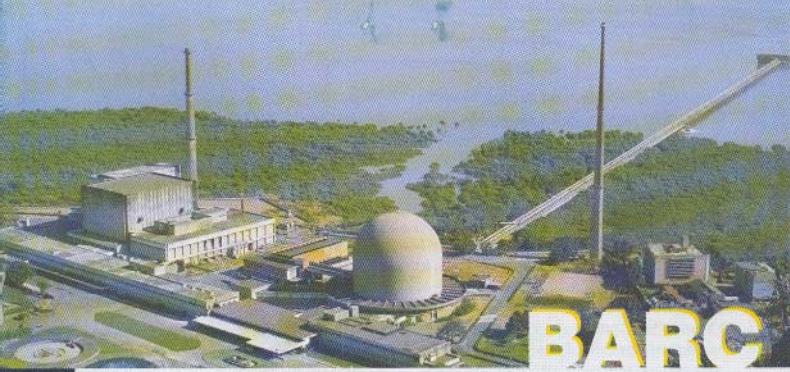


BARC
NEWSLETTER

No. 220
May
2002

FOOD IRRADIATION : RECENT GLOBAL TRENDS

V. Venugopal, S. B. Warrier and Arun Sharma
Food Technology Division

Work on radiation treatment of food products was initiated more than 100 years ago, within a few years after the discovery of X-ray by the German physicist Roentgen in 1895. During the World War II, particular interest was shown in the technique. However, because of lack of adequate control of the process, most of the products were overexposed to radiation resulting in undesirable changes including taste. During the early twentieth century, detailed studies on irradiation of food items were undertaken by pioneer institutions such as Massachusetts Institute of Technology in USA and Natick Laboratories of the US Army which led to more optimisation of the process to suit requirements of indiviqual commodities and the purpose of treatment. These studies led to the birth of food irradiation technology as a novel process similar to thermal canning and pasteurisation of milk.

During the latter part of the twentieth century, there was a world-wide interest in radiation processing of food and many beneficial effects of low dose irradiation of food items were recognised. These included the ability of radiation to inhibit post-harvest sprouting in potato and onion, disinfestation of fruits, vegetables and grains, delay in ripening of fruits, elimination of pathogens from flesh foods and also spices. Great strides were made in production of radiation sources, both radioisotopes as well as machine sources, and in the realisation of specific advantages of the individual sources. While the radioisotopes, ^{60}Co and ^{137}Cs, were made available either by neutron bombardment of natural cobalt and as a by-product of nuclear reactors,

Contents

respectively, electron and X-ray machines were also developed for radiation processing of foods. These sources have different characteristics with respect to their ability to treat food products (Table 1). Research on basic aspects of radiation processing of food also led to detailed information on radiation sensitivities of food-borne micro-organisms, parasites and insects, and biochemical changes associated with delay in ripening in irradiated fruits. Radiation was also shown to have potential use in combination with various conventional food processing techniques for use as what is known as 'hurdle technology'. This could help reduce the radiation doses required to get desired effects with respect to preservation of perishable foods including fish and meat products. Along with these developments, the major international development came through the recognition by a Joint Expert Committee of World Health Organization (WHO), Food and Agriculture Organization (FAO) and International Atomic Energy Agency (IAEA) that food irradiated up to a maximum dose of 10 kGy was safe and did not require toxicological evaluation. In 1997, the Expert Committee also endorsed the safety of using doses higher than 10 kGy to achieve a technological objective. The Codex Committee on Food Additives and Contaminants is also actively considering the removal of maximum dose limit of 10 kGy. This will help use of higher radiation doses, that may be required to develop food products that are shelf-stable and ready-to-cook.

Major Benefits

Low doses of radiation bring about improvements in quality of foods which can be beneficial in several ways. These include, control of spoilage of food commodities, enhancement of hygienic quality and safety of processed foods, use of radiation treatment as a tool for quarantine purpose and as an alternative to chemical fumigants for inactivation of insects in food commodities.

Table 1: Comparison of ionizing radiation from different sources

Type of source	Advantages	Disadvantages
Gamma	Good penetration Reliable Adjustable capacity Proven technology Source, Co-60, Cs-137.	Low energy and intensity Continuous emission Licensing tightly regulated Characterized as nuclear Few number of suppliers
Electron beam (EB)	High efficiency and intensity Beam shut-off	Limited penetration (0.5 cm per MeV) Machine parameters not easy to monitor Potential for interruption Limited range of operation Not widely used in high energy applications
X-rays	Hybrid of electron beam and gamma Good penetration Forward direction radiation Small radiation area Simple conveyors Less product hold-up	High power machine still under development Low conversion efficiency Higher cost than EB High heat in converter plate

The role of radiation processing in improving food hygiene is being widely recognised. According to the World Health Organization (WHO), more than one billion cases of acute diarrhea occur in children under the age of 5 years in developing countries. Most of these illnesses are caused by contamination of food by micro-organisms including *Salmonella* and *Campylobacter* sp. The Centre for Disease Control and Prevention, USA, estimates that there are 76 million cases of food-borne illnesses resulting in 5000 deaths annually in the US. The high penetration power of radiation is useful to eliminate radiation-sensitive pathogenic microorganisms such as *Salmonella, Vibrio, Listeria, Campylobacter* and *Escherichia coli* O157: H7 from pre-packaged foods including poultry, meat and fishery products. Most of these organisms have low sensitivities to radiation, with D_{10} values (dose required for 90% killing) of 1 kGy or less. Dr James Steele, renowned public health expert, in his article published in the *Twenty-first Century Science and Technology* magazine, has observed that application of food irradiation is a public health measure, which is long overdue.

Presence of insects and parasites in importing foods has been a cause of great concern with respect to internationally traded agro-based foods. This has adversely affected export of fruits and vegetables from Asian to European countries. These foods are currently treated with fumigants such as methyl bromide, ethylene dibromide, ethylene oxide, etc. for disinfestation purposes. This world-wide practice will be discontinued because of the realisation of the ill effects of chemical residues on human health and environment, and will be replaced by radiation processing.

Recent Consumer Attitude towards Irradiated Foods

Consumer acceptance is a major parameter for any food processing technique to become commercially viable. A few decades ago, consumer organisations were concerned about irradiation of foods. Their concerns were several including possibility of foods becoming radioactive, possible replacement of good sanitary practices, worker as well as environmental safety and economics. However, educational programmes for the consumers undertaken during the last few decades have shown that these fears could be removed. It has been well established that the energy of radiation (gamma, X-ray or electrons) used for treating food is incapable of making any of the food component radioactive. In a nationally representative survey during March 6 – 8, 1998, commissioned by the Food Marketing Institute, the Grocery Manufacturers Association of America, the National Restaurant Association and the American Meat Institute, 1003 respondents gave their opinion about food irradiation. The opinions of the respondents included concerns about possible chemical changes, unsafe food handling, hazardous materials, worker safety, unnatural way of treating foods, etc., while the concern about radioactivity in treated food was more casual. Most of the unfounded fear with respect to this technology stem from the word 'irradiation,' raising scare of nuclear holocaust in the consumer's mind. According to a food science communicator, Christine Bruhn, Director for Consumer Research, University of California, the use of the term 'irradiation' can be misleading. She suggests specific language for labels, namely 'Treated with cold-pasteurization (irradiation) for improved safety' (*Food Technology*, 55 (1), 2001, 94). Recent surveys conducted in USA and some other countries have indicated willingness of consumers to buy irradiated foods even at an extra cost for the safety of the products. In a survey conducted by University of Georgia, USA, 84% of consumers observed that irradiation was 'somewhat necessary' or 'very necessary'. Similar positive responses have also been noted in consumer surveys conducted by the Food Technology Division, BARC.

One major concern that still exists among some segments of consumers is the opinion that use of irradiation can encourage poor sanitary conditions in

food processing plants. US FDA in December 1997 has made implementation of Hazard Analysis and Critical Control Points (HACCP) system mandatory in seafood processing plants in the country and also for seafood exporters to USA. There is a fear that such safety programmes may be overlooked if the processed products were to be irradiated. The US Department of Agriculture in a February 12, 1999 news release announced that it will allow irradiation of meat to help improve food safety. The Department observed that 'when used in conjunction with other science-based prevention efforts, irradiation can provide consumers with an added measure of protection'.

International Approval

With the observation of the Joint Expert Committee of FAO, IAEA and WHO in 1980, as mentioned above, more than 40 countries have approved food irradiation technology. The International Consultative Group on Food Irradiation (ICGFI), established under the aegis of FAO, IAEA and WHO in 1984, helps to evaluate global developments in the field of food irradiation, provide a focal point of advice on the application of the technology and furnish information as required from time to time. The Codex Alimentarius Commission, which is the Executive Organ of the Joint FAO/WHO Food Standards Programme, adopted a General Standard for Irradiated Foods in 1983 and recommended International Code of Practice for the operation of radiation facilities for the treatment of foods. Under the scope of ICGFI, Food Irradiation Process Control School (FIPCOS) has been established to provide training programmes for operators of irradiators. In India, a similar programme called Training Course for Operators of Food Irradiation Facilities is being conducted by the Food Technology Division, BARC.

Several countries have conducted marketing trials on various food items such as irradiated strawberry, papaya, mango, shrimp, spices and wheat products. Clearance for irradiation of shrimp have been accorded and marketing trials have been reported in Canada, the Netherlands, and in some Asian countries. Several professional bodies have endorsed irradiation of food (Table 2). The United States Food and Drug Administration (FDA) has approved irradiation of a variety of foods, including fresh fruits, and vegetables and spices (Table 3). The Administration has recognised the importance of safe foods to avoid outbreaks of food borne diseases and the role of low dose irradiation in realising these objectives. FDA is allowing use of X-ray and electron beam irradiation to treat pre-packaged foods. FDA is considering a petition for clearance of irradiation of shellfish for sanitization. Recently, a coalition of food industry trade associations, health organisations, academic and consumer groups under a common banner of 'The Food Irradiation Coalition' has filed a petition requesting US FDA to extend the use of irradiation to ready-to-eat products.

Table 2 : Some professional bodies endorsing food irradiation

Food and Agricultural Organization
World Health Organization
Food and Drug Administration, USA
National Food Processors Association, USA
The American Association of Meat Processors
The American Spice Trade Association
Food Distributors International, USA
The Food Marketing Institute, USA
The Food Safeguards Council, USA
The Infection Control Advisory Network, USA
The National Cattlemen's Beef Association, USA
The National Chicken Council, USA
The National Meat Association, USA
American Society of Microbiology
Association of Food and Drug Officials, USA
Consumer Alert, USA
Centre for Disease Control and Prevention, USA
US Department of Agriculture
Institute of Food Technologists, USA

Table 3: Approval of irradiation for various foods by the US Food and Drug Administration

Product	Dose (kGy)	Purpose	Date
Wheat, wheat flour	0.2-0.5	Insect disinfestation	1963
White potatoes	0.05-0.15	Sprout inhibition	1964
Pork	0.3-1.0	Control of *Trichinella* sp.	1985
Fruit	1.0	Disinfestation, Delay in ripening	1986
Vegetables, fresh	1.0	Disinfestation	1986
Herbs	30.0	Microbial control	1986
Spices	30.0	Microbial control	1986
Vegetable seasonings	30.0	Microbial control	1986
Poultry, fresh or frozen	3.0	Microbial control	1990
Animal feed and pet food	2.0-25.0	Salmonella contro	1997
Meat, uncooked, chilled	4.5	Microbial control	1997
Meat, uncooked, frozen	7.0	Microbial control	1997
Eggs	8.0	Salmonella control	2000
Seeds	3.0	Microbial control	2000
Raw and processed crustaceans		Microbial control	Under
Ready-to-eat foods (Poultry, fruits & vegetables)		Microbial control	Consideration

Adapted from: Olson, D.G., 1998, "Irradiation of Food - Scientific Status Summary", *Food Technology*, Vol.52 (1), 56-61.

The European Parliament and the Council of European Union have adopted the Directive 1999/3/EC on the establishment of a community list of foods and food ingredients treated with ionizing radiation. Foodstuffs authorised for irradiation treatment include dried aromatic herbs, spices and vegetable seasonings to a maximum overall average absorbed radiation dose of 10 kGy. Among the member states of the EU, Belgium, France, Italy, the Netherlands and United Kingdom have given unconditional clearance for treating several foods (Table 4). In the year 2000, Germany has given clearance for irradiation of dried herbs, vegetable seasonings and spices at a dose of 10 kGy. Other member states such as Austria, Greece, Luxembourg, Portugal, Ireland and Sweden are likely to permit the marketing of irradiated foodstuffs. In September 2001, Australia has cleared herbs, herbal infusion and spices at 6 and 30 kGy, as per requirements.

Commercial Applications

Currently, over 30 countries are using irradiation of foods on a commercial scale including USA, France, The Netherlands, Belgium, Hungary, South Africa and India. It has been estimated that about 300,000 metric tonnes of irradiated foods were available in the world markets in the year 2000, spices forming bulk of the irradiated items. The availability of irradiated spices alone in different markets including those in European Union increased from 10,000 tonnes in 1990 to 90,000 tonnes in 2000. There was a rapid development on commercial application of food irradiation in the USA during the year 2000 following the approval of the US Department of Agriculture for quality control of irradiated meat (to eliminate pathogenic bacteria) in February 2000. Starting in mid-May 2000, irradiated ground beef was put on sale in 84 supermarket stores. The number of supermarkets selling the product has multiplied significantly by the end of the year. Approximately 200 metric tonnes of ground beef were irradiated per week using two electron beam machines located at Iowa and Florida, USA. The product, labelled as 'electron irradiated' or 'electronically pasteurised', attracted good consumer response. A commercial X-ray irradiation facility in Hawaii started operation in July 2000 and has

Table 4 : Authorisation of irradiation of food and food ingredients by member states of European Council

Product	Authorised maximum overall average absorbed Radiation dose (kGy)				
	BE	FR	IT	NL	UK
Deep-frozen aromatic herbs		10			
Potatoes	0.15		0.15		0.2
Yams					0.2
Onions	0.15	0.075	0.15		0.2
Garlic	0.15	0.075	0.15		0.2
Shallot	0.15	0.075			0.2
Vegetables, pulses					1.0
Fruit (includes fungi, tomato, rhubarb)					2.0
Dried vege-tables, fruits		1.0		1.0	
Cereals					1.0
Cereal flakes, germs for milk products		10			
Cereal flakes				1.0	
Rice flour		4.0			
Gum arabic		3.0		3.0	
Chicken meat				7.0	
Poultry		5.0		7.0	
Deboned poultry meat		5.0			
Offal poultry		5.0			
Frozen frog legs	5.0	5.0		5.0	
Dehydrated blood, plasma		10.0			
Fish, shellfish, molluscs					3.0
Frozen peeled shrimp	5.0	5.0			
Shrimps				3.0	
Egg white		3.0		3.0	
Casein, caseinates		6.0			

Authorised under Article 4 (6) 1999/2/EC of the European Parliament and of the Council on the approximation of the laws of Member States concerning foods and food ingredients treated with ionising radiation.BE, Belgium; FR, France; IT, Italy; NL, The Netherlands; UK, United Kingdom.
Source: Marine Products Export Development Authority, Cochin, *Newsletter*, Vol.7, No.2, February 2002.

treated commercial volumes of fruits, particularly, papaya to meet quarantine requirements in the US mainland. Several new commercial irradiators are under construction in the US states of Arkansas, New Jersey and New York.

In other countries, during the past two years, new commercial irradiators have been commissioned for treating food. In India, the Government has accorded clearance for radiation processing of a number of products (Table 5). A plant for irradiation of spices has been operating for the last two years, and another plant for sprout control of onion is expected to be completed shortly at Lasalgaon, near Nasik in Maharashtra. A women's social organisation, Annapurna Mahila Mandal, has taken up marketing of irradiated spices in consumer packs through their retail outlets in Mumbai. The products are irradiated at the spice plant being operated by the Board of Radiation Isotope and Technology, located at Vashi, Navi Mumbai.

Chemical fumigation of food items is in the process of being phased out. Ethylene dibromide was banned as a fumigant in 1984 in the USA. Under the Montreal Protocol, methyl bromide, because of

Table 5 : Clearances for radiation processed foods by Government of India

Food item	Radiation dose (kGy)		Purpose
	Minimum	Maximum	
Onions	0.03	0.09	Sprout inhibition
Potatoes	0.06	0.15	Sprout inhibition
Shallots (small onions), garlic and ginger	0.03	0.15	Sprout inhibition
Rice, semolina (sooji, rawa) Atta (wheat flour), maida	0.25	1.0	Insect disinfestation
Pulses	0.25	1.0	Insect disinfestation
Dried seafood	0.25	1.0	Insect disinfestation
Resins, dried figs, dates	0.25	0.75	Insect disinfestation
Mango	0.25	0.75	Shelf life extension & quarantine
Meat and meat products	2.5	4.0	Shelf life extension, pathogen control
Spices	6.0	14.0	Microbial control
Fresh seafood	1.0	3.0	Shelf life extension
Frozen seafood	4.0	6.0	Pathogen control

its ozone-depleting property, will be banned in advanced countries by 2005 and in developing countries by the year 2015. Irradiation, which does not leave any residues in the food, has the potential to successfully replace chemical fumigation practices. The role of food irradiation as a sanitary and phytosanitary tool has been well recognised. The Interim Commission for Phytosanitary Measures of the International Plant Protection Convention in its third session held in April 2001 agreed to develop international standards on irradiation as a phytosanitary treatment. Commercial application of irradiation as a sanitary and phytosanitary treatment for fruits and vegetables has already been initiated in the USA..

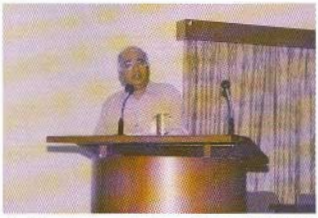
Although several countries have permitted irradiation of foods, at present inter-country trade in irradiated foods is not common due to lack of harmonised regulatory infrastructure. Because of this, several products, for which irradiation can be profitably applied, are not yet available in international markets. Harmonisation of regulations for food irradiation and commercial scale facilities are important for commercialisation of food irradiation technology. There is an effort in this direction based on the Codex General Standard for Irradiated Foods and relevant recommendations of the International Consultative Group on Food Irradiation. Such a regulation will ultimately open international markets to irradiated fruits and vegetables treated to meet quarantine requirements. It is expected that standards at an international level for use of irradiation as a phytosanitary measure and for treatment of foods will be available by 2003. It is likely that the emerging areas of commercial applications of food irradiation are likely to be focused on improvement of food safety, quarantine treatment of fresh horticultural produce and as a substitute for current fumigation practices.

SCHOOL ON 'PHYSICS OF BEAMS'

The 'Charged Particle Accelerators' have played a key role in the area of basic and applied sciences including industry. To spread its awareness among the young students belonging to the Universities and the National Institutes, a two-week school on the 'Physics of Beams' was organized by BARC at the Homi Bhabha Centre for Science Education, Mumbai. It was inaugurated by Dr V.C. Sahni, Director, Physics Group, BARC, on December 24, 2001. About 50 students from the different universities and the national institutes participated in it. Teachers for the school were drawn from BARC, Mumbai, CAT, Indore, VECC, Kolkata, and Pune University. The school was sponsored by the Department of Science and Technology and was the sixth in the series. The other five have been held at CAT, Indore.

The inaugural function of the school on 'Physics of Beams'. Seated from left to right are : Dr R.V. Nandedkar, CAT Indore, Chairman, Organising Committee, Dr V.C. Sahni, Director, Physics Group, BARC, Dr H.C. Pradhan, Dean, Homi Bhabha Centre for Science Education, Mumbai and Dr S. Krishnagopal, CAT Indore, Convenor of the school.

The topics covered included the physics of RF Linacs, Cyclotrons, Synchrotrons, Storage Rings and DC accelerators. Special topics like Free Electron Lasers and Chaos were also taught. Apart from the exhaustive exposure to the theory of accelerators, the students were given the hand outs



Dr R.C. Sethi, Head, Accelerator & Pulse Power Division, BARC, delivering the presidential address

and tutorials, as an aid to understand the subject in a better way. And, for further insight, quite a few laboratory experiments were conducted within the premises of BARC. These experiments dealt with the characterisation of RF cavities, electron beam sources, DC magnetic field and the measuring devices. The experiments were backed up by educational visits to FOTIA and Industrial Electron Accelerators like 500 keV & ILU6.

Dr V.C. Sahni, Director, Physics Group, BARC, giving the inaugural talk

The school was concluded on January 4, 2002, with a half-day seminar on the 'Application of Accelerators'. In this seminar, Dr S.S. Kapoor, Professor, Homi Bhabha Chair, gave a talk on the 'Role of Accelerators in Nuclear Energy', Dr R.V. Nandedkar covered the topic on the 'Application of Synchrotron Radiations', and Dr R.C. Sethi, Head, Accelerator and Pulsed Power Division, BARC, highlighted their role in the industry.

BRNS - IANCAS NATIONAL WORKSHOP

The Indian Association of Nuclear Chemists and Allied Scientists (IANCAS) conducted its 46th National Workshop at Jiwaji University, Gwalior, during December 3-11, 2001.

BRNS-IANCAS Workshop at Gwalior. Seated from left to right: Dr Radha Tomar, Workshop Director, Jiwaji University, Dr V.Natarajan, Workshop Coordinator, Dr G.A.Rama Rao, General Secretary, IANCAS, Prof. V.P.Saxena, Vice-Chancellor, Jiwaji University, Prof. Girish Saxena, Vice-Chancellor, B.R. Ambedkar University, Agra, Mr Surendranath Yadav, Inspector General of Police (Chambal Region), ex-BARC Scientist, Dr V. Venugopal, Head, Fuel Chemistry Division, BARC and Vice-President, IANCAS and Prof. K.K. Dwivedi, Dean, Faculty of Science, Gwalior University.

Prof. G.C.Saxena, Vice-Chancellor, B.R.Ambedkar University, Agra, in his inaugural address, highlighted the progress in the field of atomic energy, medicine and agriculture and advised research scholars to focus their quest in the frontal areas of science. Prof.V.P Saxena, Vice-Chancellor, Jiwaji University, Gwalior, presided over the function and appreciated the aim of the Workshop in giving practical knowledge of hands-on experience in handling radioisotopes to the teachers. Mr Surendra Nath Yadav, Inspector General of Police, Chambal Division, an ex-BARC scientist, was the Guest of Honour. Dr V.Venugopal, Head, Fuel Chemistry Division, BARC and Vice-President, IANCAS, delivered the keynote address on 'Overview of Indian Nuclear Fuel Cycle'. He said that the Indian Nuclear Energy programme is a self-sufficient 3-stage programme comprising of power production from natural uranium, use of plutonium in fast reactors and use of thorium to get U-233 to sustain the cycle. Dr G.A.Rama Rao, General Secretary, IANCAS, elucidated the various activities of the association in imparting training in radiochemistry to teaching community and research scholars from different universities across the country. Dr Radha Tomar, Workshop Director, Jiwaji University, proposed the vote of thanks.

Mr S.C.Parida, Fuel Chemistry Division, BARC, conducting an experiment on half-life determination of Ba-137m.

44 faculty members and 29 research scholars from all branches of science participated in the Workshop. There were 10 Resource persons from DAE who gave lectures on various topics in "Radiochemistry and Applications of Radioisotopes". Dr Arun Sharma, Head, Food Technology Division, BARC, gave a lecture on the applications of radioisotopes in food preservation, and explained various activities of BRNS in the promotion of research in universities. Dr (Ms) Karir from BRIT gave an invited talk on Radioimmunoassay at the local Cancer hospital on invitation. Dr S.B.Manohar, President, IANCAS, gave a lecture on Radioactivity in the K.R. Post Graduate College for Women. Dr G.A.Rama Rao and Dr B.S.Tomar answered the questions from 12th std. students on Radioactivity at St.Paul convent. 80 students participated in this programme. Dr V. Natarajan was the Workshop Coordinator and Mr S.C.Parida was the Practical Coordinator on behalf of IANCAS.

The valedictory function was presided over by Prof. V.P.Saxena, and Prof. Satyaprakash, Dean, Faculty of Science, Dayalbagh Institute of Science, was the Chief Guest. A video show, provided by the Publicity Division, DAE, titled 'Blessing to Humankind' and 'Atoms for peace', was well appreciated.

Financial support for the BRNS-IANCAS National Workshop was extended by BRNS.

DAE-BRNS REGIONAL WORKSHOP

Biomedical Group, BARC, and Kerala Agricultural University (KAU), Trichur, Kerala, jointly organised a Workshop on the 'Impact of Applications of Radiation on Food and Agriculture' at KAU on December 27 and 28, 2001.

Dr Anil Kakodkar, Chairman, AEC, lighting the inaugural lamp. Others standing are Mr P.P. George, MLA, Ms K.R. Gauri Amma, Minister for Agriculture, Government of Kerala, Dr (Ms) A.M. Samuel, Director, Biomedical Group and Chairperson of the Workshop, Dr K.V. Peter, Vice-Chancellor, KAU, Dr K. Kumaran, Director, Research, KAU, and Dr K.K. Surendranathan, NABT, BARC, Convenor of the Workshop.

The objective of the Workshop was to create an awareness amongst the faculty and scientists from various educational and research institutions of Kerala about the contributions made in the field of nuclear agriculture and food preservation by BARC and identify the scope for interactive research in these areas.

With this objective in view, a well-focused Workshop in the area of nuclear agriculture and radiation preservation of food was conducted. As the applications of radiation and radioisotopes was a subject to which there was little exposure, the first session deliberated on the myths and reality pertaining to radiation, irradiators and radiation processing. Its main intention was to clear off the apprehensions and misconceptions amongst the participants about the effect of radiation and radioisotopes.

The Workshop was inaugurated by the Hon'ble Minister for Agriculture, Government of Kerala, Ms K.R. Gauri Amma, who assured that the State Government would display the political sagacity and commitment to usher the technology developed so far to achieve food security and value addition. She reminded the audience that it was high time to have another "green revolution".

The chief guest of the inaugural function of the Workshop, Dr Anil Kakodkar, Chairman, Atomic Energy Commission and Secretary, Government of India, Department of Atomic Energy, pointed out that the developed countries, including the United States and China and many European States, use radiation processing as an effective process for extension of shelf life and value addition of several food commodities. He urged the agricultural universities all over the country to come forward to clear the misconceptions of the process and reach the benefits of the technology to the common man.

Dr (Ms) A.M. Samuel, Director, Biomedical Group, BARC, in her address as Guest of Honour, informed the gathering that BARC had already established collaborative research with a number of universities in the field of food and agriculture. She expressed the hope that the Workshop would act as the interface for a strong tie-up to initiate collaborative research between BARC and KAU in the areas having direct relevance to Kerala, especially crop improvement, post-harvest preservation of spices, fruits, fish and meat, employing radiation technology.

Professor K.V. Peter, the Vice-Chancellor, KAU and Chairman, Organising Committee (KAU), while giving the welcome address, looked forward for a useful collaboration between BARC and KAU to develop interactive research and enrich the scientific environment. Professor Peter lauded the contributions of BARC in agricultural research and placed on record his appreciation of the earnest effort of BARC in conducting this Workshop.

Dr K.K. Surendranathan, the Convenor of the Workshop, elaborated on the theme and design of the Workshop and expressed the hope that this Workshop would clear the apprehensions and misconceptions, if any, regarding radiation and its applications. Dr N. Saifudeen, Secretary, Organising Committee, proposed a vote of thanks.

The Workshop generated considerable enthusiasm amongst a number of scientists attending the Workshop. A meaningful and constructive discussion on the potentials and prospects of projects for collaborative research were discussed at length in the concluding session. Dr S.F. D'Souza, Head, Nuclear Agriculture & Biotechnology Division, BARC, Dr K.B. Sainis, Head, Cell Biology Division, BARC, Dr A.K. Sharma, Head, Food Technology Division, BARC, and Dr S.K. Mahajan, Head, Molecular Biology & Agriculture Division, BARC, detailed on the scope and feasibility of various projects which came up for discussion and identified the possible areas for developing collaborative projects.

Besides motivating to hold this Workshop, Dr A.P. Jayaraman, Head, Media Relations, LISD, BARC, could generate an intensive discussion among the Kerala public through the 'Media' reports on the benefits of applications of radiation for improvement in agricultural production and control of food losses due to spoilage. Dr M.V. Thampi, LLRR, CBD, BARC, thanked the Vice-Chancellor and faculty of KAU for all their help and efforts in making this Workshop a success.

IAEA-RCA TRAINING WORKSHOP ON 'RADIATION PROTECTION IN INDUSTRIAL RADIOGRAPHY'

The Radiological Physics & Advisory Division (RPAD) of the Health, Safety & Environment Group, BARC, conducted a one-week IAEA-RCA Training Workshop on 'Radiation Protection in Industrial Radiography' at Hotel Parle International, Vile Parle, Mumbai, during February 11-15, 2002. The Workshop was inaugurated by Dr V.Venkat Raj, Director, Health, Safety & Environment Group, BARC. Dr B.C. Bhatt, Head, Radiological Physics & Advisory Division, BARC, welcomed the participants. Dr John Wheatley, Radiation Source Specialist from IAEA, also a faculty member for the Workshop, briefed the participants and the invitees about the training programme and the role of IAEA. Dr K. Raghuraman, RCA National Representative, DAE, talked about the excellent work being done in the field of radiation protection under RCA programmes. Mr D.P. Bhatia, Course Director, proposed the vote of thanks.

Dr V. Venkat Raj, Director, HS&E Group, BARC, giving the inaugural address at the IAEA-RCA Workshop on 'Radiation Protection in Industrial Radiography'. Seated on the dais (left to right) are Dr B.C. Bhatt, Head, RP&AD, Dr John Wheatley, Radiation Source Specialist, IAEA and Dr K. Raghuraman, RCA National Representative, DAE

Twenty-one participants, two each from Indonesia, Republic of Korea, Malaysia, Phillippines and Thailand, one each from China, Mangolia, Myanmar and Vietnam and seven from India attended the Workshop. The faculty consisted of Dr John Wheatley from IAEA, Dr (Ms) Joane Shaw from NRPB, UK, apart from eleven senior officers from BARC, AERB and BRIT. The course concentrated on the importance of radiation monitoring, safety in handling of radiography sources, radiation accidents that may occur and have occurred, origin of such accidents and lessons learnt from them. The programme consisted of 18 lectures and a visit to BRIT, Vashi. During the Workshop, the participants also gave presentations on the status of radiation protection in the respective member states and shared their experiences in the field.

Mr G.R. Srinivasan, Vice-Chairman, AERB, giving the valedictory address on the concluding day of the Workshop. Seated on the dais are (left to right) Dr A.N. Nandakumar, Co-Course Director, Dr John Wheatley, Dr B.C. Bhatt, and Mr D.P. Bhatia, Course Director

The programme was concluded by summing up of the deliberations of the Workshop by Dr A.N. Nandakumar, Co-Course Director. Dr John Wheatley, in his remarks about the Workshop, pointed out that the programme was well conducted and hoped that it would be very fruitful for the participants in their profession when they go back to their countries. He thanked BARC for hosting the Workshop in India and making excellent arrangements for the stay of the participants and the faculty from abroad, and for the hospitality offered. Mr G.R. Srinivasan, Vice-Chairman, AERB, in his valedictory address to the participants, stressed the importance of safety in any activity in general and in the use of radiation in particular. RP&AD, BARC, offered to conduct, in collaboration with IAEA, more such programmes in the field of Radiological Safety. All the participants were awarded certificates by the IAEA.

TRAINING COURSE ON 'RADIOIMMUNOASSAY AND ITS CLINICAL APPLICATIONS'

The 43rd batch of the training course on 'Radio-immunoassay and its Clinical Applications' was jointly organised by the Radiopharmaceuticals Division and Board of Radiation & Isotope Technology at Doctors Diagnostic & Research Centre (DDRC), Thiruvananthapuram, during December 6-21, 2001.

Mr B. Bhattacherjee, Director, BARC, inaugurating the 43rd batch of the training course on 'Radioimmunoassay & its Clinical Applications'.

Radioimmunoassays and immunoradiometric assays are sensitive and specific analytical tools for the measurement of minute (nano-molar and lower) concentrations of bio-molecules such as hormones, tumour markers, etc. in blood and other body fluids. Millions of assays are carried out world over every

year and the applications of immunoassays have extended to many other areas in the recent past. Since 1980, Radiopharmaceuticals Division has been conducting training courses on 'Radio-immnoassay and its Clinical Applications' regularly and over a thousand medical and paramedical professionals have been trained thus far. More than 500 RIA laboratories have been established in India manned by such trained personnel.

Mr B. Bhattacharjee, Director, BARC, along with the faculty and trainees of the 43rd batch of the training course on "Radioimmunoassay & its Clinical Applications".

Doctors Diagnostic & Research Centre (DDRC) is a speciality laboratory chain in Kerala offering a complete spectrum of clinical analytical services and is managed by Mr Joy Joseph, Administrative Director.

The training course was inaugurated by Dr B. Bhattacharjee, Director, BARC in a function presided over by Dr V.K. Rajan, Director of Health Services, Govt. of Kerala, and was held at Hotel Residency Towers, Thiruvanthapuram. The inaugural function was attended by over 300 invited dignitaries. Dr (Ms.) A.M. Samuel, Director, Bio-medical Group, BARC, delivered the key-note address. Prof. Balaraman Nair, Medical Director, DDRC, gave the welcome address, and Dr M.R.A. Pillai, Head, Radiopharmaceuticals Division, BARC and Senior General Manager, Medical & Biological Products Programme, Board of Radiation & Isotope Technology, gave an introduction to the course. Dr N. Ramamoorthy, Chief Executive, Board of Radiation and Isotope Technology & Associate Director, Isotope Group, BARC, and Prof. M.O. Annamma, Director, Medical Education, Government of Kerala, addressed the audience on some relevant aspects of RIA practice. 19 para-medical professionals working in various laboratories such as pathology clinics, endo-crinology laboratories of various hospitals, etc. from all over India participated and successfully completed this course.

Mr B. Bhattacharjee, Director, BARC addressing the press conference.

A press conference was also organised after the inaugural function in which Mr Bhattacharjee answered a variety of questions related to the Atomic Energy Programme. The press conference was covered by all the major TV channels of Kerala and there was a wide coverage in the Press.

IAEA-RCA TRAINING COURSE ON 'IN-SERVICE INSPECTION OF RESEARCH REACTORS'

A two-week training course on 'In-Service Inspection of Research Reactors' was organised by Reactor Group, BARC, during January 21-February 6, 2002. The course was conducted by IAEA-RCA for Asia-Pacific region in collaboration with Government of India. The course was meant to increase the awareness in the field of in-service inspection of research reactors. A total of 30 participants, including 11 foreign participants from Bangladesh,

China, Indonesia, Philippines, Korea, Thailand and Vietnam, underwent the training course.

Mr P.S. Rao of Reactor Group, BARC, speaking during the inaugural function of the IAEA-RCA training course. Others in the picture include (from left): Mr D.K. Lahiri, Reactor Group, BARC, Prof. Theodore Parish, IAEA, Chief Guest, Mr S.K. Sharma, Director, Reactor and Engineering Services Groups, BARC, Mr S. Sankar, Associate Director, Reactor Group, BARC, Dr V. Venkat Raj, Director, Health, Safety and Environment Group, BARC, Mr A.C. Tikku, Head, RRSD, BARC & Course Director; Mr S.K. Mishra, Assistant Course Director, Health, Safety & Environment Group, BARC.

Mr S.K. Sharma, Director, Reactor and Engineering Services Groups, BARC, inaugurated the training programme. Mr A.C. Tikku, Head, Research Reactor Services Division, BARC, was the Course Director and Mr S.K. Mishra, Health, Safety & Environment Group, BARC, was the Assistant Course Director.

Chief Guest Mr A.K. Anand, former Director, Technical Co-ordination and International Relations Group and Reactor Projects Group, BARC and former RCA National Representative, handing over the IAEA certificate to one of the participants from Korea during the Valedictory function.

The course programme consisted of 23 lectures on various topics such as rationale for ISI of research reactors, material degradiation mechanisms, non-destructive examination techniques, flaw characterisation and residual life assessment. Lectures on ISI of concrete structures and elastomeric components, application of robotics, ISI of pool type research reactors, designing for ISI, training and certification of NDT personnel for ISI, radiological, codal and regulatory aspects of ISI for research reactors were also included. Invited talks on topics such as safety of nuclear facilities, ISI of nuclear power plants, material behaviour in research reactors, advances in NDE techniques and ISI for ageing assessment were also included for the benefit of the participants. During their technical visit to BARC participants were given live demonstration of various NDT instruments employed for ISI work, including remote repair tools and special gadgets developed indigenously for ISI of in-core components in PHWR and BWR.

A book of lecture notes was formally released by Dr V. Venkat Raj, Director, Health, Safety & Environment Group, BARC, and Chairman, BARC Safety Council. Mr A.K. Anand, former Director, Technical Coordination & International Relations Group and Reactor Projects Group, BARC and former RCA National Representative, presided over the Valedictory function and awarded the training course completion certificates to all the participants.

भाभा परमाणु अनुसंधान केंद्र के वैज्ञानिकों को सम्मान

• श्री बी.के.शाह, परमाणु ईंधन प्रभाग, भाभा परमाणु अनुसंधान केंद्र को अनाशक संपरीक्षण के लिए भारतीय समाज के आजीवन सदस्य के रूप में चुना गया है । इसके साथ-साथ उनकी नियुक्ति एन डी टी के राष्ट्रीय प्रमाणीकरण बोर्ड की परीक्षाओं के क्षेत्रीय नियंत्रक (पश्चिमी क्षेत्र) के लिए भी की गई ।

• पिछले कई वर्षों से भारतीय भौतिकी संघ द्वारा नाभिकीय एवं ठोस अवस्था भौतिकी पर लिखे गए पी.एच.डी., शोध पत्रों के सर्वोत्तम प्रस्तुतिकरण के लिए पुरस्कार प्रदान किया जाता रहा है । यह पुरस्कार डॉ. एल.एम.पंत, नाभिकीय भौतिकी प्रभाग, को उनके शोध पत्र भारी आयन प्रेरित विखंडन -संलयन प्रतिक्रिया पर दिसंबर 2001 में कोलकता में आयोजितपारमाणु ऊर्जा विभाग नाभिकीय भौतिकी संगोष्ठी में दिया गया ।

• डॉ ए.के.त्यागी, अध्यक्ष , ठोस अवस्था रासायनिकी अनुभाग, अनुप्रयुक्त रसायनिकी प्रभाग, भाभा परमाणु अनुसंधान केंद्र को दिसंबर 2001 में कानपुर स्थित भारतीय प्रौद्योगिकी संस्थान में भारतीय ठोस अवस्था रसायनिकी संघ और सम्बद्ध वैज्ञानिकों द्वारा आयोजित द्विवार्षिक सम्मेलन के दौरान डॉ लक्ष्मी पुरस्कार से सम्मानित किया गया । यह सम्मान उन्हे ठोस अवस्था रसायनिकी के क्षेत्र में उल्लेखनीय योगदान के लिए प्रदान किया गया । उन्होंने उच्च ताप अतिचालक, विरल मृदा आधारित फ्लूराइड, मिश्रित ऑक्साइड, आयनिक चालक, थोरिया आधारित नाभिकीय ईंधन आदि क्षेत्रों में अनुसंधान कार्यों को आगे बढ़ाया ।

• डॉ ए.विनोद कुमार,पर्यावरणीय मूल्यांकन प्रभाग, भाभा परमाणु अनुसंधान केंद्र को 2 दिसंबर 2001 को उनके शोध पत्र मुंबई में यातायात जंकशन पर परिवेशी वायु घटकों का निक्षेपण पर इंजीनियरी संस्थान (भारत) द्वारा प्रोफेसर आर.सी.सिंह पदक प्रदान किया गया। उनका शोध पत्र इंजीनियरी संस्थान (भारत) पर्यावरणीय खंड, ई एवं 81 पृष्ठ 48-51, 2001 के जर्नल में प्रकाशित हुआ । यह शोध पत्र ए.विनोद कुमार, आर.एस.पाटिल, के.एस वी.नामबी और टी.एम.कृष्णमूर्ति द्वारा लिखा गया ।

• डॉ पी.वी.वराडे, रिएक्टर प्रचालन प्रभाग, भाभा परमाणु अनुसंधान केंद्र ने होटल ली रॉयल मेरिडियन, मुंबई में गुणवत्ता विश्वसनीयता तथा नियंत्रण (ICQRC-2001) पर आधारित अंतर्राष्ट्रीय सम्मेलन में क्षणिक एकीकरण के लिए कृत्रिम तंत्रिक जाल का प्रयोग करते हुए दाबित भारी पानी रिएक्टर (PHWR) डाटा का अनुकरण विषय पर अपना शोध पत्र प्रस्तुत किया । इस शोध पत्र के लेखक आर.चौधरी, गोपिका विनोद, ए.के.बाबर और एच.एस.कुशवाहा है तथा इसे सम्मेलन में सर्वश्रेष्ठ घोषित किया गया । इस सम्मेलन में डॉ. वराडे को नियंत्रणों के तकनीकी सत्रों में सह-अध्यक्ष के रूप मे भी आमंत्रित किया गया ।

• डॉ.एस.के.खोबरे, रिएक्टर नियंत्रण प्रभाग, भाभा परमाणु अनुसंधान केंद्र ने 27 से 28 दिसंबर 2001 को होटल ली रॉयल मेरिडियन, मुंबई में IETE एवं भारतीय प्रौद्योगिकी संस्थान (IIT) मुंबई द्वारा आयोजित गुणवत्ता, विश्वसनीयता तथा नियंत्रण (ICQRC-2001) पर अंतर्राष्ट्रीय सम्मेलन में नाभिकीय विद्युत संयत्रों में कंप्यूटर आधारित नियंत्रण यंत्रीकरण प्रणाली की गुणवत्ता तथा विश्वसनीयता विषय पर अपना प्रमुख उद्बोधन प्रस्तुत किया जिसके लिए उन्हे प्रशस्ति पत्र प्रदान किया गया ।

• श्री एम.बी.काकडे, पदार्थ विज्ञान प्रभाग, भाभा परमाणु अनुसंधान केंद्र को 21 जनवरी से 23 जनवरी 2002 तक अणुशक्तिनगर, मुंबई में आयोजित तापीय विश्लेषण (Thermans 2002)" पर तेरहवीं राष्ट्रीय संगोष्ठी और कार्यशाला के दौरान श्रेष्ठ पोस्टर प्रस्तुतिकरण के लिए द्वितीय पुरस्कार प्रदान किया गया । यह पुरस्कार उनके शोध पत्र थरमल डेकोमपोसिशन एण्ड फेस इवोलूशन बिहेवियर ऑफ इट्रियम एलुमिनियम गारनेट प्रिपेयरड बाई सोलूशन कोमबशन टैकनीक पर दिया गया । यह शोध पत्र एम.बी. काकडे और एस.रामनाथन, पदार्थ विज्ञान प्रभाग तथा बी.बी.कालेकर, विश्लेषणात्मक रसायनिकी प्रभाग द्वारा लिखा गया ।

BARC SCIENTISTS HONOURED

• Mr B.K. Shah, Atomic Fuels Division, BARC, has been elected as Life Fellow of the Indian Society for Non-destructive Testing. He has also been appointed as Regional Controller of Examination (Western Region), National Certification Board on NDT.

• The Indian Physics Association (IPA) has been awarding prizes for best Ph.D. thesis presentation in Nuclear and Solid State Physics for the past many years. In the DAE Nuclear Physics Symposium held at Kolkata in December 2001, Dr L.M. Pant from Nuclear Physics Division was awarded the IPA prize for his thesis entitled, "Heavy Ion Induced Fusion - Fission Reactions", based on his work carried out at the BARC - TIFR Pelletron accelerator facility.

• Dr A.K. Tyagi, Head, Solid State Chemistry Section, Applied Chemistry Division, BARC, was presented 'Dr Laxmi Award' by Indian Association of Solid State Chemists and Allied Scientists, at its biennial conference, at Indian Institute of Technology, Kanpur, in December 2001. This award was conferred on him in recognition of his contribution in the area of Solid State Chemistry. Some of the major research activities pursued by him are in the areas of high T_c superconductors, rare-earth based fluorides, mixed oxides, ionic conductors, thoria based nuclear fuels, nanocrystalline ceramics, etc.

• Dr A. Vinod Kumar of Environmental Assessment Division, BARC, received the 'Prof R.C. Singh Medal" on December 2, 2001 from the Institution of Engineers (India) as a subject award for the paper, "Deposition of Ambient Air Constitutents at a Traffic Junction in Mumbai'. This paper was published in their journal, *The Institution of Engineers (India) Environmental Section*, EN81, pp. 48-51, 2001. This paper is authored by A. Vinod Kumar, R.S. Patil, K.S.V. Nambi and T.M. Krishnamoorthy.

• Dr P.V. Varde of Reactor Operations Division, BARC, presented a paper entitled "Simulation of PHWR Data using Artificial Neural Network

for Transient Identification", at the International Conference on Quality, Reliability and Controls (ICQRC-2001) held at Hotel Le Royal Meridian, Mumbai. The paper was co-authored by R. Chowdhury, Gopika Vinod, A.K. Babar and H.S. Kushwaha, and was adjudged as one of the best papers in the conference.

Dr Varde *(left in the above photograph)* was also invited to be Co-Chairman for one of the Technical Sessions on "Controls" in this conference.

• Mr S.K. Khobare of Reactor Control Division, BARC, was presented a 'Certificate of Appreciation' for his Keynote Address entitled, "Quality and Reliability Issues in Computer-based Control Instrumentation Systems in Nuclear Power Plants", at the International Conference on Quality, Reliability and Controls (ICQRC-2001) organised by IETE and IIT Bombay, held during December 27-28, 2001 at Hotel Le Royal Meridien, Mumbai.

• Mr M.B. Kakade of Materials Science Division, BARC, was awarded the second prize for the best poster presentation in the Thirteenth National Symposium and Workshop on Thermal Analysis (Thermans 2002) held at Anushaktinagar, Mumbai, during January 21-23, 2002. The award was for the paper, "Thermal Decomposition and Phase Evolution Behaviour of Precursors for Yttrium Aluminium Garnet prepared by Solution Combustion Technique" by M.B. Kakade and S. Ramanathan, Materials Science Division, and B.B. Kalekar, Analytical Chemistry Division, BARC.

Edited and published by Dr Vijai Kumar, Head, Library & Information Services Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085.
Editorial Management : T.C. Balan; Computer graphics & layout : P.A.S. Warrier

BARC Newsletter is also available at URL:http://www.barc.ernet.in (for private circulation only)