use is limited to areas having relatively high humidities. For dry areas a new and similar defoliant just tested in 1955 was "free cyanamide" or stabilized solutions of H_2CN_2. Both agricultural researchers and its manufacturer look to considerable use of free cyanamide in 1956.

In addition to removing leaves, defoliants for cotton do other jobs. Defoliation helps to open or fluff out the boll permitting air movement through the cotton, thus drying it and reducing boll rot—cause of an average annual loss to planters of 192,000 bales over the past three years. And not to be discounted is the sun's bleaching effect, important in improving or at least maintaining good fiber color. Combining defoliation and second growth retardation for three to six weeks, amino triazole (3-amino-1,2,4-triazole) developed by USDA's Delta Branch Experiment Station, has been under test since 1952 and was used on a limited scale in 1955.

The largest part of cotton defoliants is applied by airplane in Arizona and California, but bottom defoliation—to reduce boll rot, to allow earlier first pickings, and a partial substitute for late cultivation—can only be done by a high clearance ground rig. Harvest-aid chemicals proved a boon to air applicators by providing work during an otherwise slack period. Calcium cyanamide is applied as a dust. Most defoliants are applied as water sprays, except newer desiccants like pentachlorophenol, which is sprayed on with hydrocarbon carriers.

Desiccation

Rapidly growing use of chemical desiccants for seed crops in the West, Midwest, and Southeast is aimed at compensating for weather effects. When used on seed clover, the desiccant lowers harvested seed moisture content, a distinct advantage, say growers. In England, however, experiments conducted to test desiccants for preharvest drying of cereal crops (wheat and barley) showed a decrease in over-all yield offsetting any benefit gained by hastening the decline in moisture.

Most research workers in the desiccant field indicate that success in crop drying requires tailoring the chemical to the plant, weather conditions, and crop value. Important desiccants are sodium chlorate-borate, Endothal (disodium salt of 3,6-endoxohexahydrophthalic acid), straight light oils and oil fortified with pentachlorophenol, and dinitros. For spray-curing legume seed crops in California, dinitros are used in greater quantity than other compounds. Although better for thick lush strands of alfalfa and cool weather conditions, Endothal takes three to five days longer than dinitro-oil sprays and is next in importance.

Starting from only a few acres in 1948, spray-curing has climbed to over 25,000 acres of alfalfa alone treated in 1953. High loss of alfalfa seed during harvesting often was caused by low humidity and high wind conditions, but now preharvest spraying followed by direct combining is used for over half of California's alfalfa seed production, cutting loss significantly.

Spray-curing is being used more and more on other crops. Sodium monochloracetate and chlorate-borate seem best to dry rice in the field. For flax, preharvest spraying is done with dinitros to eliminate weeds rather than to dry the crop. In Washington State potates are sprayed with arsenicals to kill vines (equivalent to an artificial frost) for early harvesting to help farmers get a better price. And in England, spraying has been used several years to kill potato haulms to make mechanical harvesting easier and prevent spreading of blight disease to the tubers at lifting time.

Chemical preharvest sprays have grown to an important place in farming in only a few years. Success with some crops has aroused interest in application to many others, but most other uses besides cotton defoliation and alfalfa desiccation are barely beyond the experimental stage. The field doesn't seem to be overpopulated and considerable development is promised within five to 10 years.

Factors Affecting Cotton Defoliation

Factors	Conditions that Favor: Good Defoliation	Poor Defoliation
Field conditions	Land level	Land not level
Stands	Stands uniform	Stands poor
Growth history	Growth rate uniform, continuous	Growth rate irregular
	Good control of insects and weeds	Poor control of insects and weeds
	Plants erect	Plants lodged
Nutrients	Fertility ample throughout season	Fertility low throughout season
	Nitrogen depleted at time of defoliation	Nitrogen level high at time of defoliation
Soil moisture at end of season	Adequate	Too low or too high
Leaves	No signs of wilt	Wilted
	Not toughened	Toughened
	Mature but active	Either immature or inactive
Maturity	Bolls mature	Bolls immature
	Little or no second growth	Too much second growth
Temperature	High, during day and night	Low, or rapidly changing from hot to cool
Humidity	Moderate to high	Low
Wind	None or low	High, continuous

SOURCE: Lamar C. Brown, Agricultural Research Service, USDA University of Arizona, Agricultural Extension Service, Circ. 203.

Food Irradiation

No breakthrough predicted, but radiopasteurization shows promise as first commercial application

RADIATION STERILIZATION has a great potential in the food industry, if viewed in a broad perspective. To date, however, there has been no break-through in any cold sterilization program. Food irradiation still poses a variety of problems. Acceptability of irradiated foods from both a nutritional and taste point of view is possibly the biggest headache. Other problems include economics of the process on a commercial scale and engineering problems related to safety.

Of the many problems involved, one is the development of a suitable technique and the establishment of proper dosage levels for food irradiation. Currently, four ranges of radiation dosage are of interest. A relatively low dose of about 10,000 roentgen equivalent physical (r.e.p.) units has been found useful in treatment of potatoes and onions for sprout inhibition and in treating grain for insect control. A dose 10 times higher has been used for radiopasteurization of refrigerated fresh meats which are to be consumed within two weeks. A million r.e.p. dose has been found useful for more intense radiopasteurization, in which all vegetative organisms are destroyed, and where the food is to be held under refrigeration for a number of weeks. The highest dose considered useful is that of 2 to 4 million r.e.p., a sterilizing dose which might be used for items like canned foods stored at room temperature.

Sterilization doses can produce undesirable color, flavor, and texture changes in food. These changes vary from product to product, and are more noticeable in animal products such as meat and milk than in vegetables. For this reason, plus the nutritional changes that may occur at very high dosage levels, use of intermediate radiopasteurizing doses is being examined with increasing interest for possible commercial application. Radiopasteurization treatment has been proposed for consideration by some of the larger packing houses, as well as by some of the larger retailers of fresh meat. Centers now investigating radiopasteurization include the University of Michigan, Massachusetts Institute of Technology, and the American Meat Institute Foundation.

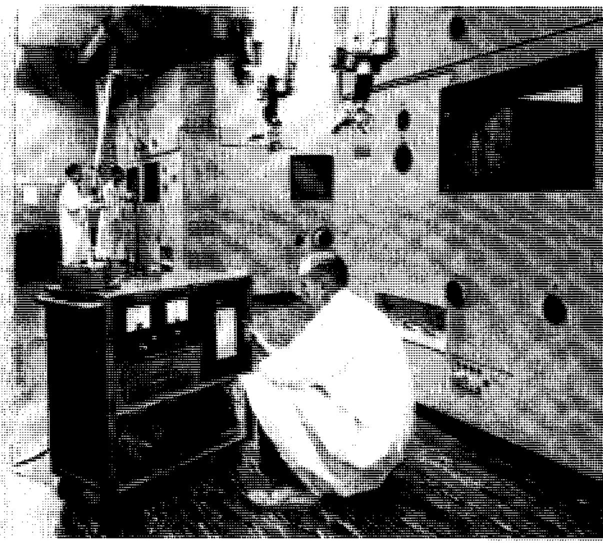
Extends Storage Life

At Michigan, limited studies have been made using a high (about 1 mega-r.e.p.) radiopasteurization dose of gamma radiation. This is insufficient to sterilize food completely, but it is enough to extend storage life. Thus, this process could not be used where growth of *Clostridium botulinum* is possible but if such growth is prevented by pH, oxygen level, or temperature control, a 1-mega-r.e.p. dose would be sufficient to preserve food from spoiling by mold or yeasts.

In the Michigan tests, smoked fish packaged in polyethylene bags was given a radiation dose of 0.8 to 1 mega-r.e.p. The irradiated fish had a good flavor immediately after treatment, and also after storage at room temperature for one month. After three months at room temperature, a rancid taste developed. Refrigeration could have delayed rancidity for several months. Tests were also made with blanched peas, string beans, and chicken. All were acceptable after two months' storage at either refrigerator or room temperatures. In all such tests, in which nonsterile food samples are to be stored at room temperature, the possibility of growth of *Clostridium botulinum* must be obviated.

The Michigan group has designed to radiation facility to radiopasteurize about 14 tons of prepackaged meats per hour. Using a cesium-137 source, the estimated cost of irradiation on this scale is less than one cent a pound.

At MIT, a 3 m.e.v. Van de Graaff electrostatic generator was used to irradiate spinach, pork sausage patties, fresh pork sausage links, ground beef, and all-beef frankfurters. Results of the study are summarized in the table.



Food irradiation facility at the University of Michigan where recent research has utilized lower cathode ray dose levels to extend the storage life of food, although the food is not completely sterilized

Recent reports of investigations by contractors for the Quartermaster Corps have shown that a partially sterilizing dose of radiation considerably increases the storage period of many fresh fruits under refrigeration. Peaches, cantaloupes, plums, prunes, grapefruit, and cherries are considered the most promising of those studied.

Radiopasteurization, or any other food irradiation program, will be of no commercial use until wholesomeness of irradiated foods has been proved to the satisfaction of the Food and Drug Administration.

Some Results of Food Radiopasteurization Studies

Item	*Preliminary Treatment*	*Cathode Ray Dose Level (r.e.p.)*	*Storage Data*
Spinach	Blanched. Packed in hermetically sealed containers	1.5×10^6	Storage life extended
Fresh pork sausage links	Packed in Saran under vacuum	1.0×10^6	Edible after 120 days at 36–40° F.
Pork sausage patties	Packed in hermetically sealed cans	1.0×10^6	Better at end of 14 weeks at 36–40° F. than when similarly packed and stored at 0° F. without irradiation
Ground Beef	0.3% sodium fumarate or 0.5% monosodium glutamate added to eliminate irradiation off-flavor. Packed in hermetically sealed container	1.0×10^6	Storage at 36–40° F. extended to about 12 weeks
Beef slices	Unable to prevent irradiation off-flavor		
All-beef frankfurters	0.25% or more sodium ascorbate added for all dosage levels to prevent irradiation off-flavor	0.25×10^6	Delayed microbial action to some extent
		1.0×10^6	Prevented deterioration for three months at 36–40° F.

Source: Based on work at MIT

Studies conducted at the University of Michigan produced no evidence that gamma-irradiated diets are not wholesome, aside from a certain amount of vitamin destruction. Work at the Army's Medical Nutrition Laboratory, Swift & Co., Columbia University, and MIT over a five-year period indicated no gross toxicity, and vitamin destruction was found to be of the same magnitude as that in heat-processed foods.

During 1955, a diet of radiation sterilized beef hamburger had been shown to have no ill effects on three generations of white rats in studies at Swift. Raw ground beef sterilized by electron radiation was used. The test covered two years, and included 2685 rats. Sterilized meat was used for about 65% of the diet for the experimental animals. Observations were made on growth rate, reproduction, food utilization, longevity, and over-all health. When compared with a control group, the conclusion was that radiation sterilization of beef does not significantly impair the nutritional value or wholesomeness of the meat. No toxic effects were observed.

The Office of the Surgeon General is supporting extensive research relating to nutritional and probable toxicological aspects of feeding irradiated foods. Consideration is being given to acute and chronic feeding experiments, carcinogenicity, effects on macro- and micronutrients, and general toxicity clearance on rats, dogs, chickens, monkeys, and human test subjects. As favorable reports continue to result from such investigations, the day of commercial pasteurization via irradiation moves closer.