Storing Meat Products
(without refrigeration)
for Several Years

Irradiation sterilization (radappertization)
can be used successfully to store ham, bacon, pork, pork sausage, beef, corned beef, chicken, codfish cakes, and shrimp for long periods under non-refrigerated conditions.

The technical feasibility of using ionizing radiations to preserve such highly perishable protein foods has been proven under the U.S. Army Radiation Preservation of Foods Programme, and technology is far enough advanced to carry this out.

Details of this futuristic foods programme were presented at an international conference of meat research scientists at the University of Guelph, Ontario, Canada, last year, by Dr. Eugen Wierbicki of the U.S. Army Natick Laboratories, Massachusetts, USA. Because preservation of foods by ionizing radiation has been part of the "Atoms for Peace" programme since its inception in 1953 the Army's programme is periodically reviewed in depth by the Joint Committee of Atomic Energy, Congress of the United States. The name of the programme, because of its wide application to civilian needs and to food industries, was changed to the National Food Radiation Programme in February, 1970.

Except for the determination of the minimum required radiation dose technology is nearly completed to produce highly acceptable ground beef (hamburger), beef with gravy, lamb and turkey.

The main objective of the food irradiation programme at this time is to prove to the satisfaction of the U.S. Food and Drug Administration, Department of Health, Education and Welfare (FDA), and to the U.S. Department of Agriculture (USDA) that radappertized beef is safe for unrestricted human consumption.

By applying recent technological advances in radiation processing (i.e. selection of radiation source, irradiation in the frozen states, use of the 12D dose* for destruction of *Clostridium botulinum* spores), the issues of induced radioactivity, excessive destruction of nutrients and hazards from botulism have been effectively solved.

The major remaining wholesomeness issues, requiring additional proof, are the absence of carcinogens, mutagens, teratogens and toxic radiolysis products in radappertized beef and other radappertized foods.

On March 1, 1971, the U.S. Army Medical Research and Development Command, after a thorough coordination with the FDA and the USDA, awarded a 54 month contract to an industrial laboratory to conduct extensive beef feeding studies with rats, mice and dogs. The study involves radappertized beef (4.7 to 7.1 Mrad at $-30^\circ \pm 10^\circ$C) preserved by both the gamma rays from a Cobalt-60 source and electrons from a linear accelerator

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* dose required to reduce the number of micro-organisms (per g.) to 10^{-12} of the original number present.

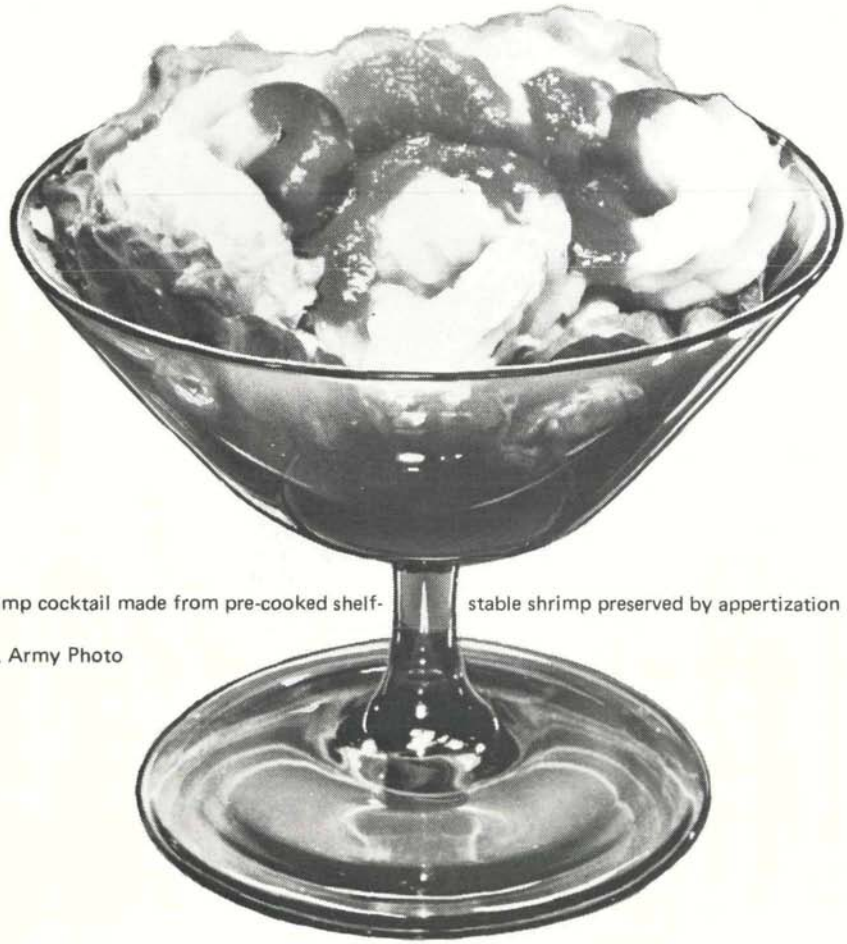
at the 12D level. Frozen beef, thermally sterilized canned beef, and a semipurified laboratory diet serve as controls. The beef accounts for 35% of the solids of the experimental diets.

The protocol involves feeding the parent generations of rodents for their entire life span and through four generations. The dogs will be on test for over three years to allow opportunity for delivery of three litters per bitch. The animal feeding studies started in 1971.

The minimum radiation doses were obtained in accordance with the 12D concept of microbiological safety.

To make the irradiated meats shelf-stable, in addition to the destruction of food spoilage microorganisms, the naturally occurring enzymes, particularly proteases, such as cathepsins, must be inactivated. The most reliable method employed so far is a mild heat treatment, or blanching, prior to irradiation.

A fast and sensitive method for the assay of proteolytic enzyme activity, if any, in irradiated meats within a few hours, instead of after many months of storage, is now available to study the shelf stability of radappertized blanched meats. This method is based on incubating meat samples (enzyme source) with ^{14}C-labelled, cysteine-treated, haemoglobin substrate and determining the radioactivity in the acid-soluble filtrate.



Shrimp cocktail made from pre-cooked shelf-stable shrimp preserved by appertization . . .

U.S. Army Photo

Two programme goals have guided progress in the packaging field:

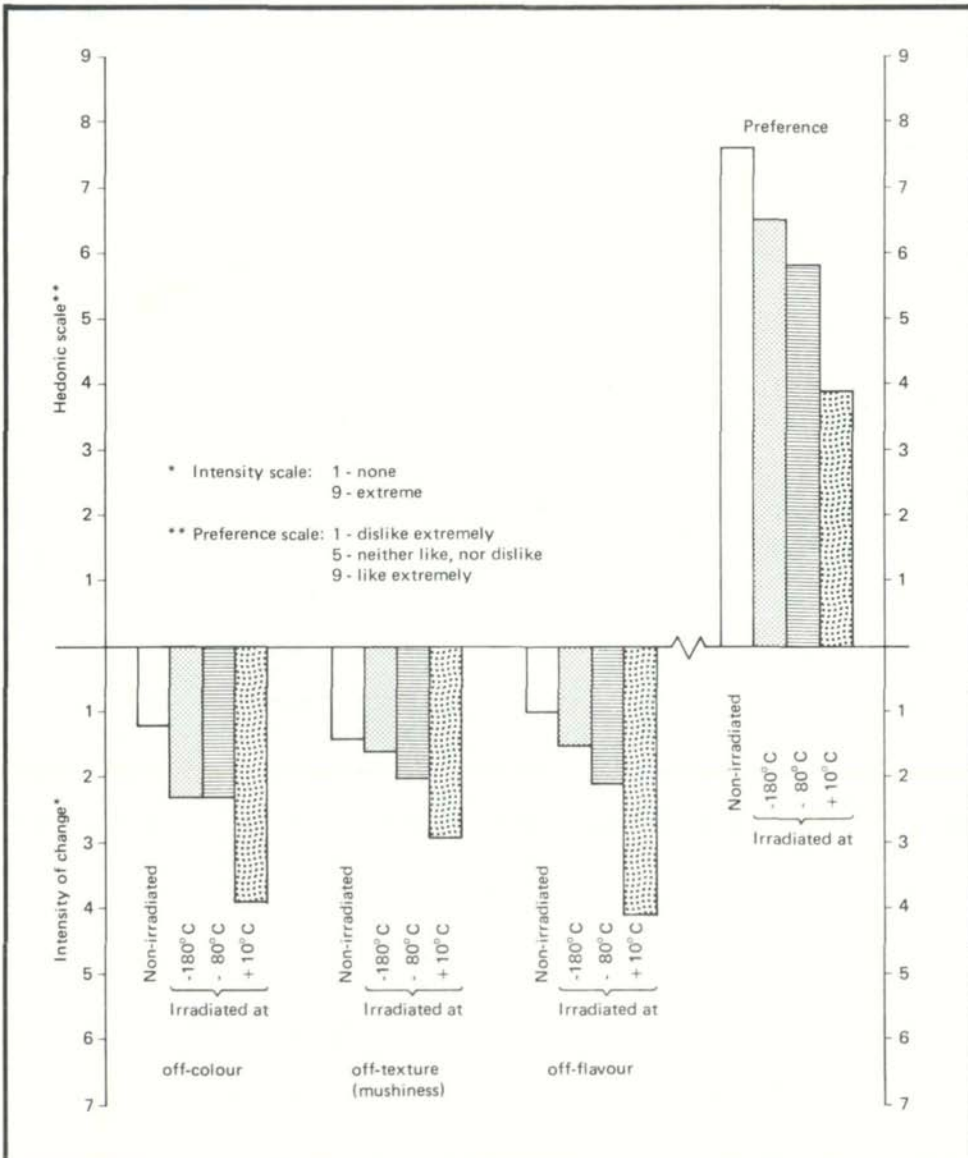
a) determining reliability of commercially available metal containers for low temperature radiation sterilization of prepackaged foods, and

b) developing flexible lightweight containers capable of withstanding rough handling and storage, retaining protective qualities during storage without any adverse effects on the food contained there in.

TABLE 1

EFFECT OF IRRADIATION TEMPERATURE ON THE SENSORY CHARACTERISTICS OF BEEF

(U.S. Choice Top Round, 4.5 - 5.6 Mrad ^{60}Co Irradiation)



There is no problem in irradiation of tinplate containers at doses up to 7.5 megarads at temperatures as low as -90°C, provided the can enamels used are of the epoxy-phenolic or phenolic types and the endsealing compounds are of the butadiene-styrene or neoprene types. Five materials were approved by the FDA as food contactants for high dose (up to 6 megarads) ^{60}Co or ^{137}Cs irradiated foods. Four food contacting plastic films (including nylon 11, not cleared as yet) are being used as components of flexible packaging in the form of pouch laminates with aluminium foil as the gas, water-vapor and light barrier.

Continued investigation of irradiation of food in the frozen state has shown that lowering the temperature to -30°C and below results in drastic improvement in acceptance over ambient temperature for most products. As shown in Table 1, improvements are significant in nearly all factors including reduction in off-colour, off-texture and irradiation flavour intensity. However, as temperatures are lowered below 0°C., higher irradiation doses are required to achieve the same degree of biocidal effect under the 12D concept. Cost increases as temperature is lowered, particularly below the limit of mechanical refrigeration which is at about -30°C. The most favourable balance of quality, cost, and required irradiation dose appears to be at about -30 ± 10°C.

TABLE 2

ACCEPTANCE OF IRRADIATED HAM WHEN SERVED AS COMPONENT OF REGULAR MEALS

(Irrad. hams stored at room temp. for 1 to 12 months prior to serving.)

Dose Mrad (+12% to +25%)	Irradn. Temp. °C (±10°C)	RECIPES	No. of Raters	Average Accept. Rating (*)
4.5	-30	Baked Ham w/Pineapple Glaze	102	6.97
4.5	-80	Baked Ham w/Pineapple Sauce	18	8.11
4.5	-30	Baked Ham w/Raisin Sauce	15	7.20
4.5	-30	Baked Ham w/Mustard Glaze	64	7.31
4.5	-30	Fried Ham Steaks	18	7.38
4.5	-30	Grilled Ham Steaks	15	8.26
3.7	-30	Baked Ham	93	7.33
3.7	-30	Baked Ham w/Pineapple Sauce	60	7.10

(*) 9-point hedonic scale: "9" = like extremely; "1" = dislike extremely; "5" = neither like nor dislike.

Ground ham was irradiated at three levels (3.0, 4.5, 6.0 Mrads) at five different temperatures (+5°, -20°, -40°, -60°, -80°C). The results indicate that as the irradiation temperature is decreased. the retention of thiamine in the product is increased.

In another study, changes in the thiamine, riboflavin, niacin and pyridoxine contents of smoked ham and pork loin were compared after irradiation or conventional thermal sterilization processing, followed by storage and preparation for serving. The results showed that, of the vitamins studied, thiamine was affected most, and riboflavin the least.

The vitamin retention of smoked, irradiated ham was proven to be as good or better after irradiation to 4.5-5.6 megarads at -80°C as it was after thermal sterilization processing. Vitamin losses during preparation for eating were negligible regardless of prior treatment. Riboflavin and niacin were stable during storage at 21°C for twelve months; however, the losses of thiamine and pyridoxine during the storage accounted for 54 and 16%, respectively.

It has been established that in order to stabilize the colour in radappertized ham, it is necessary that the curing solutions contain both sodium nitrate and ascorbate in addition to sodium nitrite. However, only about 25 parts per million (ppm) nitrites are needed, instead of the 200 ppm allowed by USDA, to get the desired cured meat colour of the product.

Sugar (sucrose, glucose or corn syrup) as an additive is not needed to get good quality irradiated cured meats.

Mixtures of about 1 percent sodium chloride and 0.25 to 0.5 percent food grade phosphates, such as sodium tripolyphosphate, have been found to be excellent binding agents both for radappertized hamburgers and for formed rolls of several meats including beef, chicken, pork and lamb. Weight loss during cooking was reduced from the normal 30-35 percent loss with no additives to 10-15 percent with these additives. All products retained their shape through extended room temperature storage and during kitchen preparation. The meat rolls may be readily sliced after reheating. Consumer acceptance approaches that of counterparts prepared from fresh or frozen meats.

For the quality evaluation of irradiated foods the 9-point hedonic scale for preference or acceptance is used. In the case of meat and poultry, the score of 5("neither like nor dislike") is considered to be the threshold of acceptability. A rating of 7 or above indicates a highly acceptable product. Table 2 shows average acceptance scores for ham irradiated in the frozen state (-80 and -30 ± 10°C) when served as a component of regular meals. These data show the high acceptance of irradiation sterilized ham. Similar data were obtained on other foods radappertized in the frozen state.

CONCLUSIONS

- *Radappertization of meat, poultry and seafood has been shown to be feasible on a laboratory scale. Fifteen foods preserved this way are well accepted organoleptically.*

- *The major remaining research problem is to obtain data sufficiently convincing to FDA that radappertized meats are safe to eat so that FDA will grant the approvals required by law. These investigations are in progress.*

- *After FDA approvals are obtained, radappertization will be able to play its role of providing high quality meat and meat products.*