DEPARTMENT OF ATOMIC ENERGY

NOTE ON "RADIATION APPLICATIONS FOR THE FOOD PRESERVATION INDUSTRY"

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Programmes of research on radiation preservation of perishable foods and disinfestation of stored grains have been in progress at the Bhabha Atomic Research Centre for some time. A number of technological and other aspects are being studied critically with reference to each type of food in order to establish process criteria, to endure wholesomeness in the irradiated food and to determine feasibility in commercial practice.

Recognising the potentials for practical application of radiation for food preservation, a Food Irradiation and Processing Laboratory has been completed at Trombay, with facilities for feasibility studies. Associated analytical, research engineering and processing laboratories will enable basic and applied investigations to be undertaken on a variety of problems peculiar to the application of radiation procedures to food preservation industry.

It is planned that, initially, programmes will be worked out to the point of usable commercial processes for (i) radiation preservation of sea-foods, especially, Bombay duck, shrimps and pomfrets and extension in their shelf life at sub-room temperatures as well as, with suitable combination treatments, at ambient temperatures; (ii) radiation preservation of poultry and flesh foods; (iii) grain disinfestion, with emphasis on wheat and wheat-flour and in relation to problems of post-disinfestation storage in bulk or in bags or other suitable packages; (iv) sprout inhibition in potatoes and onions; and (v) delayed ripening

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in tropical fruits of economic importance. Specifically, the following problems will be studied:

(i) Radiopasteurization of sea foods: Experiments have shown that, with Bombay duck, promfrets and shrimps packed in brine medium, sealed in polythene bags and exposed to gamma rays, shelf-life extension of 2 - 3 weeks at 10-12°C could be achieved; unirradiated they spoil within 3 - 4 days. Pretreatments such as blanching enhance the shelf-life of irradiated (0.25 Mrads) shrimps by 2 months at 10-12°C and partial drying enables storage even at room temperature without spoilage for 3 - 4 months. These experiments will be scaled-up and further studied for selection of tolerance doses, pre-treatment conditions such as blanching, dip treatment in salt solutions, irradiation and storage temperatures, partial drying, etc. The shifts in microflora and control of food-borne pathogens by radiation will also be investigated. Various flexible packaging materials and laminates will be examined for their suitability. The products will be evaluated for sensory and acceptability attributes and in wholesomeness tests. Extensive tests will be included on product stability during storage and transportation and on consumer preferences with different population groups.

(ii) Radiation preservation of poultry and flesh foods; Preliminary observations with dressed poultry have indicated that shelf-life extension could be successfully achieved by low dose irradiation, preferably in combination with certain permitted antibiotics or other bacteriostatic additions. These studies will be extended and the products tested for quality, shelf-life and freedom from pathogenic organisms and other parasites.

Although initial emphasis will be on protective radiopasteurization, studies will also be undertaken on absolute sterilization. Since off-odours and textural impairment in flesh foods by sterilizing doses of radiation (4.5 Mrads) could be minimised at freezing temperatures, suitable procedures will be worked out for <u>in situ</u> freezing and irradiation; pre-cooling of packaged products prior to radiation sterilization will also be attempted. Since radiation sterilized foods can be stored at room temperature for prolonged periods, the process will have especial advantages where cold storage facilities are inadequate.

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(iii) Radiation disinfestation of cereals, cereal products and premixes: In the grain disinfestation programme, efforts will now be directed to conduct large-scale trials with wheat and wheat based products, with particular attention to prevention of reinfestation during storage following disinfestation. Radiation sterilized wheat will be stored in bulk in experimental silos under controlled conditions as well as in bags and other flexible packages, precoated to prevent reinfestation.

Shelf-life, quality attributes and prevention of reinfestation in radiation disinfested and stored cereal products and premixes will also be studied, using pre-coated flexible wraps and packaging materials. Indigenously leavened and baked breads will also be studied for storage behaviour after mild irradiation or radio-sterilization, using appropriate flexible packagings.

(iv) Inhibition of sprouting in potatoes, onions and garlic bulbs: Promising results, obtained earlier on prevention of spoilage due to sprouting in potatoes, onions and garlic, will be scaled up to obtain data on large scale handling, storage and acceptability aspects; controlled conditions of irradiation will also be investigated. Storage behaviour under warehouse conditions and in the retailer's godown will be ascertained. Data will also be obtained on user reactions to the application of the procedure.

(v) Radiation-induced delay in ripening of tropical fruits. Ripening of bananas and mangoes could be delayed with use of tolerance doses of gamma radiation for up to 10 days at ambient temperatures. Protective skin coatings and controlled gaseous environment could augment shelf life still further. These earlier observations will be extended using banana varieties, prepacked as hands and bunches and with controlled cultural and environmental conditions. Similar studies will be carried out with commercially important mango varieties.

Thus, the experience which will be gained in these feasibility trials will enable successful control of factors such as handling the foods after harvest as well as during and after irradiation, packaging, dose distribution and measurement, auxiliary methods of shelf-life extension, and so forth. When these variables have been worked out for a given food and when, with the irradiation of large quantities,

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of food, distribution and acceptability studies are concluded, pilot units for operation with specific foods are expected to be set up with eventual scale up to actual commercial practice. Concurrently, necessary clearances from the Health authorities will also be sought for the successful processes.

Radiation sources for food preservation:

Two Co^{60} radiation sources have been installed and commissioned for use at FIPLY. The food package irradiator has a processing rate of 100 lb/hr at 0.5 Mrad. This source is being used for irradiation of foods, particularly fish, meat products, fruits, vegetables, cereal products and other food commodities. Through-flow irradiator has a capacity to handle 500 lbs of grains or other free-flowing material per hour at 15 Krad.

A portable cesium irradiator (100,000 curies) is expected to be installed shortly. This will be particularly useful for radiation sterilization studies with flesh foods and sea foods.

Provision has also been made at FIPLY for the installation of a linear accelerator for comparative studies relating to preservation of foods.

Food irradiation researches at Trombay constitute part of the regular research and development activities of the Bhabha Atomic Research Centre and are, therefore, planned on a continuing basis. When, as outlined above, processes emerge to the point of usability in practice, appropriate agencies are expected to be set up for production, with facilities by way of personnel and know-how which Trombay will provide.

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In the evolution of processing technology for food preservation and distribution through application of radiation procedures, it is envisaged that, during the next 5 years or so, the stage will be set for the establishment of processes for (i) preservation of sea-foods; (ii) grain disinfestation; and (iii) sprout inhibition in potatoes and onions.

Research and Development work done during 1966-67 and 1967-68 and proposed to be undertaken in 1968-1969:

The Division has initiated certain new lines of research in (a) fundamental and applied aspects of cell metabolism and (b) food irradiation procedures of possible application in practice. A report of the studies carried out in the Division has appeared in the Annual Report of the Department of Atomic Energy 1966-67, pp 34-40 and 1967-68, pp 41-44.

Progress has been made, among others, on the following research and development programmes:

(1) Metabolic factors related to radiation sensitivity

(2) Metabolic disorders in radiation injury

(3) Heterogeneity and genesis of mitochondria

(4) Control of gene function and DNA replication in micro-organisms

(5) Regulatory factors involved in pathways of metabolism

(6) Control mechanisms in animals during nutritional, hormonal and other stress states.

(7) Biochemical changes during differentiation and dedifferentiation processes such as embryogenesis and carcinogenesis.

(8) Biogenesis and distribution of storage and functional forms of Vitamins.

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(9) Post-irradiation effects and repair mechanisms with respect to gluconeogenesis, amine accumulation, nucleic acid biosynthesis and lipid metabolism.

(10) Development of radiation preservation procedures for perishables such as fruits (mangoes, guavas, bananas, etc), vegetables (potatoes, onions, peas, etc.), sea-foods (Bombay duck, shrimp, pomfrets and other local varieties), and dairy products (Cheese, Khova).

(11) Quantitative evaluation of food-brone micro-flora with reference to radiopasteurisation processes.

(12) Standardisation of sensory methods for quality evaluation of radiation-preserved foods.

(13) Nutritional and wholesomeness studies with irradiated foods using experimental rats and mice through successive generations.

(14) Compositional changes and evaluation for wholesomeness of irradiated foods.

Several papers based on the work done in the Division have been published in various scientific journals.

Food Irradiation and Processing Laboratory (Project FIPLY) has been completed and experimental programmes aimed to scale up promising radiation preservation procedures have been initiated. Other details on Project FIPLY are stated in (iii) below.

The work proposed to be carried out in 1968-69 will be a continuation of the foregoing lines of study. There has been no change from the original IV Plan 1966-71 proposals.

A perspective Plan for Research and Development work to be done during the next 10 years, i.e. 1969- 1979.

Biochemistry and Food Technology Division constituted in January 1964 is concerned with research programmes of fundamental

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and applied aspects of biochemistry, microbiology, nutrition, food science and technology and other related subjects with special reference to the applications of ionising radiations and radioisotopes. The objectives of this Division are briefly outlined below.

Food Technology: Radiation provides an effective means for food conservation through control of respiratory rate of food-borne spoilage organisms in perishables and eradiation of pests in stored grains. Programmes of research are organised with reference to ;

(1) shelf-life and storage changes in perishables such as fruits, vegetable products, sea-foods and other meat foods;

(2) Sterilization and pasteurisation of foods through judicious use of ionising radiation and other physico-chemical treatments or bio-engineering techniques;

(3) changes in food constituents and biochemical, nutritional and other quality aspects of irradiated foods; and

(4) development of feasible preservation processes based on the application of radiation procedures and design of plant and equipment for experimental and pilot-scale operations.

Biochemistry: Ionising radiations are known to cause in animals diverse metabolic disorders, induction of malignancy and shortening of life span. Life processes being essentially a sequence of biochemical events, loci of biochemical lesion in radiation injury are being ascertained by concurrent studies on -

(a) basic metabolic events in the normal cell;

(b) controlling factors for various pathways of metabolism;

(c) functional status and organisation of subcellular components;

(d) tissue differentiation and dedifferentiation processes; and

(e) biological activity of macromolecules.

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The research and developmental work enunciated above will be carried out on a continuing basis during the next ten years.

Details of Research and Development project/programmes (both Capital and Revenue) to be undertaken by Biochemistry and Food Technology Division, BARC during the new IV Five Year Plan 1969-74 inter alia indicating also the main areas for which depth studies will have to be undertaken.

The work of the Division constitutes research and developmental activity of the Bhabha Atomic Research Centre and the expenditure is met from the Revenue Budget of the Bhabha Atomic Research Centre.

The areas of research in Biochemistry, as stated in (ii) above, are aimed at eliciting information on loci of biochemical lesions in radiation injury and several lines of investigations have been already initiated as indicated in (i) above. During the Plan period these programmes will be intensified with additional approaches.

Recognising the potentials for practical applications of ionising radiations to food preservation procedures, Food Irradiation and Processing Laboratory (Project FIPLY) has been established. The project was undertaken during the III Five Year Plan period (vide: DAE U.O. No. 32/2/65/T.II(P) dated 1.11.1965) and part of expenditure against the project grant (Capital Budget) will be incurred during the initial two years of the new IV Five Year Plan period. The work in FIPLY will continue to be part of the activity of Biochemistry and Food Technology Division.

The facilities in FIPLY include laboratories for analytical, quality control and nutritional studies besides other requirements for research and development as well as various bio-engineering unit operations. Two Cobalt-60 irradiators gifted by the Canadian

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Government under Colombo Plan Aid are now installed. These are (a) a large Package Irradiator (100,000 Curies) designed to handle 45 Kg per hour at 0.5 Mrads and (b) a thru-flow Irradiator (28,000 Curies) to handle grains and other free flowing food materials at a processing rate of 230 Kg per hour.

Promising processes developed in extensive laboratory experiments (as summerised in (i) above) are now being scaled up to feasibility studies prior to possible commercial applications of irradiation procedures, particularly in respect of inhibition of sprouting of potatoes and onions, delayed ripening of fruits like mango, banana, etc. ; extension of shelf-life of fish including Bombay Duck, shrimp, etc. and disinfestation of stored grains.

It is expected that during the next two plan periods these processes will be taken up to pilot-scale and production schedules with help of concerned Ministries.

A note on the outlay required for implementing the projects/ programmes covered in the note mentioned in (iii) above supported by adequate details regarding the estimated personnel requirements, foreign exchange requirements, etc:

An yearwise break-up of the provision for implementing the programmes covered in (iii) above is given herewith with appropriate explanations for working out the figures.

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Yea rwise break-up of the provision for research and development work during the new IV Five Year Period.

BIOCHEMISTRY & FOOD TECHNOLOGY DIVISION

(in lakhs)

S.No.	Item of expenditure.	1969-70 Rs.	1970-71 Rs.	1971-72 Rs.	1972-73 Rs.	1973-74 Rs.	Total
1.	Establishment	12	13	14	15	16	70
2.	Equipment	10	8	6	4	4	32
3.	Contingencies, including chemicals, glass-ware, laboratory supplies, etc.	4	5	6	5	5	25
4.	Foreign exchange component required for 2 & 3 above.	6	5	4	3	3	21
	Total: (1 + 2 + 3) :	26	26	26	24	25	127

(See attached explanatory notes).

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EXPLANATORY NOTES

Establishment Costs: Biochemistry and Food Technology Division is composed of 12 Scientific sections, each consisting of 6-15 Scientific and Technical staff. It is envisaged that during the Plan period the activities will be expanded to 15 to 16 sections necessitating additional scientific and technical personnel. The present position (as on 1.4.1968) of the Division is 64 Scientific, 73 technical, 8 administrative and 4 supporting staff. Taking the average salary of the scientific personnel as Rs. 800/- p.m. and that of technical staff as 300/- p.m., the present total expenditure works out at approximately Rs. 9,00,000 per year. The increase in staff is reckoned at 15 (10 + 5) during the first two years and 10 (5+5) in the subsequent years of the Plan period. The estimates for Establishment are presented on this basis.

Equipment, contingencies, foreign exchange component etc : The figures tabulated are based on the actual expenditure incurred during the past two years and the budget estimates of the Division for the current financial year. Foreign exchange component shown is for items required for maintenance and replacement which include consumables like essential chemicals and biochemicals, specialised glass and quartzware, etc.; spares and accessories for the equipment already acquired, and for additional equipment anticipated to be imported during the Plan period.

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Note on "Programme of the work done and proposed, on genetic mutants".

A programme of work on the induction of mutations for crop plants was initiated in Biology Division in 1957. Initially the investigations were oriented towards the study of relative efficiencies of physical and chemical mutagens and the spectrum of mutations. Gradually farm and other facilities were provided for testing the mutants for crop improvement and the mutants obtained from the more academic type of studies were evaluated for yield and other useful characters. Some of them when tested for three or more years against their parent varieties gave yields higher than the untreated. The next stage involved the evaluation of the mutants on All India basis against standard and high yielding local varieties. Such tests were conducted through the goodwill of State Agricultural Departments but the information so obtained was either inconclusive or fragmentary to justify release of these strains. The All India Coordinated Crop Improvement Projects recently organised by the Indian Council of Agricultural Research have now included the Trombay mutants obtained in rice and groundnut in various stages of their evaluation trials.

Among the large number of mutants obtained in rice and groundnut, the following mutants which have shown promise under Trombay conditions are included in the trials.

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Rice :

TR - 1 - This mutant, obtained from variety GEB-24 with pile neutron irradiation has yielded 12 to 20% more than the control and is early by three weeks.

TR -2 - A mutant of Ptb- 10 gave 50% higher yield at Vellayani and is under trials in Kerala as Vellayani -1.

These two varieties however tend to lodge at high levels of nitrogen.

TR-5 - The mutant having good plant characters such as dwarf habit and stiff-straw is obtained from SR 26 B with combined treatment of gamma rays and diethyl sulphate. This mutant is being tested by Central Rice Research Institute to find out whether it is saline resistant like its parent variety.

Groundnut :

Six mutants (TG-1 to TG-6) obtained from the variety, Spanish Improved, are included in the Initial Evaluation Trials being conducted by All India Coordinated Oilseeds Improvement Project. One of them is a large pod mutant which has given 30% higher yield in Trombay. Another mutant short 4 is of particular interest for its capacity to bear large number of flowers in the first two internodes.

Wheat :

A wheat strain with a single added chromosome of Rye and the grasses, Aegilops umbellulata and Agropyron elongatum possesses genes for disease resistance. Radiations are employed to transfer resistance to black and brown rust into the Indian varieties of tetraploid and hexaploid wheats.

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Future Programme:

It now seems desirable and also possible to orient future work towards specific mutations which fulfil the requirements of plant breeders in India. For example in rice, mutants with good plant characters such as dwarf habit with high manurial response are needed. Since early varieties permit double and triple cropping, earliness is the prime consideration in grounnut. The broad aspects of the future programme of work are given below:-

Rice:

1. Coordinated project in collaboration with Central Rice Research Institute, Cuttack is under consideration to evolve dwarf mutants in high yielding varieties of CRRI.

2. A contract with International Atomic Energy Agency is drawn up to carry out research work on the effects of fast neutrons on crop plants. Apart from studies on dosimetry and radio-sensitivity, mutation breeding work on rice is included.

3. Work will be taken up to improve the introduced varieties like Taichung Native 1 and IR 8 with particular reference to quality of grains.

4. TR-5 is an important source of genes for dwarfness and stiff-straw. These characters will be transferred to other Indica varieties by conventional hybridisation methods.

Groundnut:

1. TG-1, the large pod mutant has undesirable characters such as lateness and low shelling percentage. Work is already initiated to improve upon these characters and will be intensified.

2. Asiriya, a groundnut variety introduced from Africa, has many desirable characters like high yield and resistance to 'tikka' disease. Work on induction of earliness and short internodes in this variety will be taken up.

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3. Considerable area in India is under spreading types of groundnut. These are high yielders but late in maturity. Radiations will be employed to induce earliness in Punjab-1, a high yielding and spreading variety, so that this variety can be fitted into double cropping.

Wheat:

Work on transfer of disease resistance to Indian varieties will be intensified.

A programme of work on induction of dwarf mutants in jowar is also under consideration. The present hybrids are tall and dwarf mutants will be utilised in evolving dwarf hybrids.

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