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Consumer acceptance and market development of irradiated food in Asia and the Pacific

Proceedings of a final Research Co-ordination Meeting organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and held in Bangkok, Thailand, 21–25 September 1998

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FOREWORD

This publication covers the activities and accomplishments of eight countries that participated in a Co-ordinated Research Project (CRP) on Public Acceptance and Market Development of Irradiated Food in Asia and the Pacific, as presented at a final Research Co-ordination Meeting held in Bangkok, 20–25 September 1998. The CRP was implemented through research agreements with Bangladesh, China (one each for Shanghai and Beijing), the Republic of Korea, Malaysia, Pakistan, the Philippines, Sri Lanka, Thailand and Viet Nam, from 1994 to 1998.

The technical work undertaken to bring food irradiation technology to the marketplace to address food security, public health and trade needs, is described. This covered the establishment of quality assurance procedures, the determination of irradiation doses for non-traditional as well as traditional foods, the conduct of techno-economic feasibility, and the identification of industry and consumer needs. In the majority of cases, R&D activities were undertaken in partnership with industry. Developments in the establishment and harmonization of regulations on food irradiation were also monitored. The participants made commendable progress in the marketing of irradiated food and in the understanding and promotion of consumer acceptance of the technology. This was demonstrated in the marketing of close to 179 000 tons of different food and related products through normal trading channels. While the volume of food irradiated varied with the capacity of irradiation plants in participating countries, the work showed that consumers would accept irradiated foods and that trade benefits would ensue from the application of the technology. Information dissemination was found to be a critical factor in public acceptance.

The discussions at the final Research Co-ordination Meeting, which are also summarized in this publication, focused on key issues and recommendations to bring about the wider commercialization of food irradiation for the benefit of the region.

The excellent assistance of A.O. Lustre in compiling the contributions of the participants is highly appreciated. The IAEA officer responsible for this publication was M.A. Matin of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

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RESULTS OF THE CO-ORDINATED RESEARCH PROJECT

1. BACKGROUND

The Co-ordinated Research Project (CRP) on Public Acceptance and Market Development of Irradiated Food in Asia and the Pacific was initiated in 1994, with the aim of achieving wide acceptance of irradiated foods by the public and promoting domestic and inter-country trade of irradiated products.

During the subsequent four years, participants made commendable progress in the implementation of food irradiation technology in the countries concerned. The research work carried out and progress made in the participating countries was presented at the final Research Co-ordination Meeting hosted jointly by the Office of Atomic Energy for Peace (OAEP), Thailand, and the FAO Regional Office in Bangkok in September 1998.

2. SIGNIFICANT COUNTRY ACHIEVEMENTS

(a) Bangladesh

Consumers in Bangladesh have no adverse views on irradiated foods. Consumer acceptability tests conducted over the years did not reveal any untoward response to irradiated products. In order to create increased awareness among the stakeholders of the benefits of food irradiation, a national seminar was organized in 1996 on ‘Irradiation As An Alternative To Pesticides’. An IAEA expert, representatives of the Consumer Association of Bangladesh (CAB), Chamber of Commerce and Industries, senior officials from food and allied industries, executives of the Pesticide Association of Bangladesh (PAB), relevant government officials from the Ministries of Food, Commerce, Industries, Science and Technology and Health and Family Planning and scientists from other research organizations and professional groups, attended. Irradiated foods were exhibited at the National Science Fair and Exhibitions. Different professional groups were appraised on irradiation technology and its role in ensuring the safety and security of food products.

Gammatech Ltd, the joint venture company of the Bangladesh Atomic Energy Commission, and a leading private company known as BEXIMCO, irradiated and marketed about 1300 tons of different food items in 1995–1998. A number of non-traditional food items (food items hitherto untried or not irradiated before) such as beef casing, flour, turtle meat, peat soil, macaroni and others, were successfully irradiated and marketed.

To facilitate commercialization and trade in irradiated foods, Bangladesh adopted in 1995, a specification for Authorization of Irradiation by Classes/Groups of Foods in line with the guidelines proposed by the International Consultative Group on Food Irradiation (ICGFI). This is essentially similar to the Harmonized Regulation on Food Irradiation for Asia and the Pacific adopted in Seoul, Republic of Korea, in April 1998.

Radiation disinfestation studies to eliminate nematodes from ginger and turmeric, and mites and thrips from cut flower are in progress at the Institute of Food & Radiation Biology. Research work is also in progress to identify irradiated fruit flies, mites and thrips with radiation sensitive protein markers. The Co-60 gamma irradiator at the Institute is being replaced by a new 50 000 Ci Co-60 source to provide research and development support to commercialization activities. A large multi-purpose Co-60 irradiation facility (500 kCi) is in the process of establishment in the campus of Atomic Energy Research Establishment, Savar, Dhaka, for food and other radiation processing applications.

(b) People's Republic of China

The Ministry of Public Health approved irradiation of food by classes in July 1998, establishing standards for six classes/groups of foods covering a wide range of items under each class, namely vegetables and fruits, grains and beans, meats and poultry (fresh, chilled or frozen), cooked meat, spices and dehydrated vegetables and dried fruits and nuts. The approval was made effective and replaced an earlier approval for 18 food items. China established 50 large irradiators (each with a source strength of over 100 000 Ci), across the country, irradiating food and other products. In 1995–1998 more than 166 000 tons of different food products were irradiated and marketed through normal trading channels. The major products included rice — 2800 tons, garlic — 130 000 tons, spices — 25 000 tons, dehydrated vegetables — 8000 tons, and health food — 200 tons.

During the period 1994 to 1996, more than 30 consumer acceptability tests covering 20 different products were conducted in a number of Chinese cities including Shanghai, Beijing, Chengdu, and Nanging. More than 40 000 bags (10 tons) of irradiated pickled meat products with grain stillage were test marketed in more than one hundred supermarkets in Shanghai and evaluated for consumer acceptability. Consumer acceptance was favourable for the treated products marketed with the international logo for food irradiation. Market testing of irradiated rice, dehydrated vegetables and spices showed that 70–80% of consumers preferred the irradiated products based on quality considerations. The work on the production of a video on 'Irradiation Processing and Commercial Application of the Technology' was completed and will be used for creating public awareness. Studies on the inactivation of pork-borne parasites, the elimination of bacterial pathogens and the extension of shelf-life (shelf-life was extended for 30 days at a dose of 3 kGy at 5°C) were carried out on irradiated prepackaged 'fresh chilled cut' pork. The cost benefit of this application was also investigated.

(c) Republic of Korea

The Republic of Korea has one large commercial irradiator (800 kCi) owned by the private sector and used for treating food and pharmaceutical products. The plant has been in operation since 1987 at full capacity. A second irradiation facility has also been built by the private sector for processing food and medical products.

In the Republic of Korea, the Ministry of Health and Welfare (MOHW) is responsible for authorizing clearances, framing necessary regulations for irradiated foods and for the operation of irradiators. This is done in consultation with the Committee of Food Sanitation Deliberation and the Korean FDA. The Korea Institute of Nuclear Safety under the Ministry of Science and Technology is responsible for the control of food irradiation facilities. The General Standards and Regulation for the irradiation of 13 types of foodstuffs was enforced in September 1987 and amended on 19 May 1995. The Republic of Korea is expected to approve the use of ionizing radiation for red meat and meat products. It is also expected to adopt the Harmonized Regulation for Food Irradiation for Asia and the Pacific authorizing the irradiation of food by classes/groups of foods in 1999.

More than 6000 tons of food products consisting of mushrooms — 470 tons, spices and their products — 2750 tons, dried meat products — 135 tons, dried fish and shellfish products — 800 tons, soybean paste and hot pepper paste powder — 250 tons, starch for condiments

— 263 tons, dried vegetables — 1200 tons, yeast and enzyme products — 22 tons, aloe products — 32 tons and ginseng products — 10 tons were irradiated from 1995 to 1998. An average of two thousand metric tons of food products are irradiated per year. The treatment has been applied to items that cannot be processed by heat sterilization or chemical treatment and to those requiring standards for HACCP for export. The Republic of Korea has been using irradiation as an alternative to ethylene oxide to treat raw materials used in finished foods.

Various activities to disseminate information and educate the consumer on the benefits of food irradiation were undertaken. As part of the effort to create a favorable public opinion for the irradiation processing of foods, a national seminar on 'Acceptance and Trading of Irradiated Foods' was organized on 30 April 1998 at the Korean University in collaboration with the Korean Society of Food Science & Technology, the Korea Atomic Energy Culture Foundation and the Korea Atomic Energy Research Institute (KAERI). The proceedings of the Seminar were published in Korean and English.

(d) Malaysia

Malaysia proposed to work on four different areas to promote food irradiation technology under the project. Scientists were convinced that a clear cut need for the process, cost benefits, regulatory control, consumer acceptance and logistics had to be addressed for viable practical application of the technology. Promotional activities were carried out and the issues related to public and food industry acceptance of the technology, were addressed. Educational materials were developed using relevant ICGFI published materials. Thirty-seven food companies were surveyed and were appraised of the technical aspects and important benefits of irradiation technology. The majority of industrial respondents were aware of food irradiation but the level of knowledge was poor. One quarter of the industries surveyed understood that the irradiation process is a safe technique. As a part of a community outreach and public education activity a cross-section of the public was provided with popular information on the process through a seminar, exhibition, lectures and visits to industrial enterprises.

(e) Pakistan

The Pakistan Atomic Energy Commission (PAEC) has been working for the scaled-up application of food irradiation technology. Consumer acceptability of irradiated products was addressed through promotional marketing and the dissemination of information to the public. A program involving different age and professional groups was carried out. About 8 tons of irradiated potatoes and onions were successfully test marketed through normal trading channels. The PAEC's commercial irradiation facility, Pakistan Radiation Services (PARAS) in Lahore, which has been in operation for about 10 years, has been irradiating spices for commercial purposes. Pakistan has adopted the harmonized standards for the authorization of irradiation by classes/groups of foods as proposed by ICGFI and by the workshop on the Harmonization of Food Irradiation Regulations in Asia and the Pacific held in Seoul, Republic of Korea, in April 1998. Interest in the commercial application of irradiation technology has increased since the approval of harmonized standards in 1996. The Pakistan Storage and Supply Corporation (PASCO), which is responsible for the bulk storage of food commodities to maintain a uniform supply in the market, has shown an interest in the technology. PAEC is considering to establish more multipurpose or commercial irradiation plants under the government or under joint venture agreements with the private sector.

(f) Philippines

Prospects for commercial utilization of irradiation technology in the Philippines for onions, garlic and spices are promising. Private sector marketing and evaluation of consumer acceptability have confirmed that irradiated onions sell better than non-irradiated onions in supermarkets, due to better quality. Labeling of the commodity as irradiated did not affect consumer response. Marketing of 56 tons of Red Creole onions, 20 tons of Yellow Granex onions and 14 tons of shallots was carried out. This large scale irradiation work confirmed significant increase in yield of good quality bulbs due to the treatment (47% and 69% higher marketable bulbs, if irradiated). A study of the viewpoints of 200 consumers indicated that 67% were unaware of the technology and 85% would not purchase irradiated foods if they knew these were available. After providing information on the technology however, the percentage of the same consumers willing to purchase irradiated food increased to 79%.

An IAEA sponsored feasibility analysis for a commercial food irradiator in the Philippines found the establishment of a facility economically viable. The Philippine-led ASEAN initiative for facilitating the adoption of a harmonized food irradiation regulation for the countries of the organization may lead to the opening of markets for irradiated food commodities in the next millennium. An ASEAN Ad Hoc Working Group on Food Irradiation was formed by the Agriculture Ministers in 1996 and is expected to adopt a draft ASEAN Harmonized Regulation for Food Irradiation. This document formed the basis for the harmonized document on food irradiation regulations adopted in Seoul, Republic of Korea, in April 1998 by member countries of the Regional Cooperative Agreement (RCA) for research, development and training in Nuclear Science and Technology. All countries of the ASEAN except Brunei and Laos, who are not party to the RCA, have given their concurrence to the Seoul document.

In view of the high capital cost for putting up a food irradiation plant resulting from the devaluation of the currency, economic feasibility has become more strongly dependent on the opening of export markets for products for which irradiation offers distinct benefits. The phytosanitary treatment of mangoes by irradiation is an example of a beneficial application for which the opening of markets is key to the commercialization of the process. Local consumer education may need to be continued, but is not as difficult a challenge to face as the opening of export markets. It is encouraging that the volume of irradiated foods treated by the Philippine Nuclear Research Institute is increasing every year. In 1996–1997, about 10 tons of spices and dried ingredients were irradiated. The volumes of irradiated onions also increased from 6 tons in 1995 to about 75 tons in 1997 and 90 tons in 1998.

(g) Sri Lanka

Sri Lanka indicated that the harmonized regulation on food irradiation would be adopted within two years to enable trade in irradiated food to take place. Successful commercialization of the irradiation technology appears to be dependent upon the opening of profitable and prospective markets. To this end profitable products have to be identified, international markets opened and consumer education strengthened. Spices appear to be a good candidate in this regard.

Consumer acceptability studies indicated low preference for irradiated products in Sri Lanka. Sri Lanka carried out decontamination of spices by irradiation and found that chili powder, pepper and turmeric were free from contamination even after 8 months of storage. Studies revealed that the total demand for spices to be irradiated was 351 tons. Results of the investigation were submitted to the Atomic Energy Authority of Sri Lanka. In the near future Sri Lanka expects to establish a commercial irradiator once the ongoing R&D activities are successfully completed.

(h) Thailand

Thailand is one of the more advanced countries in the region with respect to the introduction of irradiated foods in supermarkets. It has successfully commercialized irradiated 'nham' (a traditional fermented sausage), spices, the enzyme bromelin and other products. The Thai Irradiation Center (TIC), which is a government facility, irradiated 5114 tons of food items on a commercial basis consisting of spices — 936 tons, herbs — 115 tons, fermented pork sausages or 'nham' — 295 tons, bromelin enzyme — 476 tons, pet products — 1336 tons and other products — 1958 tons. Thailand has regulations for the irradiation of 18 different food items. As a member of the ASEAN and the RCA, it is expected to adopt the draft ASEAN Harmonized Regulation for Food Irradiation as well as the related document adopted in Seoul in April 1998.

Identification of a suitable material for consumer packaging, market testing and survey of consumer attitudes for irradiated rice, were also carried out. Special grade fragrant rice and Jasmine rice (800 bags of 5 kg per bag) were irradiated to a minimum absorbed dose of 0.5 kGy at the TIC. The product was distributed weekly to local food stores in the Donmuang district in Bangkok, and the Klong Luang district, Pathum Thani, as well as to various government organizations and interested individuals. The irradiated rice was sold at 60 bahts per bag (about US $2.4) to retailers at a time when various commercial brands of non-irradiated rice (5 kg.pack) were available in the market at 52 to 78 bahts, depending on quality and brand. An information leaflet and a simple questionnaire were given to the consumers. It was found that 72% of consumers bought irradiated rice because of its high quality based on visual inspection and 28% were willing to try new products. In general, there was no consumer resistance to irradiated foods, especially irradiated fermented pork sausage ('nham') which is well-known in Bangkok supermarkets. The food industry has set up a very high requirement for the microbiological quality of food and therefore of raw materials used for food processing. Since 1997, the volume of spices and food seasonings for irradiation has increased rapidly due to the acceptance of the technology by the food industry. The use of irradiation is also on the increase for other products.

(i) Viet Nam

Viet Nam will adopt the harmonized food irradiation regulation prepared at the workshop in Seoul in April, 1998. A commercial demonstration type irradiation facility is available for the treatment of food and other related items. During the project period 45 tons of rice, 500 kg of litchi and 400 kg of mushrooms were successfully irradiated and test marketed. Consumers were found to accept the treated products. The dissemination of educational materials to the public was found to be the catalytic agent for enhancing public acceptance of the technology and of irradiated foods. Viet Nam is expected to complete the establishment of a full scale commercial irradiation facility in Ho Chi Minh City for food and medical products. The source is being purchased from Hungary and will have an initial loading strength of 500 kCi of cobalt-60.

3. DEVELOPMENTS AND TRENDS

Public acceptance, commercialization and trade development were the main areas addressed in this Co-ordinated Research Project (CRP) under the Asian Regional Co-operative Project on Food Irradiation (RPFI-Phase IV) of the RCA. Substantial progress was achieved in the earlier RPFI Phases I–III on research and development and semi-commercial/pilot-scale processing and storage of irradiated foods. This led to technology transfer activities, process control procedures and evaluation of public acceptance in countries party to the RCA. The fourth phase of the project aimed at strengthening public acceptance and market development in order to bring about trade in irradiated food products and the commercial exploitation of the technology on a wider scale. Three working groups were formed to consider developments in commercialization, public acceptance and trade/market development for irradiated food in the countries of Asia and the Pacific during the project. Summarized reports of the three working groups are presented below:

(a) Commercialisation

Many countries in Asia and the Pacific region have cleared the way for commercialization of food irradiation by establishing food irradiation regulations. Harmonization of these regulations is important to facilitate trade in irradiated foods. Bangladesh and Pakistan have adopted the authorization of food irradiation by groups/classes of food in accordance with the guidelines framed by the International Consultative Group on Food Irradiation (ICGFI). This is essentially similar to the Harmonized Regulation for Food Irradiation for Asia and the Pacific adopted in Seoul, Republic of Korea, on 27–29 April 1998. Korea, Malaysia, the Philippines, Sri Lanka, Thailand and Viet Nam will be adopting the harmonized regulation in the next 1–2 years. China approved the irradiation of food by six classes in July, 1998, covering a wide range of items under each class, namely vegetables and fruits, grains and beans, meats and poultry (fresh, chilled or frozen), cooked meat, spices and dehydrated vegetables and dried fruits and nuts. This replaced the clearance given earlier for 18 food items. Recently, Singapore liberalized food irradiation regulations allowing the marketing of irradiated foods. No special permission would be necessary other than what is generally required for other food items.

Bangladesh also adopted in 1997 a Nuclear Safety and Radiation Control Act covering the use of nuclear sources, devices and radioactive materials. This will help facilitate the establishment of commercial food irradiators in the country. A number of countries in the region have pilot scale/commercial irradiation facilities for irradiating different foods. China is leading in this respect with 50 large scale irradiators with a source strength of over 100 000 Ci each. The Republic of Korea has one large commercial irradiator (800 000 Ci) owned by the private sector for food products. A second irradiator for food and medical products will be built by the private sector in 1999. A government-owned demonstration plant (300 000 Ci) is available in Thailand and a new one is planned to be built by the private sector in the near future. Commercial/demonstration plants are also available in Bangladesh, Pakistan, Viet Nam, Malaysia and the Philippines.

Harmonized regulations for food irradiation and commercial scale facilities are important for commercialization of food irradiation technology. However, successful commercialization will also be dependent on the opening of profitable markets for irradiated foods. To achieve this, profitable products will have to be continuously identified, international markets opened and consumer education strengthened. Regional cooperation in this regard is necessary.

(b) Public acceptance

Most of the countries participating in the project have performed consumer acceptability tests on irradiated foods. In general, consumers expressed no reservations about irradiated products and generally preferred to buy irradiated food items because of better visual quality and knowledge of its hygienic quality.

In Bangladesh, consumer acceptability and test marketing of irradiated potatoes, onion, dried fish and pulses were conducted with participation of traders and wholesalers of normal trading channels. Consumers accepted irradiated food favorably. Information on food irradiation was disseminated through seminars, symposia, interaction with media, national science fairs and exhibitions to consumer organizations, Chambers of Commerce and Industries, food and pharmaceutical industries and other professional groups. People's republic of China carried out over 30 different test marketing and consumer acceptance studies over the years in Shanghai, Beijing and Chengdu and other major cities. Consumers (70–80%) accepted irradiated food products without any reservation. A video on "Irradiation Processing and Commercial Application of Food Irradiation" was produced in Chinese and English and telecast on Chinese Central Television (CCTV). Test marketing of 10 000 kg of irradiated pickled meat products using a laser viscose irradiated food label was carried out in over 100 supermarkets in Shanghai. Irradiated food products sold well and consumer acceptance was encouraging.

In the Republic of Korea two national seminars on "Safety of Irradiated Food" and "Acceptance and Trading of Irradiated Foods" were conducted in 1997 and 1998 respectively. A book on Wholesomeness of Irradiated Food was published by the Ministry of Health and Welfare, and consumer surveys were conducted which indicated consumer preference for irradiated product. A food industry attitude survey was conducted on 37 food processors in Malaysia and findings indicated poor knowledge and low acceptance of the irradiation process. Following the survey, three food processors were assisted in product testing using irradiation. During the project years information on food irradiation was disseminated to food industries, food regulators, quarantine inspectors, students and members of the public through newspapers, seminars, exhibition, lectures and visits to MINT radiation facilities.

Successful test marketing of 8 tons of irradiated potatoes and onions in Pakistan confirmed consumer acceptance of these items. In the Philippines consumer attitude towards irradiated food was evaluated through market testing of 6 tons of irradiated onions and conducting a survey with 200 consumers. The sale of labeled irradiated onions was brisk and always higher than the non-irradiated. Studies indicated that there was low consumer awareness of food irradiation technology and the willingness to purchase irradiated foods increased from 15% to 79% after information had been disseminated. Acceptance of food irradiation by industries was demonstrated by irradiation of 95 tons onions by food industries during the period as compared to only 6 tons previously.

A consumer acceptance study for irradiated spices was conducted among 500 educated participants (30–40 years old) in Sri Lanka. The study indicated low consumer preference for irradiated spices. Workshops, seminars and lectures were organized during the years to improve consumer acceptance on irradiated food. In contrast, there was no consumer opposition to irradiated food in Thailand. Consumer acceptance of irradiated rice was confirmed during this period. Consumer acceptance of other irradiated food products such as fermented pork sausage ('nham'), spices and food seasonings were established earlier. Information on irradiated rice and food irradiation technology were successfully disseminated to cross-section of consumers. In Viet Nam, effective information dissemination on food irradiation was carried out through mass media including TV, radio and newspapers to improve consumer awareness of food irradiation technology. The irradiation center was kept open to visitors from schools and universities. By adopting this practice a considerable volume of information regarding this technology has been disseminated to the public.

(c) Trade developments

Interaction with the commercial sector producing, supplying and/or marketing foods was a major activity in the project and led to the introduction of irradiated food products in domestic markets.

A total volume of 178 801 tons of different food and related products were irradiated and marketed during the period (1995–1998) through the normal trading channels. In *Bangladesh 1377 tons* (frozen foods 936 tons, dried fish 172 tons, wheat flour 167 tons, macaroni 63 tons, beef casing 33 tons, beans and pulses 6 tons and turtle meat 200 kg); in *China, 166 000 tons* (garlic 130 000 tons, rice 2800 tons, spices 25 000 tons, dehydrated vegetables 8000 tons and health food 200 tons), in the *Republic of Korea 6072 tons* (mushrooms 470 tons, spices and their preparation 2750 tons, dried meat products 135 tons, dried fish and shellfish products 800 tons, soybean paste and hot pepper paste powder 250 tons, starch for condiments 263 tons, dried vegetables 1200 tons, yeast and enzyme products 22 tons, aloe products 32 tons and ginseng products 10 tons); in *Malaysia 43 tons* (herbs 25 tons and spices 18 tons); in *Pakistan 18 tons* (onions and potatoes 8 tons and spices 10 tons); in the *Philippines 146 tons* (fresh onions 95.5 tons, onion powder 35.4 tons, garlic powder 5.4 tons, cayenne powder 9.2 tons and rice 0.39); in *Thailand 5114 tons* (spices 936 tons, herbs 115 tons, fermented pork sausage or “nham” 295 tons, the enzyme bromelin 476 tons, pet products 1336 tons, and others 1958 tons) and in *Viet Nam 45.9 tons* (rice 45 tons, mushroom 0.4 tons and litchie 0.5 tons) of products were irradiated and marketed.

Large volumes of products were marketed in countries such as China, Republic of Korea, Thailand and Bangladesh where commercial scale facilities for food irradiation exists. Smaller but sizeable volumes and/or increases in volume occurred in other countries as the Philippines, Pakistan and Viet Nam.

Applications for which irradiation has traditionally been established as beneficial, as in the control of sprouting in garlic, onions and potatoes and the decontamination of spices, dried vegetables and herbs dominated the list of traded products. In addition several new product applications were reported as pasteurized cooked meat products and pre-packaged fresh chilled cut meats in China, pet foods in Thailand, litchies in Viet Nam and beef casings and turtle meat in Bangladesh. All of the above irradiation applications were a reflection of a beneficial need for the technology under the conditions in which the products were marketed. It also signified the importance of these products to the food industry and/or consumers of participating countries.

Inter-country trade on irradiated foods was not initiated due, among others, to the lack of a harmonized regulatory infrastructure. In addition, several products, for which irradiation can be profitably applied, are not yet accepted in international markets. The opening of these markets was considered essential to the commercialization of the technology. Product quality also played a role in consumer acceptance. Appropriate post-harvest and irradiation quality control were important to consistently achieving the expected benefits in product quality and thus to the continued trade in irradiated foods.

(d) Global trends of public acceptance and trade

The role of irradiation processing of foods for combating post-harvest losses, curtailing food-borne diseases and overcoming quarantine barriers has been increasingly recognized. The potential benefits of irradiation technology have been well perceived in recent years in the wake of food-borne diseases caused by pathogenic organisms such as *E. coli* 0157: H 7, *Salmonella*, *Campylobacter*, *Listeria* in the USA and elsewhere. In fact, many target groups are considering food irradiation as a 'technological saviour' in ensuring food safety and quality by bringing down the number of incidences of food-poisoning caused by pathogenic organisms of public health concern.The scientific basis and technological adaptation of the process are now firmly established to make the technique virtually, risk-free and widely effective safe physical process. Food irradiation would be regarded as an essential tool to attain food security as we step in the 21st century. Introduction of irradiation technology is likely to significantly ease the food safety scenario (reduction of food-borne diseases through inactivation of pathogens present in foods by irradiation treatment) which has been regarded as most important threat to public health in the contemporary world.

International trade of irradiated food products is rapidly expanding. Some 30 countries are now using irradiation for preservation and processing of one or more food items at a commercial scale. Volumes of food products processed by irradiation and entering trade are significantly growing every year. Although total volume of irradiated food products (over 200 000 metric tons in 1997) in the global trade is small, certain items such as irradiated spices are occupying a big portion of the international trade of the commodity. About 63 000 metric tons of irradiated spices and dried vegetable seasonings were produced in1997 against less than 10 000 tons in 1990 and just over 30 000 tons in 1994 for international trade, half of which was in the USA. Prestigious media/press are reporting success stories of irradiation treatment and claiming the process as important to public health as the advent of pasteurized milk and chlorinated water at the turn of the century. More and more studies on consumer attitude and food industries' likely acceptance of the process, conducted in different countries, speak of encouraging responses. Following regulatory approval by US FDA in December, 1997 irradiated red meat is expected to be available in the United States supermarket shelves along with certain other irradiated products which are being routinely sold in the supermarket in some States in the USA.

4. CONCLUSIONS AND RECOMMENDATIONS

(i) There has been encouraging progress in the commercialization, public acceptance and domestic trade of irradiated food products in the RCA countries during the project period.

(ii) The RCA countries party to the project have identified the need for further acceleration of promotional activities in a co-ordinated manner. The sharing of information and experiences on marketing benefits, industry response and consumer acceptance have been valuable to identifying market opportunities and should therefore continue to be provided through regional activities.

(iii) The momentum gained should be sustained for smooth commercialization and trade development of irradiated food products within and outside the region. It is hoped that the adoption of a Harmonized Regulation on Food Irradiation for Asia and the Pacific as well as by ASEAN, will lead to enhanced inter-country trade of irradiated products in the region.

(iv) Further collaboration of RCA member countries in specific areas of application of food irradiation (e.g. irradiation as a sanitary and phytosanitary treatment for foods) should be strengthened and practical applications sought.

GLOBAL TRENDS OF ACCEPTANCE AND TRADE IN IRRADIATED FOODS

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Abstract. Issues as relevant to wide scale application of food irradiation are presented in this paper to provide current status of the technology. Global development on key issues such as public acceptance, public health improvement, safety and wholesomeness, regulatory aspects, potential application of the technology to ease quarantine problems in the trade of food and agricultural commodities as a viable alternative to fumigation with methyl bromide have been presented. Irradiation ensures the hygienic quality of food and extends shelf-life. Many international organizations and respected regional/national bodies agree on the merits of the technique and valuable contribution that the process can offer to safeguard the food supply worldwide. Codex General Standard for irradiated food and the associated Code of Practice for operation of the irradiation facilities used for the treatment of foods adopted in 1983 forms the regulatory basis for commercial utilization of the processing technology. More than 40 countries of the world have Standards/Regulations to process one or more food products by the irradiation process. Efforts are underway to harmonise national regulations on food irradiation to remove obstacles for international trade of irradiated products. There is a rapid development on commercial application of food irradiation in the USA and elsewhere in the past few months. There are already several existing commercial irradiators available for treating food in the USA and many more are planned to be built. Such commercial food irradiation facilities are also in different stage of development in Brazil, India, Mexico, Thailand, People's Republic of China, Republic of Korea. Roles of irradiation ensuring food safety, contributing food security and facilitating trade are more and more recognized in developed and developing countries alike.

1. INTRODUCTION

Irradiation processing of foods for combating post-harvest losses, curtailing food-borne diseases and overcoming quarantine barriers has been pursued since the mid-50's. The scientific basis and technological adaptation of the process have been well established probably more than any other post-harvest technique for food processing. Safety of the treatment has been internationally recognised and as the technology is a 'cold process' it is suitable for frozen products in the form of pre-packaged food as well as for bulk treatment such as the irradiation of grains. Necessary infrastructure such as regulatory approvals of the treatment, mechanisms to control irradiation facilities and necessary protocols to carry out individual commodity treatment are now available. The merits and benefits of the irradiation technology in addressing post-harvest food problems are, in some cases, unique and can improve the quality of a number of food products by eliminating the risk of pathogenic contaminants. The potential of the irradiation technology has been well perceived in recent years in the wake of food-borne diseases caused by pathogenic organisms such as *E. coli* 0157: H 7, *Salmonella*, *Campylobacter*, *Listeria*, etc. in the USA and elsewhere. In fact, many parts of the world are considering food irradiation as a 'technological saviour' in finding a suitable solution for the problems caused by pathogens in food. Food irradiation can be regarded as a useful tool to attain food security in the 21st century. Introduction of irradiated foods would become as important to public health as the advent of pasteurised milk and chlorinated water was at the turn of the century.

2. PUBLIC ACCEPTANCE

Over 40 countries have regulatory approvals in place for irradiation processing of one or more food products. But not all these countries are utilising the process on a commercial scale. Currently, some 30 countries are practically applying the technology for a limited number of food items. The lack of acceptance of food irradiation has been mainly due to misconceptions and irrational fear of nuclear related technologies. Also, people are confused and fail to differentiate irradiated food from radioactive foods. Radioactive foods are those which have become accidentally contaminated by radioactive substances from weapons testing or nuclear reactor accidents, and are totally unrelated to irradiated foods which are deliberately processed with certain types of radiation energy to bring about desirable changes (i.e. to destroy food poisoning pathogens, for disinfestation purposes, or to inhibit sprouting).

Informed consumers evaluate the process and irradiated foods in a rational manner. According to Christine Bruhn, a consumer food market specialist at the University of California at Davis, when consumers are told what irradiation is, a majority of people support the process and will buy irradiated food (Bruhn, 1995). The earliest use of irradiation in the United States (US) was to provide astronauts with food as free from contamination as possible. Astronauts consumed irradiated sandwiches during the 1972 moon mission and the US Space Agency (NASA) has routinely provided a complete menu of irradiated food since the Apollo17 mission. Consumer acceptability tests of irradiated foods have been carried out in many countries of Western Europe and North America as well as in a number of countries in Asia and Latin America. Marketing trials of irradiated food have been conducted over the past several years in countries such as France, Hungary. USA, Holland, Belgium, Argentina Chile, China, Israel, Poland, Thailand, Indonesia, Bangladesh, India, Pakistan and the Philippines, all with favourable results. Quantities of irradiated papaya, mango, fermented pork sausage (Nham), strawberries, onion, potato, spices were test marketed and allowed through wholesale and retail supermarket chains; without exception the ventures were successful.

3. COMMERCIAL APPLICATION

Large scale commercial exploitation of food irradiation has been rather slow even after the positive recommendation of the technology by the FAO/IAEA/WHO Joint Expert Committee on Food Irradiation (JECFI) in 1980. Necessary infrastructure such as government approvals, standards for foods to be treated, codes of practice for operation of irradiation facilities, protocols for individual applications and process control parameters using criterion as embodied in Good Manufacturing Practice (GMP) and associated Good Irradiation Practice (GIP) are now available for commercial application of the process. Unqualified fear related to nuclear technologies has adversely affected commercial applications of the technology. However, the misconceptions and undue fear have now largely been removed and steady growth of commercial application of the technology is in sight. Contamination of food with pathogenic organisms and resultant deaths and medical situations during the last 4 to 5 years have led to a review of the post-harvest food processing scenario and a growing realisation of the usefulness of the food irradiation technology.

At present some 30 countries are commercially applying the technology to process a limited number of food items. USA, France, the Netherlands, Belgium, Hungary and South Africa are major countries producing irradiated food items including spices and vegetable seasonings on a commercial basis. Countries like the Peoples' Republic of China, Thailand, Republic of Korea and Argentina are also irradiating certain food items for commercial purposes. Practically unlimited scope exists for wide scale application of the process of food irradiation in view of recent food safety scares. The GATT Uruguay Round in 1993 with the conclusion of Agreements on the Application of Sanitary and Phytosanitary Measures (SPS) and subsequent establishment of the World Trade Organisation (WTO) in 1995, along with growing awareness of the risks of pathogenic contaminants in food, may provide a basis for expansion of commercialisation of food irradiation in different countries of the world.

The approval of the US Food & Drug Administration (FDA) in December, 1997 on irradiation of red meat for the control of pathogenic organisms is regarded as a milestone in paving the way for extensive exploitation of the technology. In fact, irradiated beef is soon expected to appear in US supermarkets. Food industries in the US have shown enthusiasm and eagerness in practically employing the technology in order to meet stringent US Department of Agriculture (USDA) requirements of quality. As there is a growing awareness on safety and increasing concerns about the use of pesticides/fumigants the radiation processing of food may turn out to be a widely accepted method in addressing major post-harvest problems of foods.

4. NEED FOR HARMONISED REGULATIONS

More than 40 countries of the world have Standards/Regulations to process one or more food products by the irradiation process. However, each country has its own way of framing these regulations and often it has been observed that trade of such treated products would face difficulties because of dissimilar or lack of harmonised guidelines. In order to remove these non-tariff barriers, the International Consultative Group on Food Irradiation (ICGFI), after careful consideration, drafted guidelines that seek harmonisation of the existing and new regulations. These guidelines have been well received and a sense of urgent action in this direction is underway. A few countries have already adopted the harmonised standards while others are in the process of doing so. The Association of the South-East Asian Nations (ASEAN) is currently in the process of adopting a harmonised regulation replacing approvals for individual food items that exist in some of these countries. A specialised workshop held in Seoul, Republic of Korea in April, 1998 on Harmonisation of Regulations in Asia and the Pacific has helped create a firm basis and countries in the region are likely to come up with such a harmonised regulation within 2 years in order that trade in irradiated foods can be established.

5. IMPROVEMENT OF PUBLIC HEALTH STANDARDS

Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) adopted at the GATT Uruguay round in 1993 and administered by the WTO has opened up immense scope and potential for the irradiation technology to ensure the hygienic standards of foods. This is particularly valuable for foods of animal origin by way of elimination of the risk of pathogenic organisms that often contaminate such foods. Raw poultry, red meat and sea foods are often sources of food-borne diseases caused by *E. coli* 0157:H7, *Salmonella*, *Campylobacter*, *Listeria monocytogenes*, etc. Treatment of such food of animal origin with ionising radiation has become more apparent in recent times as stringent quality standards are applied in the US and Western Europe (European Union countries) following detection of hamburger meat contaminated with *E. coli* 0157:H7 which led to losses of life in the US and elsewhere. In fact, such situations led to authorisation of irradiation processing of red meat by the FDA in the USA.

The regulatory approval by the FDA to process meat by irradiation in order to eliminate pathogens has set the stage for large scale industrial application of the irradiation technology in the US and elsewhere. Belgium, France and the Netherlands have been irradiating frozen shrimp, frog legs, etc. to remove pathogenic organisms of public health concern. For the same reason, in Thailand, fermented pork sausages (Nham) are irradiated at the Thai Irradiation

Center and are available in the supermarket. As consumers and the food control authorities in developed as well as developing countries are becoming increasingly cautious on the question of food safety the food irradiation technology would be expected to be applied commercially at a wider scale.

The countries of Asia and the Pacific are urgently required to implement appropriate standards to ensure food quality to avoid its rejection by western countries. In recent times a number of such rejections have been the cause of major concern. Rejection of shrimps due to contamination by pathogens such as Salmonella poses a severe problem which may worsen in the near future as increasing quantities of shrimp and sea food are produced through intensive farming practices of culture and harvest. Irradiation could be used as a sanitary treatment as part of the Hazard Analysis Critical Control Point (HACCP) system which is being practiced by the sea food industries world-wide.

Irradiation is also an effective way of ensuring hygienic standards of foods of plant origin. Certain vegetables and fruits may already become contaminated with pathogens such as Salmonella in the field. Some outbreaks from consuming such produce in its raw form have been reported. Certain vegetables and fruits produced in the tropical developing countries are popular in Western countries and pathogens must be removed prior to export. In addition, certain fruits may be contaminated with parasites such as *Cyclospora* spp. which may cause severe health problems. Such protozoa/parasites can be controlled with irradiation treatment at doses as low as 1 kGy.

6. IRRADIATION FOR QUARANTINE PURPOSES

Irradiation is regarded as a broad spectrum quarantine treatment, not specific to insect species nor host crops. The North American Plant Protection Organisation (NAPPO), Asian and the Pacific Plant Protection Commission (APPPC), European and Mediterranean Plant Protection Organisation (EPPO) and many such organisations have endorsed irradiation as a quarantine treatment of fresh horticultural produce. Countries in Asia and the Pacific region produce a number of important fresh horticultural commodities which are exported and have potential for trade expansion to countries in the West. Unfortunately, many of these fresh products are often infested with insects thereby limiting or posing a threat to potential trade opportunities. Irradiation as a phytosanitary treatment of fresh fruits and vegetables against fruit flies is well documented (NAPPO,1997; USDA,1996).The USDA/Animal and Plant Health Inspection Service (APHIS) issued a policy notice on 15 May, 1996 accepting irradiation as a quarantine treatment of fresh fruits and vegetables against major species of fruit fly regardless of host commodities or pest (USDA, 1996). Such phytosanitary guidelines of uses of irradiation as quarantine treatment are also expected to be applied in Canada and Mexico. Countries in South East Asia (ASEAN) are in the process of implementing a harmonised protocol on the use of irradiation for horticultural commodities to satisfy quarantine requirements of the importing countries.

7. IRRADIATION AS AN ALTERNATIVE FOR CHEMICAL FUMIGATION

The use of ethylene dibromide (EDB), ethylene oxide (ETO) and methyl bromide (MB) has been either prohibited or is being restricted due to health, environmental or occupational hazards. EDB had been banned since 1984, and the use of ETO as a decontaminant (widely used for spices) has been prohibited by the European Union since 1991. The US Environment Protection Agency (EPA) has banned the use of ETO since 1996. MB, the most widely used fumigant for food and agricultural commodities against pests such as insects and nematodes, will suffer the same fate as EDB as it has been listed as ozone depleting substance under the Montreal Protocol and its use is being gradually restricted. Irradiation has been shown to be a very effective method for replacing chemical fumigation. The irradiation dose required for disinfestation of insects in grains and other stored products are low requiring less than 1 kGy (IAEA, 1991). Irradiation of food is a physical method which unlike chemical fumigants does not leave residues on the products and thus, merit-wise, it is an excellent means of achieving desired objectives without affecting consumers or the environment.

8. IRRADIATED FOOD IN TRADE

In spite of the fact that irradiated foods and the process of food irradiation have been thoroughly tested and the superior quality of treated products established, the quantity of irradiated foods in the global food trade is not significant. However, the value of the technology is becoming more and more evident as food security and consumer safety questions are discussed. In general, consumers are conservative and unless properly explained they are reluctant to accept products processed by new technologies and especially when it comes to irradiated foods it is more so. A number of countries including USA, France, Hungary, the Netherlands, Belgium, South Africa, the People's Republic of China, Thailand, Republic of Korea, Argentina, etc. are irradiating one or more food items commercially. The total volume of irradiated food in trade is still small, i.e. in the order of 200,000 metric tons/annum. However, the volume of irradiated spices in the world's trade is steadily increasing with about 63,000 metric tons in 1997 as opposed to 7500 metric tons in 1987. A quantity of 30,000 metric tons of irradiated spices and dried vegetable seasonings was produced in the US alone in 1997.

Since January 1992, irradiated products have appeared in some Midwest and Florida supermarkets in the USA. At least a dozen different irradiated foods are being sold in the USA including strawberries, oranges, tomatoes, onions, mushrooms. Irradiated tropical fruits such as papaya, atemoya, rambutan, lychee, starfruit, banana and Chinese taro have been sold in the Midwest. Irradiated poultry has also been on the supermarket shelves in the same areas.

The growing public awareness on food safety and quality combined with recent incidences of food-borne diseases has underscored the need for the irradiation technology to effectively deal with the problems of food-borne pathogens. The recent approval in the US by the FDA allowing irradiation of red meats on a commercial basis and enthusiasm for the technology among food industries may signal wide commercial applications in the future (DA Consumer, 1998). The European Union countries and South-East Asian countries would be expected to follow by initiating regional and international trade of irradiated foods. Recently, Australia has approved irradiation of food for export (AIFST, 1998).

As stated earlier the process of irradiation of food is hailed as the technological saviour in the context of food-borne diseases and it holds a promising future in attaining food security and public health intervention in stepping to the 21st century.

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PUBLIC ACCEPTANCE, MARKET DEVELOPMENT AND COMMERCIALIZATION OF FOOD IRRADIATION TECHNOLOGY IN BANGLADESH

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Abstract. Current status of food irradiation technology in Bangladesh with respect to public acceptance, commercial application, trade development and present research and development activities are summarized in the paper. Irradiated food products are generally accepted by people. To further boost public opinion on the usefulness of the technology, two national seminars were successfully organized in 1995 and 1996 respectively with wide participation and media coverage. A number of non-traditional items such as beef casing, flour, turtle meat, macaroni, peat soil, etc. were irradiated and successfully marketed during the last 5 years. Bangladesh adopted a "Specification for Authorisation of Irradiation by Groups/Classes of Foods" in 1995 in line with the ICGFI Guidelines. The Bangladesh Standard is essentially similar to the Harmonised Regulations adopted for the RCA countries in April, 1998. About 1300 metric tons of different food items were irradiated for commercial purposes at the Gammatech Irradiation Facility in Chittagong during the past 5 years. Present research activities in Bangladesh include irradiation disinfestations of nematodes in ginger and turmeric, and mites and thrips from cut flowers. Work on identification of fruit flies, mites and thrips by using sensitive protein markers are in progress.

1. INTRODUCTION

The current status of public acceptance, trade development, commercialization, research and development activities in relation to food irradiation in Bangladesh is presented.

2. PUBLIC ACCEPTANCE

Consumer acceptability trials and test marketing of promising food items such as potato, onion, dry fish and pulses were carried out in collaboration with traders and wholesalers. It was found that the consumers have accepted irradiated products very favorably, especially when the superior quality and hygiene of these products were immediately apparent. Two national seminars were organized in 1995 and 1996 to promote irradiation as an effective alternative to pesticides for food preservation. These were attended by representatives of the Consumer Association of Bangladesh, Chambers of Commerce and Industries, scientists from other organizations and officials of relevant government departments. No inhibition, unfavorable reaction or organized resistance was observed against irradiated foods.

3. MARKET DEVELOPMENT AND PROMOTION

Pilot and semi-commercial scale irradiation and storage studies of promising food items were carried out in collaboration with traders and wholesalers. Studies on optimum doses, packaging, storage conditions, transportation, nutritional aspects and toxicological studies of specific irradiated food items were undertaken. Techno-economic studies on commercialization of food irradiation technology were carried out. The scientific community, the Consumer Association of Bangladesh (CAB), the potential investors and the public at large were kept informed about merits of food irradiation through seminars, symposia and the information media. In addition, lectures on food irradiation to different professional groups, participation in national science fairs and exhibitions to demonstrate irradiated foods and distribution of leaflets containing relevant data and information on food irradiation have been conducted.

A number of non-traditional items (items hitherto untried or not irradiated before) such as beef casing, flours, turtle meat, macaroni, peat soil, etc. were irradiated and marketed successfully.

4. LEGAL FRAMEWORK FOR COMMERCIALIZATION

To provide the legal framework for the commercialization of food irradiation clearance for the irradiation of 12 food items was issued by the Bangladesh Standards and Testing Institute in 1983. Subsequently, in 1995, Bangladesh adopted a "Specification for Authorization of Irradiation by Groups/Classes of Foods" in line with the guidelines framed by ICGFI. This authorization for irradiation by groups/classes of foods is essentially similar to the final draft of the Harmonized Regulations for Food Irradiation in Asia and the Pacific adopted by RCA Member States in Seoul, Korea in April 1998.

Bangladesh promulgated in 1997 a Nuclear Safety and Radiation Control Act covering use of nuclear sources, devices and radioactive materials.

The establishment and operation of a commercial food irradiation facility will be governed by the provisions of the national Nuclear Safety and Radiation Control Act and the Bangladesh Standards and Testing Institute.

5. COMMERCIALIZATION OF FOOD IRRADIATION TECHNOLOGY

A demonstration cum-commercial Co-60 irradiation plant was set up in March 1993 in the port city of Chittagong as a joint venture project (Gammatech Ltd) of the Bangladesh Atomic Energy Commission and BEXIMCO, a leading private company in the country.

Gammatech Ltd has irradiated over 1300 tons of different food items brought by clients (see Table I). These items have been marketed successfully both at home and abroad. In

TABLE I. QUANTITY OF PRODUCTS IRRADIATED AND REVENUE EARNED BY GAMMATECH Ltd

Year Products irradiated	1993 (July-Dec)	1994 (Jan-Dec)	1995 (Jan-Dec)	1996 (Jan-Dec)	1997 (Jan-Dec)	1998 (Jan-Apr)
Food Items						
Dried fish (kg)		129,959	495	154	42,265	-
Frozen foods (kg)		8,842	319,453	276,193	175,028	157,097
Beef Casing (kg)		8,842	8,980	10,475	5,028	
Bean/Pulses (kg)		-	2,000	-	4,000	
Flour (kg)		-	11,940	4,620	-	
Turtle meat (kg)		-	-	200	-	
Macaroni (kg)		-	-	33,176	30,158	
Total (kg)		147,643	342,867	323,818	256,751	157,097
Medical Items						
Shell Dressing (Pcs)	9,542	-	10,260	-	-	
Plastic bottle, caps, droppers, etc. (cft)	886	1,559	1253	1992	1,280	265
Magnesium Trisilicate (kg)	7,650	-	5,120	-	-	-
Magnesium Silicate (kg)	-	-	52,850	51,326	40,065	
Safe delivery Kits (cft)					235	
Gum accasia (kg)					575	
Peat soil (kg)					3,045	
Total revenues (Tk.)	379,504	812,930	2,400,000	2,300,000	1,802,354	851,735

addition, a number of pharmaceutical items are being irradiated regularly with the limited strength of the irradiator. The initial strength of the source was about 85 kCi. The present strength of the source is around 40 kCi. The revenue earned as service fees can meet 95–100% of annual operating expenses.

Most of the irradiated food items are sold in the local market which is not very quality conscious as there is lack of grading and standardization and lack of enforcement of food laws and regulations. This acts as a disincentive to traders to bear the extra cost and effort associated with the handling, packaging and transportation of irradiated products, even if the actual cost of irradiation is quite small. For example, there are technical considerations that have to be met with food irradiation. Irradiated potatoes have to be stored in cool storage (10–12^{o}C) which are not immediately available; onions are to be irradiated within 2-3 weeks of harvest; dried fish, pulses and other products are to be properly packaged before irradiation to prevent post-irradiation reinfestation during storage.

For the export market, the product with the most potential for treatment is frozen shrimp and other fishes. Presently Bangladesh is exporting about 50–60 thousand tons of frozen fish and the bulk of it is exported through the Chittagong port. The major importing countries are the EEC countries, USA and Japan. With the clearance of irradiated frozen fish in these countries, the exporters are expected to be motivated to irradiate their products to meet the quality standards of the importing countries.

6. RESEARCH AND DEVELOPMENT ACTIVITIES

Participation in a number of CRPs related to the promotion of food irradiation technology has taken place. Radiation disinfestation studies are in progress at the Institute of Food and Radiation Biology (IFRB) to eliminate nematodes from ginger and turmeric and, mites and thrips from cut flowers. Research work is also going on to identify irradiated fruit flies, mites and thrips by detecting radiation sensitive protein markers. The successful completion of these studies is expected to expand trade in irradiated fruits, vegetables and flowers.

The present strength of the existing Co-60 source at IFRB has come down to about 12 kCi. It is now being replaced by a new Cobalt-60 source of 50 kCi strength. Tender for the new source has already been floated and the offers are under process. It is expected that the new source will be installed within about a year from now.

7. CONCLUSION

Food irradiation technology is now in a take-off stage in Bangladesh. It is now clear that future growth of the technology will depend on the commercial profitability of specific applications. IFRB will continue to provide necessary research and development support in this regard.

TEST MARKETING AND CONSUMER ACCEPTANCE OF IRRADIATED MEAT PRODUCTS

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Abstract. This study consists of two parts: irradiation processing of cooked meat and irradiation preservation of prepackaged chilled fresh cut meats. Irradiation of prepackaged pickled meat products dipped in grains stillage+ at a dose 6–8 kGy eliminated common food-borne microorganisms, such as *E. Coli* and other microbial pathogens and extended the shelf life of the product to 10 days at 5°C. Test marketing of 40,000 bags (about 10,000 kg) of the product in more than 100 supermarkets in the city of Shanghai showed no untoward problem with consumer acceptance. Irradiation of prepackaged chilled fresh cut pork at a dose 3 kGy led to inactivation of microbial pathogens and parasites with a concomitant reduction in numbers of common spoilage microorganisms and extension of shelf life of the product for 30 days at 5°C. The cost benefit and marketing applications were evaluated.

Grain stillage is the mixture of Chinese yellow wine distilled from grain and spices squeezed into the wine. The mixture is held in the pottery vessel for about a year followed by addition of boiled water with spices in the vessel.
Pickled boiled pork, poultry or organs are then soaked in the extract and stored at 2^0C for 4–6 hours before consumption.

1. INTRODUCTION

Food irradiation is an extremely promising technique that could substantially increase the supply of safe food and contribute to improving public health throughout the world. Over the years, special research efforts have been put into two important applications of food irradiation namely, the reduction of food losses and the incidence of food-borne diseases. Food-borne disease has been a major factor adversely affecting human health and productivity in many parts of the world. Foods, especially of animal origin, which are contaminated with microorganisms, particularly pathogenic non-spore-forming bacteria, or infected with parasitic holminthes and protozoa, have been a cause of human suffering and malnutrition.

Food-borne disease has been a major factor adversely affecting human health and productivity in many parts of the world. Foods, especially of animal origin, which are contaminated with microorganisms, particularly pathogenic non-spore-forming bacteria, or infected with parasitic holminthes and protozoa, have been a cause of human suffering and malnutrition.

According to WHO, up to 70% of diarrheal diseases which cause about 25% of all deaths in developing countries, have food as the transmission vehicle for the causative agents. In the United States of America, there are between 24 and 81 million cases of food-borne diseases every year, and some 10,000 cases lead to death. Salmonellosis alone accounts for about 2 million of these cases and is estimated to cost at least US $1,500 million annually [1].

USDA agricultural economists and parasitologists recently estimated that the total annual cost, which includes income losses, medical cost, and over a lifetime of disability, due

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to congenital toxoplasmosis in the USA is of the order of US $5 billion. About half of the cases are estimated to be related to pork consumption, compared to 781,578 due to trichinellosis. Medical and productivity loss attributable to toxoplasmosis from meat and poultry consumption costs over US $2.6 billion. This far exceeds that for individual microbial pathogens as well as for other parasites of concern [1].

It has been demonstrated that ionizing radiation can eliminate or greatly reduce the population of microbial pathogens in food products and extend shelf life while preserving the desired nutritional and sensory properties. In fact, food irradiation is now recognized as an important post-harvest technique for food industries and the technology may become a viable alternative to hazardous chemical treatment. The Shanghai Irradiation Center has conducted R&D projects on irradiated prepackaged meat products for many years. The projects have been carried out in collaboration with the Shanghai Institute of Food Hygiene and Supervision and supported by the Science and Technology Commission of the Shanghai Municipality.

The Center took part in the Research Agreement No. 8167/CF of the FAO/IAEA Co-ordinated Research Programme on Public Acceptance and Market Development of Irradiated Food in Asia and the Pacific. This Research Agreement No. 8167/CF is entitled “Test Marketing and Consumers Acceptance of Irradiated Meat Products”. It includes two sub-projects: Irradiation pasteurization of prepackaged cooked meat products and Irradiation processing of prepackaged fresh chilled/refrigerated cut pork.

2. STUDY OF IRRADIATION PASTEURIZATION AND TEST MARKETING OF PICKLED MEAT PRODUCTS WITH GRAIN STILLAGE

2.1. Irradiation of cooked meat products

Cooked meat products are important ready-to-eat food in China and constitute a large portion of China’s meat consumption. The meat products are processed by cooking or boiling. However, they could be contaminated by microorganisms in the course of storage, transportation, selling, cutting and packaging. Without an effective means to disinfect the product after packaging, the hygienic quality of the meat products is still an open question. High temperatures and pressures cannot be used for Chinese dishes, especially Chinese meat products with a special color, flavour and taste. Therefore, food irradiation processing through “cold disinfection” has been welcomed by the food industry in China and in 1994, a national standard on this type of food "Hygienic Standard for Irradiated Cooked Meat Food" (G B 14891.10) was established by the Ministry of Public Hygiene. Since then, the number of food factories that use food irradiation for this purpose has increased gradually.

Pickled meat products are special type of meat products prepared by dipping boiled pork, poultry and organs (e.g. tongue, belly, gizzard, etc.) in rice wine, salt and spice berry (grain stillage). This kind of food has a special flavor and is especially popular in the summer. Every year, hundreds of tons of such pickled meat products are consumed in Shanghai. A process has to be developed that can replace high temperature sterilization used to ensure the hygienic quality of the prepackaged pickled meat products with grain stillage and extend shelf-life, while maintaining the special color, flavor and taste of the product. Based on these requirements, the Shanghai Irradiation Center and Shanghai Institute of Food Hygiene Supervision and Inspection jointly conducted studies on irradiation pasteurization, test marketing and consumer acceptance of the irradiated pickled meat product.

2.2. Study on irradiation pasteurization of prepackaged pickled meat products with grain stillage [2]

2.2.1. Materials and method

Pickled chicken or pork with grain stillage were vacuum-packaged with OPP/PET film bag. The samples were divided into four groups namely, 1) the control, 2) 6 kGy irradiation, 3) 8 kGy irradiation, and 4) the microbial test group. Each group had 90 bags of product. The groups were further divided into three subgroups. The products of subgroups of Group 1, 2 and 3 were stored at <10°C, 23°C and 35°C respectively, after irradiation. The products of the subgroups of Group 4, were inoculated with 1×10^3 cfu/g of *E. Coli*, and the treatments repeated on Group 1, 2 and 3. Regular observations were made to monitor changes of the samples in Group 1, 2 and 3 in terms of color, flavor and taste. Group 4 was used for microbial tests, which were performed as stipulated in China's National Standard, with every single test being done on two parallels.

2.2.2. Results of the sensory tests

The samples irradiated with 6 kGy and stored at <10°C lasted for 10days without change in color and flavor. The samples irradiated at 8 kGy and stored at <10°C did not change in color, flavor and taste for the entire experimental period of 15days. However, the control group changed color on the 10th day, whereas the flavor and taste changed on the 11th day. Statistical calculations on the results showed $x^2 = 8.13$ and $P < 0.05$, which indicated that there were notable differences in sample observations between the control and irradiated group. There were also notable differences between the two irradiation groups. The statistical results for the latter were $x^2 = 3.84$ and $P < 0.05$.

2.2.3. Shelf life of the samples under different storage temperatures

Shelf lives of the samples under different storage temperatures are shown in Table I. Statistical calculations of the shelf lives indicated $x^2 = 3.84$ and $P < 0.05$ between the two irradiation groups. All the differences were notable.

TABLE I. SHELF LIFE OF IRRADIATED PICKLED MEAT PRODUCTS WITH GRAINS STILLAGE AT DIFFERENT STORAGE TEMPERATURES AND IRRADIATION DOSES

Storage	Control			6 kGy			8 kGy		
Day	<10°C	23°C	35°C	<10°C	23°C	35°C	<10°C	23°C	35°C
2	-[a]	+[b]	+	-	-	-	-	-	-
3	-	+	+	-	+	+	-	-	-
4	-	+	+	-	+	+	-	+	+
5	-	+	+	-	+	+	-	+	+
6	-	+	+	-	+	+	-	+	+
7	-	+	+	-	+	+	-	+	+
8	-	+	+	-	+	+	-	+	+
9	-	+	+	-	+	+	-	+	+
10	+	+	+	-	+	+	-	+	+
11	+	+	+	+	+	+	-	+	+
15	+	+	+	+	+	+	-	+	+

[a]Mark (-) means that the sensory results and microorganisms in the samples conform to the National Hygienic Standard.

[b]Mark (+) means that the sensory results and microorganisms in the sample do not conform to National Hygienic Standard.

[c]Between control and irradiation groups, $x^2 = 7.46$, $P<0.05$.

[d]Between the 6 and 8 kGy groups, $x^2 = 3.84$, $P<0.05$.

2.2.4. Results of microbial tests of the contaminated group

E. coli, 1×10^3 cells/g, was added to group 4 of the samples. The subgroups 2 and 3 were irradiated to 6 and 8 kGy, respectively. The subgroup I was the control. Ten samples in the subgroups were stored at <10°C, 23°C and 35°C, respectively. Microbial tests on the samples were done everyday during the experimental period. The results are shown in Table II.

TABLE II. RESULTS OF MICROBIAL TESTS ON GROUP 4 OF THE SAMPLE (CFU/g)

Storage	Control			6 kGy			8 kGy		
Day	<10°C	23°C	35°C	<10°C	23°C	35°C	<10°C	23°C	35°C
2	0	1.4×10^5	1.4×10^5	40	20	<10	30	<10	120
3	2.3×10^3	3×10^4	3×10^5	<10	3×10^6	3×10^6	<10	90	1.2×10^5
4	1.2×10^3	U.C.	U.C.	<10	3×10^6	3×10^6	100	3×10^6	3×10^6
9	1.4×10^4	U.C.	U.C.	<10	U.C.	U.C.	<10	5.3×10^6	U.C.
10	3.4×10^4	U.C.	U.C.	1.9×10^5	U.C.	U.C.	400	U.C.	U.C.
11	9×10^6	U.C.	U.C.	2.8×10^6	U.C.	U.C.	<100	U.C.	U.C.
15	U.C.[a]	U.C.	U.C.	6×10^6	U.C.	U.C.	80	U.C.	U.C.

[a] U.C. means unable to count.
[b] Compare the rate of qualified and unqualified samples between the control and irradiated groups, $x^2 = 7.96$, $P < 0.05$.

The results showed that irradiation pasteurization can effectively prevent the growth of microorganisms. The results of *E. coli* tests are similar to these results. Bacterial pathogens of the samples were not studied.

2.3. Test marketing and consumer acceptance of the irradiated products

The irradiation pasteurized prepackaged pickled meat products with grain stillage that had been used in industrial production (the irradiation dose 8 kGy), had a shelf life of 10 days under 5°C.

For test marketing, a laser viscose label was placed on the top side of bag. It was marked with the terms “Irradiated Pasteurized Food”, “Chinese Food Hygiene Inspection” and the international logo for food irradiation. A total of 40,000 bags (about 10,000 kg) of irradiated products with the above label were sold for about 1 month (from July to Aug. 1996) in more than one hundred supermarkets in the city of Shanghai. The sale was normal in the entire period and no opposing views were received.

Data on consumer acceptance had been carried out many times before. In visiting consumers, the following remarks were obtained:

“These irradiated products are cleared by the government, we believe that these foods are hygienic and safe.”

“This laser label is a label of a high quality product.”

“On the label had been marked Chinese Food Hygiene Inspection, means this product is reliable.”

“I had tasted these products, the quality and flavor are all nice, so that I buy these products many times.”

The above consumer remarks indicate that the test marketing of irradiated products with the irradiated food label was successful and that consumers can accept irradiated food.

3. STUDY OF IRRADIATION PRESERVATION OF PREPACKAGED FRESH CHILLED PORK

3.1. Fresh chilled meat consumption in Chinese cities

China is a big country for raising hogs and consuming pork. According to statistics, the output of pork reached 37 million tons in 1995, almost a half of the world's output. Per capita consumption has reached about 31 kg/man year, making pork the chief source of meat for Chinese people.

Prepackaged fresh chilled pork has been widely sold in supermarkets in large Chinese cities with a higher standard of living and where more goods are sold in supermarkets. There is high consumer demand today and even more in the next century, for natural, nutritious, convenient and good-tasting food that is fresh or fresh-like, preferably non-frozen, with extended shelf life.

Several interrelated factors such as storage temperature, gaseous environment, pH, water activity, light, indigenous enzymes and the presence of microorganisms affect meat stability (shelf life) and keeping quality. Microbial growth is, by far, the most important factor in the shelf life and keeping quality of fresh meat and is influenced by many of the above factors. Losses of up to 20 million pounds of meat due to microbial spoilage have been reported in the United States [3], and 90% of these losses could be accounted at slaughter, fabrication and in the retail area. Losses due to spoilage of unprocessed meat could account for higher figures than those mentioned, particularly in markets with a lack of an appropriate cold food chain. Current practices for the production and distribution of fresh meat are inadequate to protect consumers. For these reasons, prepackaged fresh chilled meat were developed and used, which have the following advantages:

– Holding of product at low temperature (0–5°C), from slaughter to retail;
– Protection of products from second contamination in the course of transportation, storage and retail;
– The meat finishes the "post-ripening course " under low temperature, resulting in better taste and flavor than the non-chilled fresh meat and frozen meat;
– The use of vacuum packaging or a vacuum-protective atmosphere package to prevent growth of spoilage microorganisms helps in extension of shelf life;
– Prepackaging is convenient for consumption.

Prepackaged fresh chilled meats are thus popularly consumed in the big Chinese cities. However, the shelf life of prepackaged fresh chilled meat is limited to about 7–10 days. Moreover, infectious parasites and microbial pathogens are not all eliminated. For this reason investigations on the use of irradiation processing were considered.

The primary purpose of irradiating meat is to eliminate microbial pathogens (e.g. *Camphlobacter jejuni*, *Escherichia coli* 0157:H7, *Listeria monocytogenes*, *Staphylococcus aureus*, the *Salmonellae*, and *Yersinia enlerocolitica*) and infections parasites (e.g. *Trichinella spiralis*, *Toxoplasma gondii* and *Taenia solim*), thereby reducing related incidence of foodborne illness and loss of life. In addition to realizing this public health objective, the technology can also provide economic benefits by extending the non-frozen (i.e. fresh and defrosted) edible-marketable life (shelf life) of meat.

In Shanghai, the daily consumption of pork is about 700 tons (1997), a greater part of these is fresh pork. From slaughter to retail or cooked, the time may be less than 24 hr under the non chilled/refrigerated condition. To ensure hygienic quality and to extend shelf life of fresh pork, the study of irradiated fresh pork is important. Shanghai Irradiation Center and Shanghai Institute of Food Hygiene Supervision and Inspection had combined to study this aspect under the support of the Science Technology Committee of Shanghai Municipality.

3.2. Irradiation preservation for prepackaged fresh chilled pork

The purposes of irradiation processing of prepackaged fresh chilled pork are the following:

- inactivitation of pork-borne parasites;
- elimination of bacterial pathogens from fresh pork;
- destruction of spoilage microorganisms in order to extend shelf life.

Our study included establishment of irradiation processing techniques, test of shelf life and test of quality (sensory test, physical–chemical test and microorganism test)

3.2.1. Test of irradiation dose

Fresh leg meat of pork (with the fat discarded) was purchased, washed by water, cut to 100g/piece, and vacuum-packed by OPP/PET film bag. These samples were used for the test.

Irradiation doses of 3 kGy and 6 kGy were tried. Ten (10) bags of control and irradiated samples were used for the test. After irradiation the samples were stored at 2–4°C in a refrigerator. Test of microbial counts and sensory characteristics were carried out on days 1, 20 and 40 after irradiation. The results are shown in Table III.

TABLE III. MICROBIAL COUNTS OF FRESH CHILLED CUT PORK AT DIFFERENT IRRADIATION DOSES AND STORAGE TIME AT 2–4°C (CFU/g)

Storage days	Control	2 kGy	6 kGy
1	3×10^5	<10	<10
20	U.C.[a]	830	<30
40	U.C.[a]	780	<30

[a] U.C means unable to count.

Results of sensory analysis indicated that the color of control samples changed to dark red after the seventh day and to grey white after the 30th day, but the color of irradiated samples (3 kGy and 6 kGy) were normal fresh-red up to the 40th day.

According to reports of Urbain, the D_{10} value of spoilage microorganisms in pork is only 01 kGy [4]. Many authors report the same conclusions. On this basis, the dose for the irradiation preservation of pork was fixed at 3 kGy.

3.2.2. Shelf life test of irradiated prepackaged fresh chilled pork

Fresh leg meat of pork (with fat discarded), was washed by water, cut in 100 g or 200 g per piece per bag, than vacuum-packed by OPP/PET film bag and irradiated by gamma ray. The samples were packed in a cardboard box and stored in a refrigerated warehouse (2–4°C, R.H.85%). Evaluation of samples were carried out at the Shanghai Institute of Food Hygiene, Supervision and Inspection after 1, 10, 20, 30, 40, 60 days. The results are shown in Tables IV and V.

TABLE IV. THE COUNTS OF *E. COLI* AND BACTERIAL PATHOGENS AT DIFFERENT STORAGE TIMES (cells/100g)

	E. coli		Bacterial Pathogens	
Storage days	Control	Irradiated	Control	Irradiated
1st	2400	<30	no[b]	no
30th	-[a]	<30	-	no
60th	-	<30	-	no

a. Mark (-) means determination was not made because microbial counts were more than 10^7 CFU/g after the 10th day.
b. Mark (no) means bacterial pathogens in samples were not detected.

TABLE V. THE TVBN VALUE OF SAMPLES DURING STORAGE (mg/100 g)

Storage Days	Control	Irradiated
1st	5.31	5.26
20th	16.6	8.03
60th	-[a]	12.9

[a] Mark (-) means TVBN of sample was not tested.

Based on above-mentioned test results, the shelf life of prepackaged fresh chilled pork at a dose of 3 kGy was 30 days at <5°C. Quality was in accordance with National Hygienic Standard GB 2704

3.3. Inactivation of meat-borne parasites and elimination of bacterial pathogens from fresh meats [21, 22]

3.3.1. Inactivation of meat-borne parasites

Studies on the inactivation of meat-borne parasites were presented in Table VI.

3.3.2. Elimination of bacterial pathogens from fresh meats

Results on this subject are shown in Table VII.

TABLE VI. INACTIVATION DOSE FOR MEAT-BORNE PARASITES

Object	Inactivation dose (kGy)	Authors	Ref.
Trichinella spinalis	0.3 - 0.6	Kasprzak	[5]
	0.15 - 0.3	Brake	[6]
Toxoplasma gondii		Dubey	[7]
		Murrell	[8]
Taenia spp.	0.6 - 0.7	Smith	[9,10]
			[11]

TABLE VII. D_{10} VALUE FOR THE IRRADIATION OF BACTERIAL PATHOGENS

Object	D_{10} value (kGy)	Condition	Authors	Ref.
A. Vegetable pathogens				
Aeromonas hydrophia	0.14–0.19	beef	Palumbo	[12]
Yersinia enleroclitica	0.20	beef	El-Iawahry	[13]
Campy lobacter spp.	0.18	refrigerated	Clavero	[14]
Salmonella spp.	0.51	5°C, pork	Thayer	[15]
Listeria monocytogenes	0.47	beef, pork	Thayer	[15]
Escherichia coli 0157:H7	0.25	3–5°C	Thayer	[16]
Staphlococcus aureus	0.45	beef	Beuchat	[17]
B. Spore forming pathogens				
Bacillus spp	0.18/2.56[a]	4°C	Thayer	[18]
Clostridium perfringes	0.586/[b]	4°C	Grant	[19]
Clostridium botulinumA	3.73–3.85	0°C	Grecz	[20]

[a] left is D_{10} of vegetative cell, right is D_{10} of spore.
[b] D_{10} of spore has not been reported.

3.4. Simulated production of irradiated prepackaged fresh chilled pork

Tests simulating commercial operations (production, irradiation, transportation and storage), were carried out. The samples of commercial prepackaged fresh chilled cut pork (vacuum-protective atmospheres package) was produced by the Shanghai Long Hui Meat Products Co., where fresh cut pork are all held under 5°C after slaughter. Transportation time from factory to our Center was about one hour and irradiation (dynamic irradiation by chain) time was about 6 hours, at a room temperature of about 15-25°C. Irradiated samples were stored at 2–4°C in a refrigerated warehouse. After irradiation, samples were tested after 35 days. The results of microbial and TVBN tests are shown in Table VIII.

TABLE VIII. QUALITY TEST ON IRRADIATED PORK AFTER 35 DAYS

Item	Results
Microbial counts, cfu/g	<30
E. coli,cells/100 g	<30
Bacterial pathogens	None
TVBN, mg/100 g	19.6

According to above results, a shelf life of 30 days can be achieved for irradiated commercial prepackaged fresh chilled pork. This will bring many benefits and convenience to the consumer in the production, transportation, storage, sale and consumption of the product.

Sensory test of irradiated pork (stored for 25 days) was carried out at the Shanghai Mei Long Zheng Restaurant. The color, taste, flavor and smell after cooking were all the same as when fresh pork was used for cooking as concluded by cooks of this Restaurant.

3.5. Market application of irradiated prepackaged fresh chilled cut pork

The marketing test of irradiated pork had not progressed due to lack funds and co-operation from a company or factory. These marketing tests may progress with the support of government or a big group of company. The application of irradiation processing can be wider. The cost-benefit analysis was analyzed and discussed below.

Using a gamma ray irradiator, and an irradiation dose of 3 kGy and a considering a throughput per hour of hundreds of kg for a $1\text{-}2 \times 10^5$ Ci source, the cost of irradiation is about 0.3-0.4 yuan R.M.B/kg. The irradiation service price will be about 0.60 yuan R.M.B/kg. The cost analysis is shown in Table IX.

TABLE IX. COST ANALYSIS FOR THE GAMMA IRRADIATION OF PORK (R.M.B yuan/kg)

Item	Results
Pork, material	10.60
Package	0.50
Transportation	0.40
Irradiated	0.60
Storage	0.30
Total	12.40
Wholesale price	12.80[a]

[a] The wholesale price is same as fresh cut pork (unpacked).

Based on the above results, application of gamma irradiation processing for prepackaged pork poses some questions which affect the cost benefit of the process.

(1) Throughput per hour is too little and cannot satisfy the need for commercial operation.
(2) Irradiated cost and irradiated service price is high and will influence economic benefit of irradiating this type of product.

The high energy (8–10 MeV) linear electron accelerator has a big application in food irradiation and could have the following advantages:

(3) Processing speeds are very fast.
(4) Processing throughput in tons per hours that can satisfy commercial scale application needs can be achieved. Irradiation cost can drop along with throughput.

For example, for a 10 MeV 10 kW linear accelerator (e.g. LINAC), the scanner width is 60 cm. With this electron energy, maximum practical penetration thickness is about 8 cm of unit density material (irradiated on both sides) which is enough to satisfy irradiation needs of cut pork. According to count, the throughput per hour is about 3 tons/hour. If an electron accelerator were used, the cost-benefit analysis is shown in Table X.

TABLE X. COST BENEFIT ANALYSIS FOR THE IRRADIATION OF PORK BY LINEAR ACCELERATOR

Item	Price, R.M.B. yuan/kg
Pork, material	10.60
Package	0.50
Transportation	0.20
Irradiated	0.10
Storage	0.30
Total	11.70
Wholesale price	12.80

Based on above analysis, the commercial application of irradiated pork by linear accelerator is feasible. The economic benefit is remarkable, the social benefit for reducing food-borne diseases, extending shelf life and reducing losses of pork, is also remarkable.

4. CONCLUSIONS

The study of irradiation pasteurization of pickled meat products with grains stillage had progressed satisfactorily. Results of study showed that irradiation pasteurization was useful for enhancing hygiene quality and extending shelf life of the products. Shelf life of irradiated products was 10 days at 5°C. Irradiation pasteurization was carried out in large scale and achieved a success.

The test marketing and consumer acceptance of irradiated pickled meat products with grain stillage was also carried out. A total of 40,000 bags products (near 10,000 kg) of irradiated product was labeled and sold in more than one hundred supermarkets in Shanghai city. The consumer acceptance was better.

The study of irradiation preservation of prepackaged fresh chilled pork was carried out. A dose of 3 kGy inactivated infectious parasites and bacterial pathogens and extended shelf life up to 30 days at <5°C. Irradiated products satisfied the needs of production, storage, transportation and sales.

The cost analysis of irradiated prepackaged fresh chilled cut pork was discussed. If a 10 MeV linear electron accelerator is used for industrial irradiation, the economic benefit and social benefit are remarkable. The potential for application of this preservation technique is bright.

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CONSUMER ACCEPTANCE, MARKET TEST AND MARKET DEVELOPMENT OF IRRADIATED RICE, DEHYDRATED VEGETABLES AND SPICES

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Abstract. Establishment of irradiation processing parameters, a quality assurance system, consumer acceptance, market test and market development of irradiated rice, dehydrated vegetables and spices were the activities carried out in this project by the Chinese Agricultural Irradiation Center. The results of the studies showed that the process dose for rice was 0.2–0.5 kGy when the non-uniformity was lower than 2.5, dose range for dehydrated vegetables was 5–7 kGy, dose for spices was 7–8 kGy. The system for quality assurance was established. The processing standards for several irradiated food items were set up. Market test showed that more than 70–80% of consumers accepted irradiated food. Industrial companies also accepted irradiated dehydrated vegetables and spices. The later were successfully introduced to the markets and successful commercialization of irradiated garlic was followed. The economic benefit of operating the Chinese Agricultural Irradiation Center was analyzed and found attractive especially for low dose irradiation of foods in sufficient supply.

1. INTRODUCTION

The Chinese Agricultural Irradiation Center joined the RPFI Phase IV on "Public Acceptance and Trade Development in Irradiated Food in Asia and the Pacific" in 1994. The work carried out in the Center focused on consumer acceptance, market test and market development of irradiated rice, dehydrated vegetables and spices. The activities carried out are described below:

(1) Irradiation processing of rice and dehydrated vegetables and major factors affecting the process.
(2) Establishment of a quality control system for industrial scale food irradiation following the ICGFI Code and Codex General Standard and considering the practice and the processing standards for food items in China.
(3) Investigation of consumer acceptance and dissemination of irradiation information to the public.
(4) Market development and commercialization of irradiated rice and dehydrated vegetables.

2. RESULTS OF RESEARCH WORK

2.1. Quantity of irradiated food

The quantities of irradiated rice, dehydrated vegetables and spices and other foods irradiated at the Chinese Agricultural Irradiation Center as well as in China are shown in Tables I and II respectively.

TABLE I. QUANTITY OF FOOD IRRADIATED AT THE CHINESE AGRICULTURAL IRRADIATION CENTER (1995–1998)

	Name and amount (tons) of products					
Year	Rice	Dehydrated Vegetables	Spices	Health Foods	Others	Total
1995–1996	1000	400				1400
1997	800	400	400	15	5	1620
1998	100	500	1500	20		2320

TABLE II. QUANTITY OF IRRADIATED FOODS COMMERCIALLY PRODUCED IN CHINA (1995–1998)

Food items	Quantity (tons)
Rice	2,800
Garlic	130,000
Spices	25,000
Dehydrated vegetables	8,000
Health Foods	200

2.2. Determination of processing parameters for rice, dehydrated vegetables and spices

To ensure quality of treated products, the related irradiation processing parameters for rice, dehydrated vegetables and spices were determined and are discussed below:

2.2.1. Rice

The objective was irradiation disinfestation

2.2.1.1. Doses for irradiation of rice

The color, smell and content of linear starch were not affected by irradiation under 1 kGy, but the taste quality (chew property, hardness) and the yield of cooked rice, starch iodine blue value and viscosity decreased with increase in irradiation dose. The viscosity was the most sensitive to irradiation followed by the starch iodine blue value, the yield of cooked rice and the taste quality. The taste quality was most affected at dosages between 500–600Gy. The results of measurements are shown in Table III.

2.2.1.2. Effect of irradiation on major storage pest in rice

The effect of irradiation on the emergence and survival of treated *Sitophilus zeamais* at different development stages is shown in Table IV. The data indicated that the egg and larvae were the most sensitive stages and the adults, the most tolerant to irradiation. The sensitivity to irradiation of the pupa was between the larvae and adults.

From the results above, good irradiation practice for rice on an industrial scale should follow the following guidelines:

(1) Wind selecting and polishing must be carried out before irradiation to take out the adults and pupae from the rice as otherwise the body of dead pupa and adults remain inside the rice.

(2) The period from egg stage to the pupae stage at different temperature was about 16–44 days. To be sure that there is no pupae of *S. zeamais* in the rice, the irradiation processing should be conducted within 20–30 days after packaging.

(3) The maximum dose should be the highest dose that will not affect the nutrition and sensory quality of treated rice, and the minimum dose should be the lowest dose that will be lethal to the pest in the rice. Considering the above, the dose and non-uniformity ratio is as follows: D_{max}/D_{min} = 500 Gy/200 Gy = 2.5.

(4) To avoid re-infestation the rice should be packaged in a plastic bag and sealed, then kept in a paper carton. The irradiated rice should be stored in a pest-free room.

TABLE III. EFFECTS OF DIFFERENT DOSES ON THE PHYSIOCHEMICAL CHARACTERISTICS AND SENSORY QUALITY OF RICE

Dose (Gy)		0	200	400	500	600	800	1000	Correlation coefficient	Correlation degree
Sensory	Color	7	7	7	7	7	7	7		
Quality	Smell	7	7	7	7	7	7	7		
	Tastes	5.7	5.6	4.8	4.4	2.9*	2.3*	2.2*	–0.945	1%
Yield of cooking rice (%)		359	354	350	347	345*	340*	335*	0.9979	1%
Starch iodide blue value (%)		22.0	20.4	19.2	18.5*	17.4*	16.5*	15.3*	–0.9859	1%
Viscosity		10.19	8.40*	7.40*	6.46	5.41*	4.68*	4.52*	–0.9812	1%
Content of linear chain starch (%)		20.62	20.61	20.63	20.62	20.64	20.61	20.61	–0.08	

*Significant difference at 1% level.

TABLE IV. EMERGING OR SURVIVAL RATE OF IMAGO AFTER IRRADIATION AT DIFFERENT DEVELOPMENT STAGES

Development Stage	Days after Irradiation	Dose(Gy)							
		0	30	60	120	200	400	600	800
Egg-larvae	Emergence rate (%)	100	7.7	0.3	0	–	–	–	–
Pupae	Emergence rate (%)	100	–	–	–	14.5	0	0	0
Imago	Survival rate (%)	86.3	–	–	–	40.6	0	0	0

TABLE V. IRRADIATION STERILIZATION ON DEHYDRATED VEGETABLES

Bacterium	Vegetable	Irradiation dose (kGy)					
		0	1	3	5	7	10
Total	Green bean sprout	44×10^4	33×10^3	26×10^2	83×10	–	–
(per gram)	Wild cabbage	160	66	50	–	–	–
Mold	Green bean sprout	93	7	14	6	–	–
(per gram)	Wild cabbage	31	15	20	–	–	–
Colon bacillus	Green bean sprout	72400	2400	200	–	–	–
(per gram)	Wild cabbage	–	–	–	–	–	–

2.2.2. *Dehydrated vegetables*

The objective of irradiation was sterilization. The suitable dose range and the change of nutrient components in treated dehydrated vegetables were investigated.

2.2.2.1. Irradiation sterilization

The effect of different irradiation doses on the microbiological quality of dehydrated vegetables is shown in Table V. The results show that unirradiated dehydrated green bean sprouts have a higher microbiological count than dehydrated wild cabbage. A dose of 5 kGy was adequate to reduce the microbiological count of dehydrated wild cabbage to zero. A dose of 7 kGy was required to achieve the same results for dehydrated green bean sprouts. Microbiological counts decreased with increasing irradiation dose.

2.2.2.2. Nutrient analysis of irradiated dehydrated vegetable

The results of amino acid and trace element analysis of dehydrated green bean sprouts and wild cabbage are shown in Table VI. The results indicate that irradiation doses of 5 kGy and 10 kGy did not induce changes on Cu, Zn, Fe, Mn, amino acids and protein.

2.2.2.3. Flavor, color and water-absorption capability

(1) Flavor evaluation

After half-year of storage, no color change could be observed for the irradiated dehydrated vegetables. Irradiated dehydrated green bean sprouts kept its original yellow color and irradiated dehydrated wild cabbage maintained its yellow green color and its good flavor. The color of unirradiated samples changed due to the growth of bacteria and insects.

TABLE VI. THE EFFECT OF DIFFERENT IRRADIATION DOSES ON AMINO ACID AND TRACE ELEMENT COMPOSITION OF DEHYDRATED VEGETABLES

Item	Green bean sprouts			Wild cabbage		
	Control	5 kGy	10 kGy	Control	5 kGy	10 kGy
Total Amino Acid	20.78	20.16	20.58	7.17	6.96	6.96
Aspartic acid	6.36	6.47	6.04	0.86	0.87	0.84
Threonine	0.84	0.78	0.84	0.37	0.34	0.36
Serine	0.91	0.80	0.92	0.40	0.41	0.41
Glutamic acid	1.67	1.48	1.80	1.52	1.45	1.45
Glycine	0.68	0.61	0.72	0.38	0.38	0.38
Alanine	0.92	0.87	0.95	0.41	0.42	0.42
Cystine	min.	min.	Min.	min.	min.	min.
Valine	1.59	1.59	1.55	0.42	0.43	0.43
Methionine	0.29	0.19	0.23	0.10	0.09	0.13
Isoleucine	1.05	1.07	1.08	0.31	0.30	0.31
Leucine	1.24	1.23	1.32	0.50	0.49	0.49
Tyrosine	0.50	0.52	0.53	0.20	0.20	0.21
Phenylalanine	1.03	1.11	1.11	0.25	0.25	0.25
Histidine	0.76	0.63	0.69	0.49	0.46	0.41
Lysine	1.23	1.16	1.16	0.48	0.42	0.39
Arginine	1.70	1.65	1.65	0.48	0.46	0.49
Cu	14.7	14.3	14.2	4.30	4.70	6.30
Zn	56.1	54.3	50.8	14.60	17.00	14.80
Fe	76.3	60.6	59.5	57.50	50.80	53.80
Mn	14.7	13.7	12.6	9.30	9.70	9.40
Crude protein	30.18	31.19	29.23	10.18	10.03	9.91

TABLE VII. EFFECT OF IRRADIATION DOSES ON WATER ABSORPTION CAPACITY OF DEHYDRATED VEGETABLES (Weight increase on immersion in water for 10 minutes)

Vegetable	Irradiation dose (kGy)					
	0	1	3	5	7	10
Dehydrated green bean sprouts	1:4.2	1:4.4	1:4.2	1:4.2	1:4.2	1:4.1
Dehydrated wild cabbage	1:4.5	1:4.0	1:4.3	1:4.3	1:4.3	1:4.1

(2) Water absorption capacity

Water absorption capacity as measured by weight of water absorbed by 48 grams of the irradiated dehydrated vegetables kept in water for 10 minutes was not affected by irradiation. The results are shown in Table VII.

The above results indicated that irradiation at 7–8 kGy was adequate to reduce the microbiological count of the above dehydrated vegetables to zero without obvious color and flavor changes and changes in amino acid and trace element composition.

2.2.3. Spices

The objective of irradiation was disinfestation. Irradiation processing parameters and irradiation doses were investigated following ICGFI recommendations (Document No. 5 [1]).

2.3. Establishment of a quality control system for industrial scale irradiation of food and agricultural products following the recommendation of ICGFI and Codex General Standard

A quality control system for assuring the quality of irradiated food was established. The key point of the system was to implement ICGFI and Codex recommendations for proper irradiation processing. The objective of the system was to ensure that the desired quality of treated products was achieved. Quality assurance involved dose mapping of the irradiation chamber, irradiation processing, control and inspection. The procedure for effective inspection to ensure that all required controls are implemented and described as follows:

Assurance of quality of agricultural products and irradiation treatment
Inspection of products' quality before irradiation. Selection of packaging material
Determination of processing dose. Irradiation of test sample
|
↓
Assurance of irradiation facility
Equipment documents. Test and calibration of equipment
Assurance of irradiator facility. Assurance of irradiation capacity
|
↓
Assurance of irradiation processing
Determination of product arrangement method. Determination of operation parameter.
Distribution of irradiation dose
|
↓
Daily irradiation control
Operation parameter. Supervision of irradiation dose. Evaluation of product quality after irradiation
|
↓
Storage control of product
Separate storage for irradiated and unirradiated products. Label for irradiated food

2.4. Consumer acceptance and market test for several irradiated foods

Studies on food irradiation started in China in the 1950's. Thirty years of research resulted in several achievements. In the 1980's exploratory activities for industrial production and commercial application began and as people gradually realized the advantages of food irradiation, the technology developed at an accelerated pace after 1990. With the support of the State Science and Technology Commission, China National Nuclear Corporation, the Ministry of Agriculture and the Ministry of Public Health, about 30 market tests and consumer acceptance investigations were carried out on different foods and at several cities during the past decade. The advantages of irradiated food were promoted and irradiation technologies were introduced to producers. Industrial production and commercial applications has developed rapidly in recent years.

TABLE VIII. THE PROCEDURE FOR ASSURANCE AND SUPERVISION OF IRRADIATED FOODS

(1) Assurance of products
The supplied foods must be evaluated before irradiation. At first the food should be cleared for irradiation treatment by related authority of the government, and GMP documents should be verified.

(2) Assurance of irradiation facility
The irradiation facility for treatment of food should be examined and approved by related department of the government. The design of the facility should satisfy the requirements for wholesomeness of the food and effectiveness of irradiation processing. Trained employee and a detection laboratory (for dose measurement and microbiology) should be provided.

(3) Assurance of irradiation processing
Irradiation parameters for treatment of products, especially new products must provide assurance that the absorbed dose is adequate.

(4) Daily irradiation control
During the operation of the irradiation facility, the written record of the treatment procedure must be kept before, during and after irradiation for checking. The contents of records should include products geometry, condition during irradiation, key processing parameter and measurement of absorbed dose.

(5) Storage control
The objective of storage control is to avoid the mistake of repeat irradiation. Stick an irradiation label on product containers for the purpose.

According to the requirement for industrial scale food irradiation of the Chinese government, irradiation processing standards for 30 food items were prepared by our institute. These standards will be submitted to the Chinese government at the end of the year for clearance. This will facilitate the development of food irradiation.

2.4.1. Market test and consumer acceptance

Two market tests and consumer acceptance investigations were conducted in Beijing. Irradiated rice, garlic, mushroom, pepper powder, braised chicken, healthy food, longan, cooked meat, refrigerated meat and others were put on display and sold.

The results of consumer acceptance investigations are shown in Tables IX and X. The results indicate that consumers were interested in the quality of products. More than 70 per cent of consumers investigated thought that a special marker should be used to help them identify the irradiated food and which could show that the food was strictly treated according to requirements. The results also showed that about 80% of producers and consumers like to try the new technology.

2.4.2. The promotion of irradiated food

A videotape titled “Irradiated Food In China” was broadcast on China Central Television (CCTV). A total 40 copies has been sold nationwide. In every kind of meeting, the advantages of irradiated food were introduced to factories and consumers. A new video entitled “Food Irradiation Processing and Commercial Application” will be completed this year for broadcast on CCTV.

TABLE IX. PUBLIC ACCEPTANCE QUESTIONNAIRE FOR IRRADIATED FOOD

No.	Questions
1	Do you know foods including grain are all treated by means, for example of chemical fumigation and insecticides, to prevent insect growth and putrefaction?
2	Do you have an idea that irradiation can be used for elimination of insects and bacteria, to keep food fresh and prevent putrefaction?
3	Do you know it is safe, reliable, economical and non-polluting to use irradiation for disinfestations of insects and inactivation of bacteria in foods ?
4	Do you know that hygienic standards for 18 irradiated foods have already been issued by government?
5	Which will you choose between chemical or antiseptic treated food and irradiated food?
6	Do you think irradiated food needs a special marker to show it was irradiated?
7	After our introduction, will you choose irradiated food in future?

Investigation place: Dianmen Market, Beijing. Date: February 1996.

TABLE X. RESULTS OF INVESTIGATION OF THE LEVEL OF PUBLIC ACCEPTANCE FOR IRRADIATED FOOD

Question number	Answer	Market Group	Institute Group
		Percentage	Percentage
1	Yes No	74 26	88 12
2	Yes No	68 32	82 18
3	Yes No	65 35	74 26
4	Yes No	33 67	33 67
5	Yes No	28 72	15 85
6	Yes No	78 22	90 10
7	Yes No	81 19	91 9

TABLE XI. QUANTITY OF SPICES IRRADIATED FROM 1995 TO 1998

Year	Total (tons)	Garlic Powder	Onion Powder	Red Pepper	Others*
1995	120				
1996	600	180	120	240	60
1997	2400	720	480	960	240
1998	5000	1500	750	2000	750

*Including ginger powder, black and white pepper powder, etc.

TABLE XII. COST PRICE, SELLING PRICE AND IRRADIATION FEE FOR IRRADIATED FOOD

Year	Name of products	Cost price (10,000 yuan/ton)	Selling price (10,000 yuan/ton)	Irradiation fee (yuan/ton)
1995	Garlic powder	0.6	0.8	480
	Onion powder	0.7	1	480
	Red pepper powder	2	2.2	480
1996	Garlic powder	0.6	0.8	480
	Onion powder	0.7	1	480
	Red pepper powder	2	2.2	480
1997	Garlic powder	1.2	1.4	500
	Onion powder	1.15	1.5	500
	Red pepper powder	0.75	0.9	500
	Chinese prickly ash	1.4	1.6	500
	Aniseed	2	2.4	500

TABLE XIII. QUANTITY OF MAJOR IRRADIATED DEHYDRATED VEGETABLES

Year	Name of Product	Amount iradiated (ton)	Cost price (10,000 yuan/ton)	Selling price (10,000 yuan/ton)	Irradiation fee (yuan/ton)
1997	Carrot granule	500	1.25	1.45	500
	Korea cabbage	250	1.25	1.6	250

2.4.3. Market development and economic benefit analysis of major irradiated foods

Along with consumer education, the market for major irradiated foods namely, rice, dehydrated vegetables and spices was developed. In cooperation with related factories in Beijing, the Chinese Agricultural Irradiation Center (which belongs to the Institute for Application of Atomic Energy, Chinese Academy of Agricultural Sciences) successfully developed the market for irradiated foods, and made great achievements in recent years.

We like to illustrate this by an example; the Beijing Meiquan Food Limited produced a variety of spices and dehydrated vegetables. The treated spices and dehydrated vegetables were supplied to instant noodle and quick-frozen food companies as materials and these companies required that the material must be treated by irradiation (1996–1998).

Income from irradiation fee for treated products (in 1997) was only 4% of total cost for garlic powder, 4.3% of total cost for onion powder and 6.7% of total cost for red pepper powder.

The products listed in above tables were supplied to following instant noodle companies in the following cities: Tianjin, Beijing, Wuhan, Guangzhou, Kunshan and Chengdu. The products of the Beijing Meiquan Food Limited were irradiated in four irradiators in Beijing, about 50% was treated in our irradiation facility.

The following results were obtained from an analysis of the economic benefit coefficient for above products according to the formula: $F = (I - C)/C$ [2] where I is income per hour, and C means operation fee per hour. The economic benefit coefficient is an indication of the rate of benefit from the irradiation of a certain food item. The higher the economic benefit coefficient, the higher the benefit rate. The factors affecting the economic benefit coefficient include irradiation dose, operation time per year, arrangement of products, etc.

Total operation cost should included depreciation of fixed capital, operating costs, cost (salary for employees, energy cost, management and maintenance cost, and others). The cost for the operation of the facility is shown in Table XIV.

TABLE XIV. COST FOR THE CHINESE AGRICULTURAL IRRADIATION CENTER

Items	Investment (10,000yuan)	Depreciation rate	Cost per year (10,000 yuan)
Construction	800	4.0%	32
Source	170	12.5%	21.5
Machinery	70	10.0%	7
Total	1040		60.5

TABLE XV. OPERATING COST FOR THE CHINESE AGRICULTURAL IRRADIATION CENTER

Items	Cost per year (10,000 yuan)
Salary	9.6
Pay for temporary workers	6
Electricity, water cost	7
Facility maintenance	1
Management cost	5
Others	2
Total	30.6

The total cost for the Chinese Agricultural Irradiation Center per year was 911,000 yuan RMB representing the sum of the operating cost and fixed capital cost.

The main food item irradiated in the Center was spices. Irradiation fee was 300 yuan RMB per hour (irradiation dose: 6–7 kGy), the cost for operation per hour was 130 yuan, so $F = (300 – 130)/130 = 1.31$.

For dehydrated vegetables, the irradiation fee was 400 yuan (irradiation dose 4 kGy), so $F = (400 – 130)/130 = 2.08$.

Comparing the calculated results of irradiated spices and dehydrated vegetables, economic benefit of low dose dehydrated vegetables irradiation was obviously higher than that of high dose spice irradiation in the 200 kCi capacity source of the Chinese Agricultural Irradiation Center.

Due to policy change and reform in the system for providing food in China in recent years, the amount of irradiated rice decreased yearly. To assure benefit from the irradiation of a product like grains, assurance of a sufficient supply of the commodity is necessary and the transportation must be considered.

3. EVALUATION OF RESEARCH PROGRAM

The research described above has been completed during the past four year. The original plan and objective of this program were to establish a system and standard for irradiation processing as well as a quality assurance system for irradiation of food. With wide publicity to factories and shops, about 70-80% consumers liked to try irradiated food. More and more food companies accepted this new food technology. This could be identified from the rapid increase in the amount of food irradiated at the Chinese Agricultural Irradiation Center. More than 95% of treated products in the Center were food items. This was also the objective of establishing the irradiation center. It was a good start for irradiation technology transfer from the laboratory to industrial and commercial application. With more and more interest from food companies, the application of irradiation technology should be supported and standardized by the government. Wholesomeness standards for six categories of irradiated food were promulgated by the Chinese government this year. This will surely facilitate the development of irradiation technology. For the irradiation company, food irradiation brings good economic benefits and significant social effects.

4. RESEARCH WORK IN THE FUTURE

The research and commercial application of irradiated food in the Chinese Agricultural Irradiation Center has been carried out for many years. The Chinese Agricultural Irradiation Center was also a major institute for the study of food irradiation application in China. The work plan for next few years is as follows:

(1) Follow the ICGFI Recommended Code and Codex, the Chinese standards for irradiation processing of food will be completed and promulgated by the government before 2000. These standards will ensure the processing quality of commercially irradiated food.
(2) Continue to develop new irradiated food items for commercial application.
(3) Complete the video on “Irradiation Processing and Commercial Application of Irradiated Food”.
(4) Develop the regional and international trade test for selected irradiated food items, to investigate the problems that will occur in import and export trade of irradiated food. This work needs the support of IAEA and other international organizations.
(5) Carry out the feasibility research for irradiation as a quarantine treatment.

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We acknowledge with thanks the support of the Food Preservation Section, IAEA for the research cooperation and the operation of the Chinese Agricultural Irradiation Center. We hereby express our gratitude to Mr. P. Loaharanu, Mr. M. Ahmed, Mr. M. A. Matin and the late IAEA expert Mr. G.G. Giddings.

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FOOD IRRADIATION IN THE REPUBLIC OF KOREA

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Abstract. There has been substantial progress in the application gamma radiation for food and medical products in Korea since the establishment of the commercial irradiation facility by Agricultural Products Distribution Corporation in 1987. The Korea Ministry of Health and Welfare in consultation with the Committee of Food Sanitation Deliberation and the Korea FDA accorded clearances of irradiation processing of a number of food products ranging from health foods, condiments and raw materials for food processing in 1987 followed by amendment in 1995. Gamma radiation from Co-60 was allowed for food processing with labeling requirement and restriction on re-irradiation. Annual irradiation processing of foods stands at about 2,000 metric tons. Authorisation to use irradiation for red meats and meat products is under consideration. A large number of business enterprises are utilizing the irradiation facility. A new multi-purpose commercial Co-60 irradiation plant is in the process of establishment in the country as a private company venture. In order to remove consumers' misunderstanding a number of consumer education programmes have been implemented successfully with improvement of public perception.

1. CURRENT STATUS OF FOOD IRRADIATION IN KOREA

A basic irradiation study was launched in Korea in 1959 with the facilities of the Korea Atomic Energy Research Institute (KAERI, Co-60, 10,000 Ci). A large-scale gamma irradiation research facility with 100,000 Ci (Co-60) began operation in 1975 where applications of irradiation techniques in medicine and pharmaceuticals, as well as in foods, were introduced.

By this time, various sterilization techniques by gamma irradiation were under investigation internationally. Local studies on the application of this technique in the food industry were actively carried out. Irradiation application studies for local industrialization began in 1980 at KAERI. As a result of this study, a commercial irradiation facility, Greenpia Company, was built in Yoju, Kyong Ki province in 1987 and financed by the Agricultural Products Distribution Corporation.

Irradiation was originally planned for the prevention of the germination of potatoes, onions, garlic and chestnuts and aging of mushrooms. But, the execution of this program experienced difficulties because of the need for additional storage facilities and distribution costs even though it would have resulted in savings of costs up to 300 times that of conventional refrigeration.

The application of gamma irradiation was gradually expanded from foods to sanitary and medical products. In the 1990's, when the International Cancer Institute announced that ethylene oxide residue, a fumigant in food, was a potent carcinogen, the Korean government prohibited the use of ethylene oxide in foods. The same measure was also recommended by WHO. As an alternative to ethylene oxide, the Ministry of Health and Welfare allowed the additional use of irradiation in raw materials for food processing.

In addition, international organizations including Codex, Food and Agricultural Organization, and IAEA permitted the use of irradiation in all foodstuffs after reexamining its safety and the effectiveness of its use when compared to other food preservation methods. This created a momentum in promoting the use of irradiation in food preservation in Korea.

The Korea Ministry of Health and Welfare (MOHW) is responsible for clearances and regulations of irradiated foods. MOHW consults with the Committee of Food Sanitation Deliberation and the Korea FDA. Korea Institute of Nuclear Safety, which is a government-funded organization under the Ministry of Science and Technology, periodically inspects the irradiator according to the Atomic Energy Law, to ensure compliance with regulations.

The Presidential decree (No. 11, 717 of 29 June 1985) and MOHW decree (No. 767 of 1 July 1985) are the legal basis for the newly established food irradiation business. The general standard and regulations for irradiation of foodstuffs was enforced in September 1987, and amended 19 May 1995 The list of authorized applications is shown in Table I.

The type of ionizing radiation used for food irradiation are gamma rays from the radionuclide, Co-60. Regulations prohibit the re-irradiation of food under any circumstances. The irradiated foods should be packaged using a proper container or appropriate materials before going to market. The regulations also require that prepackaged irradiated foods should be labeled with the international symbol (above 5 cm) for food irradiation. Gamma radiation from Co-60 source is authorized for use in food irradiation of 13 food groups as shown in Tables II and III.

TABLE I. LIST OF AUTHORIZED APPLICATIONS OF FOOD IRRADIATION FOR HUMAN CONSUMPTION IN KOREA

Product	Type of clearance	Dose (kGy) permitted	Date of approval	Note
Potato, Onion, Garlic	Unconditional	0.15 max.	16 Oct. 1987	
Chestnut	Unconditional	0.25 max.	16 Oct. 1987	
Fresh and Dried Mushrooms	Unconditional	1.00 max	16 Oct. 1987	
Dried meats, Powdered-fish and shellfish	Unconditional	7.00 max.	14 Dec. 1991	Only for the processing of food
Soybean paste powder, Hot pepper powder, Soybean sauce powder	Unconditional	7.00 max.	14 Dec. 1991	
Starch	Unconditional	5.00 max.	14 Dec. 1991	Only for the processing food
Dried Spices and their Preparations	Unconditional	10.00 max.	19 May 1995	
Dried Vegetables	Unconditional	7.00 max.	19 May 1995	Only for the processing of food
Yeast and Enzyme Foods	Unconditional	7.00 max.	19 May 1995	
Powdered Aloe	Unconditional	7.00 max.	19 May 1995	
Ginseng products Including red ginseng	Unconditional	7.00 max.	19 May 1995	
Second sterile meals for patient	Unconditional	10.00 max.	19 May 1995	

TABLE II. ANNUAL QUANTITY OF IRRADIATED FOODS IN KOREA

Food Items	Quantity of Irradiated Foods (ton)			
	1994	1995	1996	1997
Mushrooms (fresh & dried)	100	60	150	160
Spice & their preparations	500	600	750	900
Dried meats	50	20	30	35
Dried fish & shellfish powders	200	150	160	170
Soybean paste powder	100	70	30	50
Hot pepper paste powder	0	0	75	65
Soybean sauce powder	70	60	65	70
Starch for Condiments	70	60	63	70
Dried vegetables	0	300	400	500
Yeast & Enzyme products	0	5	7	10
Aloe products	0	7	15	10
Ginseng products	0	0	5	5
Total	1,090	1,332	1,750	2,045

TABLE III. STATUS OF FOOD RESEARCH USING IONIZING RADIATION IN KOREA

Group	Items	Research Contents
Fresh Vegetables	Potato, Onion, Garlic, Sweet Potato, Tomato, etc.	Sprout inhibition, Delay of ripening.
Fruits	Chestnut, Strawberry, Apple, Pear, Grape, Peach, Mandarin, Orange, etc.	Sprout inhibition, Delay of ripening.
Mushroom	Fresh and Dried Mushroom	Growth inhibition Disinfestation
Ginseng Products	White and Red Ginseng Product, Fresh ginseng	Decontamination, Improvement of Quality, Extention of self-life
Grain & Legumes	Rice, Corn, Soybean, etc.	Disinfestation, Wholesomsness
Spice, Herb & Dried Vegetable	Pepper, Ginger, Garlic, Onion, Green Onion, Spinach, Carrot, etc.	Decontamination
Fish & Fishhery Product	Fresh and Dried fish, Dried laver, Fried fish paste, etc.	Radurization, Decontamination
Meat & its product	Chicken, Beef, Pork, Ham, Sausage, etc.	Radurization
Fermented Foods	Kimchi, Soybean paste powder, etc.	Extention of self-life, Decontamination
Quality evaluation	Irradiated food, Oil, Malt, Enzymes, etc.	Physical, chemical and Orgarnoleptic properties.
Qualiy improvement	Soybean, Corn starch.	Reduction of soaking and Cooking time, modified starch process
Microorganism	Bacteria, Molds, Yeasts, Insect, Parasite.	Radiosensitivity
Animal feeds	Poultry feed, etc.	Decontamination

Items granted irradiation clearance were confined only to some health foods, basic condiments and raw materials for food processing. The use of irradiation had little effect in stimulating the food industry as a whole. At present in Korea, irradiation is applied to foods where boiling or chemical sterilization is inapplicable and to some items requiring standards for a HACCP system for export (Fig. 1). Annual irradiation processing reaches around two thousand metric tons of food. In addition, there are plans to apply for authorization to use ionizing radiation on red meat and meat products.

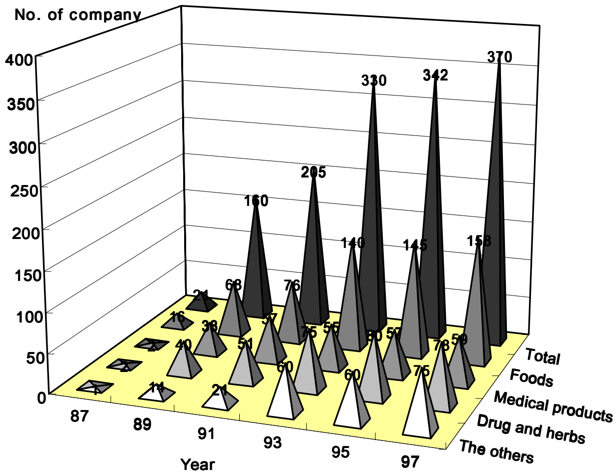

Fig. 1. The number of business enterprises commercially using γ-ray facility in Korea.

2. FUTURE RESEARCH AND ACTION

A number of important public health benefits can be realized by irradiation of food. However, a commercially successful food irradiation program must be based on sound economics with serious consideration being given to both the general business requirement and the appropriate irradiation technology in order to obtain affordable cost and profitability. In addition to irradiation itself, other factors must be considered for successful implementation. These factors include the development of a necessary infrastructure for transport and the storage and distribution of foods which are of considerable importance to the country.

In order to heighten commercial irradiation of food, we are urged to issue broader regulations for the proposed use of irradiation on these foods based on the principles of the Codex General Standard for Irradiated Food and on current research findings. In addition to the fact that most fumigants have been eliminated because of health or environmental reasons, we have found that economic analysis, consumer surveys and organoleptic tests indicate a clear advantage for the use of irradiation. Therefore, practical data related to the commercialization of food irradiation technology are very important from the standpoint of government, industry, trade, and consumers. The guidelines issued by international organizations are more effective than the domestic point of view as a persuasive power in promoting food irradiation.

Taken as a whole, the most critical impediment to the commercial application of food irradiation has been the general consumers' low acceptance. However, the positive attitude towards irradiated foods was easily found among the consumers when they understood the safety and advantages of this technology. In this respect, further efforts have been required to educate the consumers with valid information on the beneficial aspects of food irradiation compared with conventional methods. The Korean government and most of the food industries have recognized the benefits and advantages of irradiation processing over the existing conventional methods. The most important task in food irradiation would be to overcome consumers' psychological resistance and transportation factors related to the products to be irradiated. A certain Korean company has contracted the establishment of a new multipurpose commercial irradiator. All the successful commercialization of food irradiation has been associated with the careful provision of well thought-out information for the consumers. There are certain essential elements that need to be included if the information of why irradiation is being used and what it is doing to a particular food is to be accepted. Also, the key to the acceptance of irradiated food lies in having high quality products readily available for the consumers to try.

A number of research activities are underway at Korea University, Kyoungbuk National University and Hallym University on detection methods for irradiated foods, evaluation of wholesomeness and survey on quarantine of imported foods. Consumer acceptance and test marketing of the irradiated food was surveyed by Gallop Korea, an agent of a survey of public opinion, under supervision of KAERI.

FAO/IAEA(RCA) Workshop on Harmonization of Procedures and Regulations on Food Irradiation for Asia and the Pacific was held in Seoul, Republic of Korea (27-29 April 1998). The meeting decided to take the ASEAN draft harmonized regulation as a basis for its deliberations and finally adopted guidelines for consideration by RCA member states. Also a national seminar on “the Acceptance and Trading on Irradiated Foods” was held in Korea University (30 Apr. 1998) in collaboration with the Korean Society of Food Science & Technology, Korea Atomic Energy Culture Foundation and KAERI.

CONSUMER AND FOOD INDUSTRIES EDUCATION ON FOOD IRRADIATION

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Abstract. A survey was conducted on Malaysian food industries to determine the interest and potential applications of food irradiation as an alternative or to complement existing food preservation treatments. A total of 37 food processors representing 5 subsectors of the food industry participated in the survey. Information collected showed that majority of respondents were aware of food irradiation but the level of knowledge was low. Half of respondents perceived food irradiation as safe and 23% will consider using it for commercial purposes. Main concerns of the food processors were safety of the process, safety of irradiated food, efficacy of the process and consumer acceptance. Food irradiation applications considered to have the most potential for use by the food industry, were those which would improve the hygienic quality of food products. Despite the limited knowledge, respondents strongly supported the need to promote food irradiation technology in Malaysia. In view of this finding, various promotional activities have been continuously carried out to increase public awareness and understanding of the technology so as to facilitate acceptance of food irradiation in Malaysia.

1. INTRODUCTION

Although Malaysia is fast becoming an industrialized nation, its agricultural sector continues to play an important role in the overall economic development of the country. Based on past trends in food production and consumption, Malaysia will continue to import its requirements for foodstuffs such as rice and dairy produce though the country is self sufficient or even able to export commodities such as poultry, fruits and vegetables. Currently, Malaysia is the major exporter of palm oil and ranks third in pepper and fourth in cocoa beans in terms of its contribution to world trade [1].

The food processing industry is one of the major contributors to manufacturing development in Malaysia with average growth of over 10% annually between 1984 to 1995 and an output value of RM 9.9 billion in 1995 [2]. The main sub-sectors within this industry are processed meat, fruits and vegetables, fish products, dairy products, cereal-based products; sugar and confectionary; edible oils and fats; (coffee, cocoa, tea and spices); beverages (non-alcohol); prepared animal feeds and miscellaneous food products. With increasing affluence, changing lifestyles and bigger population base, the industry is expected to record another phase of growth. As it gears for expansion, the industry is faced with a host of technical issues and challenges which include understanding food trends, compliance to legal requirements, choice of technology, acceptable levels of chemical contaminants/pesticide residues and emergence of new pathogens such as Listeria and certain strains of *E. coli*. To meet these challenges, food irradiation is being considered as an alternative or/and complementary technology for the food industry.

In Malaysia, a research and development programme on food irradiation was established in 1982 with the final aim of transferring the technology to the food industries. A National Working Committee on Food Irradiation was also formed to coordinate activities pertaining to R&D applications, adoption and technology transfer of food irradiation. To date, technical feasibility studies on several food items of economic importance were successfully undertaken (Table I). Economic feasibility studies on a multipurpose Co-60 facility indicated that with sufficient throughput of less than 18,000 MT/annum, the unit cost of irradiating local products are cheaper compared to that in developed countries [3]. Malaysia's infrastructure for promoting radiation technology was enhanced with the installation of a demonstration Co-60 irradiator 'Sinagama' (present activity 0.95MCi) at MINT in 1989 followed by the commissioning of a 3MeV electron beam machine 'Alurtron' in 1991.

Presently, Sinagama provides irradiation services mainly for medical products and pharmaceuticals. This facility is also being used for demonstrating economic feasibility and semi-commercial trials of food irradiation.

TABLE I. POTENTIAL AGRICULTURAL COMMODITIES/FOOD FOR IRRADIATION

Types of food	Purpose of irradiation	Max. dose (kgy)
Milled rice	Control insect infestation	1
Black and White Pepper	Control insect infestation	1
Reduce microbial load		10
Frozen shrimp	Eliminate pathogenic Microorganisms	5
Chilled chicken	Eliminate pathogenic	3
microorganisms		
Fresh ginger	Inhibit sprouting during storage	0.05
Cocoa beans	Control insect infestation	1
Control fungi infection		6
Fresh fruits (papaya, starfruit)	Control insect infestation (quarantine)	<0.5
Cut flowers	Control insect infestation	<0.5

For food irradiation to reach its full potential benefit, it must gain acceptance from all sectors i.e. the government, the food industry and consumers. In Malaysia, the commercial application of the technology suffers delay, possibly due to a number of economic and technical issues facing the food industry and national regulatory control authorities as well as the attitude of the public to the irradiation of food. Recent global trade developments, in particular adoption of the Agreement on the Application of Sanitary and Phytosanitary Measures (GATT Uruguay Round) and the prohibitions/restrictions of a number of food fumigants such as ethylene oxide and methyl bromide are likely to increase trade in irradiated food [4]. In view of these developments, Malaysia realized the need to promote food irradiation. A comprehensive education programme has been developed by the National Working Committee on Food Irradiation in 1995 with IAEA assistance [5]. Based on the experiences of other countries, the approach of the programme will be to examine consumer and food industry attitudes towards this technology, develop and measure impact of education materials on their attitude, then pilot test the education materials with actual irradiated food products in the market place. Under this CRP, the following activities were identified and conducted with the specific objectives:

1. Evaluation of food industry attitude to food irradiation: to determine food industry awareness and interest to utilize irradiation technology.
2. Development of consumer education materials: to produce materials which address consumer concerns and highlighting the benefits of the technology.
3. Promotion of food irradiation: to increase fact-based information on food irradiation seen by general public.

2. EVALUATION OF FOOD INDUSTRY ATTITUDE

A survey was conducted on local food processors to evaluate current awareness/knowledge on food irradiation, to identify interest and to determine potential application by the food industry.

2.1. Methodology

The survey involved development of questionnaire, selection of food processors as respondents, data collection and data analysis. Food processors were selected based on food products/agriculture commodities, which have the potential to be irradiated. In Malaysia, these include spices, frozen seafood, fruits, cocoa products, poultry, cereal and food packaging materials. These food products made up five of the ten subsectors in the Malaysian food processing industry. A total of 107 food processors was selected and approached as respondents for this study.

2.2. Results and discussion

A total of 37 food processors participated in the survey. Although participation rate was relatively low, each sub-sector was represented as shown in Table II.

TABLE II. PROFILE OF RESPONDENTS (N = 37)

Sub-sector	Respondents	
	Frequency	Percentage
Cereal-based products	6	16
Coffee, cocoa, tea and spices	6	16
Processed meat	9	24
Fish products	7	19
Processed fruit and vegetables	3	8
Miscellaneous food products	6	16

The study indicated that 78% of respondents were aware of food irradiation but level of knowledge on the benefits, applications, safety of process and safety of irradiated food was low i.e. only 4–7% of respondents have good knowledge (Fig. 1). Current sources of information were from publications such as newspaper, journals, magazines (59%) followed by seminars (46%) and electronic media (11%). Hence the use of electronic media (TV and radio) should be increased for information dissemination food irradiation.

Awareness of respondents on some of the important developments and advances in food irradiation internationally and in Malaysia were also evaluated (Fig. 2). Apparently, 58% of respondents were aware that food irradiation is recognized by FAO, WHO and Codex Alimentarius Commission. However, more than half of the respondents were not aware that irradiation has been commercially used by 28 countries or that tropical food products such as spices and frozen shrimps are irradiated at facilities in the importing countries. Similarly, respondents were not aware of the availability of radiation facilities in Malaysia nor the existence of Malaysian Standard on Guidelines for Irradiation of Food which was formulated in 1992 to assist food industries in applying the technology. In addition, 48% of respondents did not realize that approval is required from the Ministry of Health before using the technology.

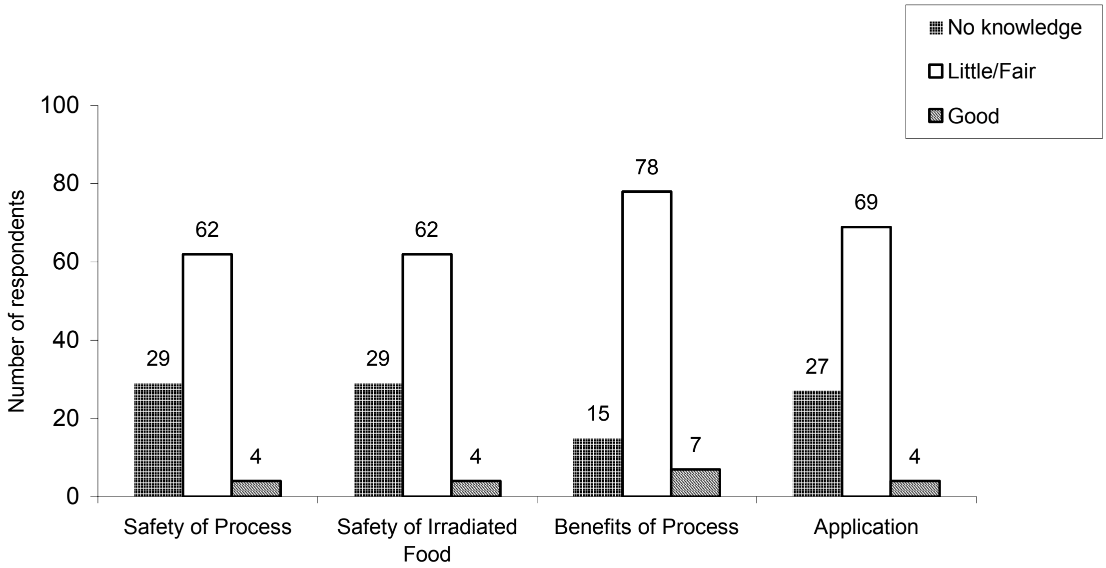

FIG.1. Level of knowledge on food irradiation.

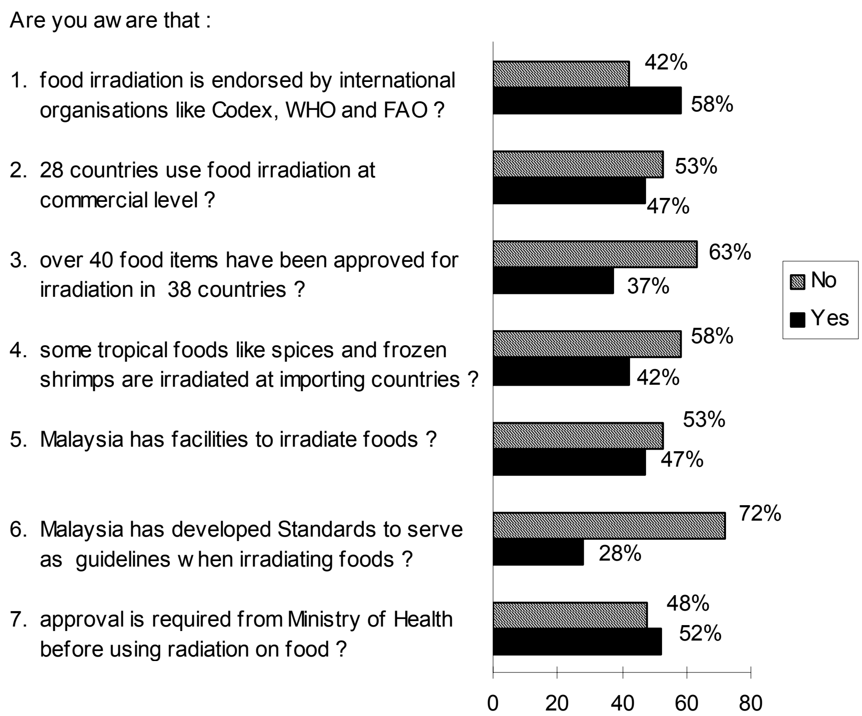

FIG.2. Knowledge on food irradiation developments.

In this study, the perception and willingness to apply the technology is used as an indication of acceptance of food irradiation by food industries. Food irradiation was perceived as safe by half of the respondents as opposed to one respondent who perceived otherwise while remaining 47% were uncertain or formed no opinion (Fig. 3). About 33% of respondents indicated willingness to use irradiation either for research or commercial purposes and a slightly higher number of respondents (43%) will not irradiate their products (Fig. 4). However, more respondents (41%) will consider using imported irradiated ingredients compared to 28% who will not use while 31% were undecided (Fig. 5). Given proper information, the number of potential users are expected to increase.

Among the various applications of food irradiation, its use in reducing spoilage/eliminating pathogenic microorganisms in food products and in sterilizing packaging materials were found to serve the requirements of half of the respondents as an alternative to heat or chemical treatments (Fig. 6). In determining factors affecting commercial application, majority of respondents (90%) considered safety of process, safety of the irradiated food, efficacy of the process and consumer acceptance as high priority compared to cost and environmental effect (Fig. 7). Hence these four factors should be emphasized in securing the acceptance of food irradiation by the food industry.

Findings of the survey suggest that food irradiation is still unknown to majority of Malaysian food processors. However, respondents strongly indicated that food irradiation technology should be promoted in Malaysia. Half of the respondents conveyed interest to conduct research or do product testing while 41% will join efforts in educating the consumers. More than 75% of respondents indicated interest to receive information and visit the radiation facilities at MINT. These information provide MINT with the opportunity to establish further contacts with the food processors for educational/promotional activities.

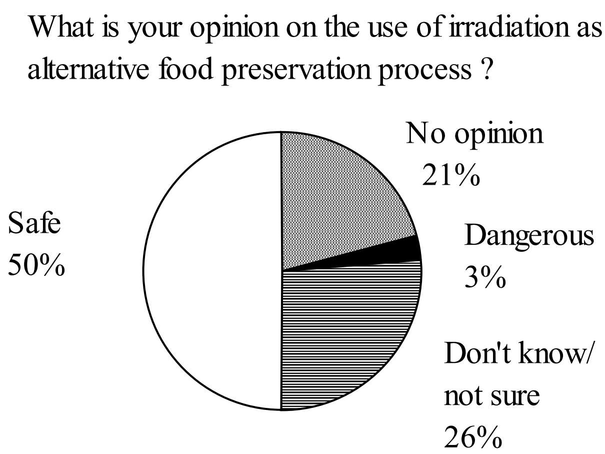

FIG.3. Opinion on food irradiation.

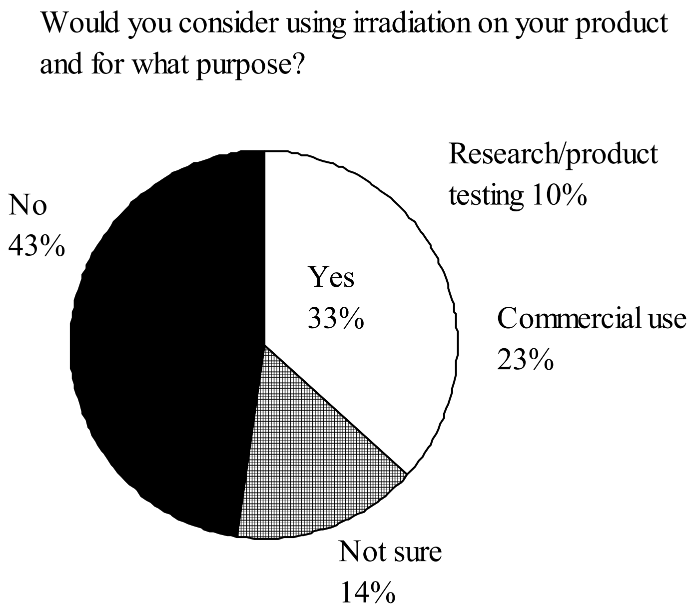

FIG.4. Consider to use irradiation process.

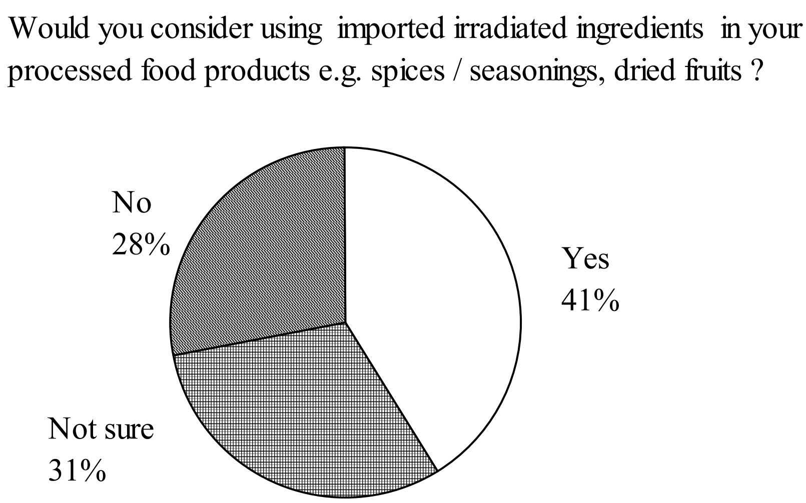

FIG. 5. Consider to use irradiated ingredients.

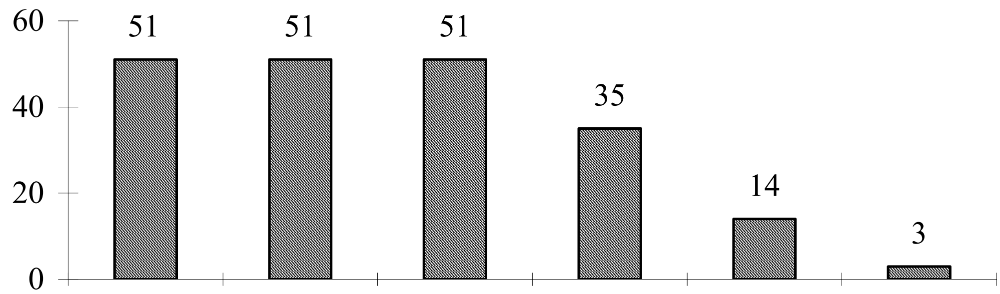

FIG. 6. Potential application of food irradiation by food industry.

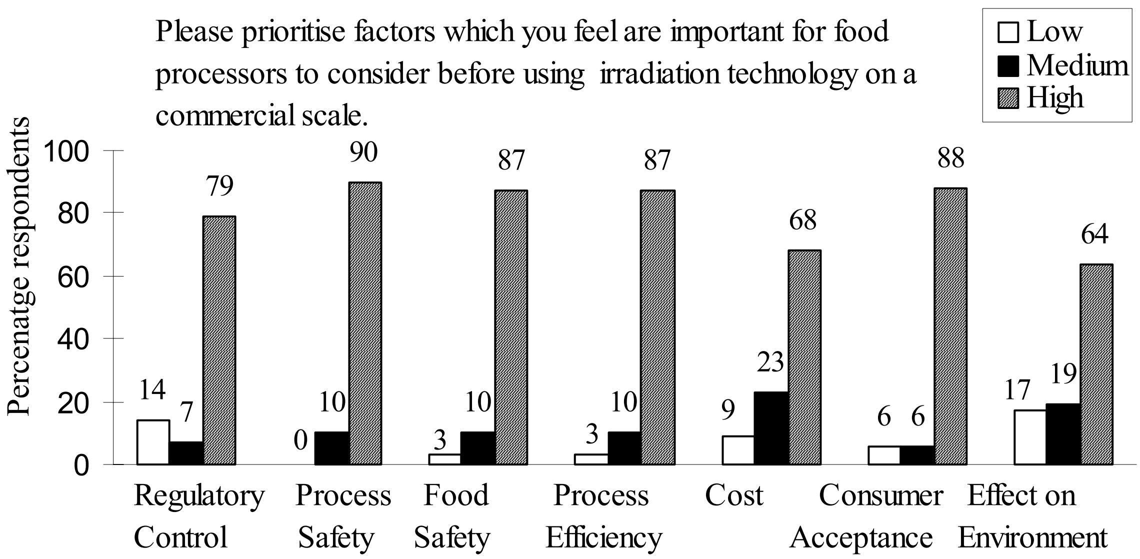

FIG. 7. Factors of concern for commercial application.

3. DEVELOPMENT OF CONSUMER EDUCATION MATERIALS

As in many other countries, food irradiation in Malaysia has attracted much attention from the local activist and media which has led to the misconception among policy makers and food industries that consumers would be reluctant to accept irradiated food. Furthermore, Malaysia used to be the regional base of the infamous anti-food irradiation activism centre in the 1980s and hence, consumers were influenced by the adverse publicity on this technology. As there are no irradiated products in the marketplace yet, it is difficult to assess the Malaysian consumer's response to food irradiation. A survey conducted in 1991 on 1029 consumers indicated ignorance of the process by two-thirds of respondents due to very limited knowledge and misunderstanding of the technology [6]. The process was perceived as dangerous by 52% of respondents with only 10% convinced it is safe. Initial acceptance was low whereby about 85% of respondents were unwilling to consume irradiated food but the number was reduced to 46% if irradiated food gets safety assurance from the health authority. Nevertheless almost all respondents responded positively towards education on food irradiation.

Findings of the survey indicated that information on food irradiation is presently very limited. To increase acceptance, there is obvious need to make available information materials addressing consumer concerns and highlighting the benefits of this technology. Continuous efforts are underway to produce such education materials by adapting materials developed by ICGFI and other sources, to the Malaysian situation. The compilation of research achievements on food irradiation in Malaysia is currently in progress and due to be ready in early 1999.

4. PROMOTIONAL ACTIVITIES ON FOOD IRRADIATION

Various activities have been conducted to increase awareness and understanding of the food irradiation technology in the past three years. As a follow up to the food industry survey, information materials on food irradiation were sent to all respondents. Visits were made to 5 food processors for further discussion on the technology while 3 others visited the radiation facilities in MINT. Three food processors conducted product testing on chrysanthemum flowers (ingredient for tea), chilled fish products and spices using gamma radiation at our commercial Co-60 irradiator.

Irradiation technology was also introduced to about 130 food processors during a National Technology Connection meeting organized by the Ministry of Science, Technology and the Environment and the Ministry of International Trade to foster commercial linkage between private sector and research institutes. A one-day seminar on “Gamma processing of pharmaceuticals, herbal and cosmetic industries” was organized by MINT which was attended by about 80 representatives from public and private sectors including food industries.

Lectures and IAEA/ICGFI videos on food irradiation were presented to various members of the public during their visit to MINT including students, food control officials, quarantine inspectors and food industry. An article by a journalist highlighting food irradiation was recently published in newspaper without negative feedback from the public or consumer group.

These activities have contributed to the commercial processing of spices and herbs at the Co-60 irradiator Sinagama since end 1997. More than 18,000 kg of spices and 25,000 kg of herbs have been radiation processed for decontamination of microorganisms and the volume is expected to increase as more processors are informed of the advantages of irradiation. As one of the major spice exporter, the banning of ethylene oxide by many importing countries would make irradiation an alternative treatment for improving microbiological quality of spices.

5. CONCLUSIONS

The Malaysian food industry is gradually showing interest on food irradiation technology. However, there remain many factors which delay its commercial application such as lack of clear cut need for the process, cost-benefit, logistics, regulatory control and uncertainty of consumer acceptance. To ensure successful commercialization, the role of food industries must be strengthened. They should be encouraged to examine their need for this technology and conduct economic feasibility studies on their food products. They should also be involved in consumer education and market testing of irradiated foods which will lead to better understanding and acceptance of the process and products.

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COMMERCIALIZATION OF IRRADIATED FOODS IN PAKISTAN

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Abstract. Preservation of food by gamma radiation is technically feasible and economically viable under conditions existing in Pakistan. to educate the consumers, Programme for dissemination of information regarding food irradiation was implemented to educate the consumers. Test marketing of irradiated products was carried out for 5–6 years and more than 8 tons of irradiated vegetables were sold to consumers who were briefed about the advantages of radiation technology. A number of condiments including pepper and chillies were irradiated on a large scale (more than 10 tons) at the Pakistan Radiation Service (PARAS) during the years 1996–1998. Comprehensive Harmonised food irradiation regulations, covering all foods in seven classes, were approved in 1996. The charges for irradiating various food commodities ranged from US$19.71/ton potatoes (0.10 kGy) to US$38.32/ton for spices (10.0 kGy). Once the techno-economic feasibility is demonstrated, huge post-harvest losses of different food commodities can be avoided. This will make the country not only self-sufficient in food, but with enough surplus for export.

1. INTRODUCTION

Agricultural production in Pakistan has increased considerably over the past two decades (Table I) [1]. However, post-harvest losses of foods are substantial (15-30%) due to high temperature and humidity. Since there are no effective and economical methods of food preservation available, shortages of some essential food items in the markets occur. This causes prices to increase considerably and to fluctuate widely during the year [2]. Consequently, the Government is forced to import some food products and consumers have to pay very high prices for such foods.

It has been established that preservation of food by gamma radiation is technically feasible and economically viable under conditions existing in Pakistan [3]. It was therefore important to undertake a program for commercial food irradiation to avoid huge post-harvest food losses, ensure uniform supply of essential food products and avoid large fluctuations in prices during the year. A research agreement entitled "Commercialization of Irradiated Foods in Pakistan" was awarded by the IAEA in 1994 under the Co-ordinated Research Programme (CRP) on Public Acceptance of and Trade Development in Irradiated Food in Asia and the Pacific. The objectives of the project were [4]:

1. To carry out test marketing of commercial quantities of irradiated products (potatoes, onions, spices, chicken, meat, mangoes, bananas, etc.).
2. To evaluate consumer acceptability of irradiated foods.
3. To prepare and implement a consumer education program (seminars, meetings, exhibitions, articles in press, lectures on food irradiation in various scientific institutions and universities, PTV program on food irradiation).
4. To involve food industry and trade in the use of gamma radiation for preservation/hygienization of foods.
5. To undertake inter-country transportation and market testing of irradiated foods (potatoes and onions) to Thailand/Sri Lanka.
6. To determine the economic cost and benefit of irradiated foods under commercial conditions.

TABLE I. PRODUCTION OF FRUITS AND VEGETABLES IN PAKISTAN
(000 tons)

No.	FRUITS	1984–1985	1994–1995	%increase/decrease
1.	Citrus	1,373	1,933	+40.7
2.	Mango	692	884	+27.7
3.	Apple	143	533	+272.7
4.	Banana	137	80	-41.6
5.	Apricot	52	153	+194.2
6.	Almonds	29	49	+68.9
7.	Grapes	27	40	+48.1
8.	Guava	288	420	+45.8
VEGETABLES				
1.	Potatoes	476.6	859.8	+80.4
2.	Onions	451.8	808.9	+79.1
3.	Tomatoes	99.1	237.8	+139.3
4.	Vegetables	1616.5	2875.5	+77.9
(excluding potatoes & sugar beet)				

2. CONSUMER EDUCATION PROGRAM

Acceptance of irradiated food by the consumers is a vital factor in the successful commercialization of food irradiation technology. Consumer education programs on irradiated foods are of utmost importance. Public awareness has to be created with the help of mass media, seminars, group meetings and science exhibitions. In order to educate the consumers, the program for dissemination of information regarding food irradiation was carried out. A number of lectures/seminars on the subject were delivered in the national research institutions, postgraduate colleges and agricultural universities in the country. Lectures were also delivered to the scientists attending courses in our institute. Adequate awareness was created among consumers for irradiated food but much more has to be done before the commercialization of irradiated foods in Pakistan [3, 4].

3. CONSUMER ACCEPTABILITY AND MARKET TESTING

Market trials are important prerequisites for commercialization of irradiated foods. Test marketing of irradiated potatoes and onions was made through retail markets after three to four-months of storage. The irradiated products were identified with a label “Irradiated Potatoes” “Irradiated Onions” [5]. The consumers were briefed about the advantages of radiation preservation. They preferred to buy the irradiated products because of better quality. The test marketing of irradiated products was performed for 5-6 years and more than 8 tons of the irradiated vegetables were sold to the consumers who were briefed about the advantages of radiation technology. The inter-country transportation and market testing could not be undertaken due to the lack of the required infrastructure.

4. FOOD INDUSTRY AND TRADE

A number of food processing industries were visited and meetings were held with officials to discuss the potentials, advantages and economics of food preservation by irradiation. The food industry was interested in radiation technology and some foods as chili, peppers and other condiments were irradiated on a large scale at the Pakistan Radiation Services (PARAS) at Lahore [4]. Commercial irradiation of food followed the approval of the Food Irradiation Regulations covering foods in several classes, in 1996. A number of condiments including pepper and chili were irradiated on a large scale (more than 10 tons) in PARAS during the years 1996-1998. A number of exporters have also requested for the radiation preservation of some fruits and vegetables for export.

5. FOOD IRRADIATION REGULATIONS

Comprehensive food irradiation regulations, covering foods in seven classes, were prepared and submitted to the competent authority i.e. the Pakistan Nuclear Regulatory Board in 1995. After examining the regulations by the Board, a presentation was also made to the members of the Board and all aspects of commercial food irradiation were explained. The Board accorded approval to the regulations which were published in February, 1996 in the Gazette Notification by the President of Pakistan (Table II). These regulations strictly conform to the Codex General Standard for Irradiated Foods and the Codex Recommended International Code of Practice for the Operation of Irradiation Facilities used for the treatment of foods [4].

TABLE II. FOOD IRRADIATION REGULATIONS
GAMMA RADIATION DOSES FOR THE TREATMENT OF FOODS

1.	Potatoes and onions - to inhibit sprouting	0.15 kGy
2.	Fresh fruits - to delay ripening/insect control	1.0 kGy
3.	Food grains, dry fruits - to control insect infestation	1.0 kg y
4.	Chicken and meat - to extend shelf-life/eliminate pathogenic microorganisms	5.0 kGy
5.	Fish and seafood - to ensure hygienic quality/ eliminate spoilage organisms	5.0 kGy
6.	Spices, herbs, condiments - to control infestation/ ensure hygienic quality	1.0 kGy
7.	Dry foods of animal origin - to control insect infestation	1.0 kGy

6. COST ECONOMICS OF IRRADIATED FOODS

The food irradiation process is highly capital intensive and its economic feasibility is seen only when there is a fairly large quantity of product to be processed. Radiation facilities must be utilized round the clock and round the year so as to fully utilize an expensive radiation source that decays at constant rate whether it is used or not. It is thus necessary, purely from the economic point of view, to find ways and means of utilizing the radiation facility all year, as potatoes/onions, fruits and vegetables are seasonal.

The total processing cost equals the annual operating cost, interest on the capital cost plus depreciation of capital. Depreciation costs are calculated based on a ten-year amortization of equipment, 15-year amortization of cobalt and 25-year amortization of buildings. The unit processing cost equals the total annual processing cost divided by the annual throughput in kg . The total cost as well as the unit processing cost for a Pallet Carrier Irradiator was worked out and is shown in Table III. The charges for irradiating various food commodities ranged from US $19.71/ton for potatoes (0.10 kGy) to US $38.32/ton for spices (10.0 kGy) [3, 6].

TABLE III. COST OF A PALLET CARRIER IRRADIATOR (US $)

A. INPUT VARIABLES

1. Cobalt	US $2.0/Ci
2. Replenishment cobalt	US $2.0/Ci
3. Irradiator efficiency	25%
4. Annual operating hours	8 000 h
5. Minimum dose	0.015 Mrad
6. Throughput	60 000 000 kg/a
7. Container rental charge	US $2 000
8. Number of product handlers	6
9. Cobalt required	84 150 Ci
10. Replenishment cobalt required	10 350 Ci
11. Product density	0.4 g/cm^3

B. CAPITAL ITEMS		US $
12. Irradiator		3,000,000
13. Total boxes		
14. Auxiliary equipment		300,000
15. Warehouse conveyors		
16. Other		200,000
17. Cobalt-60 requirements (Ci) 84150		
18. Cobalt-60 costs	@ 2.0/Ci	168,300
19. Container rental 1 container	@ 2.000	200
20. Land (0.5-0.75)ha)		
21. Radiation shield		900,000
22. Warehouse		350,000
23. Shipping		50,000
24. Startup costs		30,000
25. Total capital		4,998,500

C. OPERATING ITEMS			
26. Salaries	– Plant Manager (PSO)		6,000
	– Radiation Safety Officer (SSO)		4,400
	– Quality Control Officer (SO)		4,000
	– Plant Operators (Tech-I)-4		5,240
	– Helpers-6		4,500
27. Utilities and communications			7,000
28. Maintenance and repairs			9,000
29. Taxes and insurance			5,000
30. Operational supplies			15,000
31. Administration			9,000
32. Cobalt-60 replenishment (Ci) 10350		@ 2.0/Ci	20,700
32. Interest on the capital			699,790
33. Total operating costs			789,630

D. PROCESSING COSTS	
34. Depreciation of capital	393,381
35. Operating Costs	789,630
36. Total processing costs	1,183,011
37. Unit processing cost	US $ 19.71/t

7. PROSPECTS OF FOOD IRRADIATION

Food irradiation is seen as a process with immense economic potential. Judicious use of the process is necessary to realize its advantages. Besides the direct economic benefits to farmers, the nation stands to gain much through the intangible benefits that it has to offer such as better price stability, increased availability and improved safety of foods marketed. Presently, neither the economic nor technical considerations appear to stand in the way for the acceptance of the process by industry and trade in the country. The first commercial food irradiator has to be installed at the campus of PARAS (Pakistan Radiation Services) at Lahore, where all necessary infrastructure is available. Once the techno-economic feasibility is demonstrated, more such plants will be installed in different parts of the country in the public and private sectors. In this way huge post-harvest losses of different food commodities will be avoided making the country not only self-sufficient in food, but with enough surplus for export [2].

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FACILITATING TRADE IN IRRADIATED ONIONS IN THE PHILIPPINES

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Abstract. The irradiation of large volumes of three varieties of onions (56 tons of red creole, 20 tons of yellow granex and 14 tons of shallots) at the Philippine Nuclear Research Institute, was carried out by the private sector (National Onion Growers Marketing Cooperative) with the technical assistance of government. The data confirmed increased profits from sale of irradiated onions due to the presence of significantly higher percentages of good bulbs after storage (26%, 36% and 69% more for the yellow granex, red creole and shallot varieties respectively) due to inhibition of sprouting. Industry's acceptance of the process was indicated by the large volume of onions irradiated during the period (96 tons) and the application of the treatment to shallots for the first time. In spite of the significant benefits, the high capital cost of the plant did not justify its operation solely for onions. The opening of markets for other applications was considered essential. The percentage of consumers willing to purchase irradiated food was low but this increased from 15% to 79% when appropriate information on the technology was provided to them. It was concluded that the provision of information is the key to consumer acceptance. However, the opening of profitable markets in order to achieve economic feasibility, is the key to the commercialization of the technology.

1. INTRODUCTION

In the Philippines, irradiation has a role to play in reducing the post-harvest losses in food commodities as onions and garlic; in ensuring the safety of food ingredients as spices, dehydrated vegetables and herbs, in ensuring the safety of frozen foods and in providing a less harmful method for the quarantine treatment of fresh fruits and vegetables for export. This project analyzed the cost-benefit picture for the use of the technology under local conditions and evaluated consumer attitudes towards irradiated foods. The information was to provide a basis for developing a program for promoting awareness and acceptance of the technology by the consumer and the industry.

The role of irradiation in reducing losses during the storage and marketing of onions was the application transferred to the industry in this project. Control of sprouting is a major concern in the marketing of onions because the crop has to be cold stored and subsequently distributed over long distances at high ambient temperatures. The use of chemicals as maleic hydrazide for sprout control has been tried by the industry but has not been widely accepted due to uncertain efficacy. The chemical reportedly does not fully control sprouting. The industry was therefore open to large scale trials on the irradiation of onions to evaluate consumer acceptance, cost and economic feasibility.

2. MATERIALS AND METHODS

2.1 Onion collection, irradiation, storage and post storage handling

2.1.1. Onion collection

Onions came from the onion collection centers of the National Onion Growers Marketing Cooperative (NAGROCOMA) in Bongabon, Nueva Ecija, 150 km from Manila. A collection center was a place where onions harvested from surrounding farms were collected, cured, sorted and packed in crates or bags, with a net weight of 25 kg/crate or bag by farmers and/or traders.

In 1995, 3 tons each of yellow granex and red creole onions were irradiated. In 1997, the industry requested to irradiate 56 tons of red creole and 20 tons of yellow granex onions. In 1998, the industry irradiated 14 tons of shallots.

2.1.2. Onion irradiation

The collected onions were transported in 5 hours to the irradiation plant of the Philippine Nuclear Research Institute (PNRI) at Diliman, Quezon City, where they were irradiated in batches of 20 bags at a time, to a dose of 0.06 kGy to 0.12 kGy. Irradiation and dosimetry were carried out by PNRI. The industry provided manpower for product handling. The volumes irradiated were much higher than what the PNRI irradiation plant could handle. There was thus extensive use of manual labor for product handling. A 3-ton lot of onions took 7 hours to receive the required dose. The PNRI facility is a Co-60 gamma facility with a source strength of 150,000 curies. The source is adequate for present needs but the lack of product handling equipment made its use for commercial trials, difficult.

2.1.3. Storage and post storage handling

After irradiation, the onions were transported to the NAGROCOMA cold storage about 20 kilometers from the PNRI irradiator. In 1995, some batches were stored at the Food Development Center located a similar distance from PNRI. The yellow granex onions were stored at 2.3°C for 4 months; the red creole, for 4-7 months at the same temperature, and the shallots, for 4 months at 15-20°C and 30°C.

At the end of the storage period, the surface of cold-stored onions were dried by blowing air through the bags or by spreading the onions on the floor for two days of natural aeration. After this process which was called reconditioning, the onions were prepared for the market by sorting to separate good bulbs from those that were sprouted, decayed and/or soft.

In 1995, the good bulbs were packed for retail sale in polyethylene bags with a net weight of 500 grams. A printed label with the radura logo and a statement “Treated by Irradiation to Control Sprouting” was placed inside each bag. Two hundred and fifty bags (250 bags) were packed and delivered daily to three metro Manila supermarkets where the onions were sold side by side with non-irradiated, non-labeled onions. A big sign giving information on onion irradiation was placed beside the irradiated bags. About 50 bags each of irradiated and non-irradiated onions were displayed. An FDC staff distributed information materials and stayed around to record consumer reaction and daily sales. In 1997 and 1998, the onions remained in the NAGROCOMA cold storage and were sold in their original containers (sacks or crates) to traders.

2.2. Industry-government cooperation in program implementation

In 1995, the Food Development Center arranged for the transport, irradiation, storage and sale of onions in the supermarkets. The industry provided the onions and monitored and collected the proceeds from sales. In 1997 and 1998, the industry carried out all the operations from the collection of onions at the collection centers, transport to the PNRI irradiation plant, cold storage and sale to traders. The Food Development Center obtained government clearance for test marketing, and monitored the quality of the crop at the NAGROCOMA cold storage. The PNRI ensured proper irradiation of the commodity, operated the plant to allow continuous irradiation and acceded to special terms of payment requested by the industry.

2.3. Evaluation of consumer attitudes

2.3.1. Determination of consumer reaction at the supermarkets

In the 1995 trials, an FDC staff stayed at the supermarkets and talked to the consumers about the product. There was monitoring of the rate of sale of the onions, consumer reaction and comments during the purchase of onions at the supermarkets

2.3.2. Survey of consumer perception of irradiated foods

Consumers were organized in groups of 5-10 to evaluate their perception of food irradiation. There were 210 consumers chosen from the public and 36, from the Food Development Center (FDC). The consumers (86%) were holders of a university degree and earning a minimum of P10,000 a month. A minority (30%) were students taking a university degree. Based on the above, the consumers were considered "educated". Sixty eight percent (68%) were female and 32% were male. Sixty four percent (64%) were 20–40 years old, 31% were 41–60 years old and 5% were more than 61 years old. Each participant in the survey filled up a questionnaire. After this, a trained moderator discussed the benefits of food irradiation, initiated discussions, distributed information materials and showed pictures and samples of irradiated onions. After the group discussion, a second questionnaire was filled up by the consumer.

3. RESULTS AND DISCUSSIONS

3.1. Profitability from the sale of irradiated onions

The semi-commercial trials showed that irradiation of onions was profitable as irradiated commodities brought higher financial returns after cold storage (Table I) resulting from the control of sprouting.

The data obtained on sprout control shown in Table II confirmed previous small scale trials. The data in Table II shows that there will be 26% and 36% more good bulbs of red creole onions after 7 months storage at 2–3^{o}C. For the yellow granex variety, there will be 34% and 30% more good bulbs after storage. Semi-commercial scale irradiation (14 tons) of shallots was done for the first time and showed an even larger 69%, increase in good bulbs due to irradiation. After 4 months cold storage, the non-irradiated shallots were almost unmarketable whereas the irradiated bulbs were 90% good.

For the industry, the trials showed that the irradiation of onions was profitable. There was reportedly not only greater profit but also greater consumer satisfaction in the quality of onions and their availability late in the storage season. The profits however were not adequately large to justify the establishment of a plant by the industry operating only to irradiate onions. Other applications were needed. Establishment of a central facility by the government was also recommended.

Industry's acceptance of the process was demonstrated by the increase in volume of onions irradiated during the project: namely, for the yellow granex variety, 2.5 tons in 1995 which increased to 20 tons in 1997. For the red creole variety, 3 tons in 1995 which increased to 56 tons in 1997 and the irradiation of a new variety, 14 tons of shallots (Table II). A total of 96 tons of onions were irradiated during the project period.

TABLE I. EFFECT OF IRRADIATION ON SELLING PRICE OF ONIONS AFTER COLD STORAGE

(A) YELLOW GRANEX ONIONS. Stored for 4 months at 2–3°C

QUALITY	IRRADIATED		NON-IRRADIATED	
	Volume (kg)	Sales (Pesos)	Volume (kg)	Sales (Pesos)
1. Spoiled	112.74	0	301.31	0
2. Sprouted, shriveled, soft	320.15	640.30	910.78	1821.56
3. Good	1718.74	22343.62	1044.93	13584.09
TOTAL	2151.63 kg	22983.92 Pesos	2257.02 kg	15405.65 Pesos
Average proceeds from sales (P/kg)*		10.68/kg		6.83/kg

*P40 = 1$US

(B) RED CREOLE ONIONS. Stored for 7 months at 2–3°C

QUALITY	IRRADIATED		NON-IRRADIATED	
	Volume (kg)	Sales (Pesos)	Volume (kg)	Sales (Pesos)
1. Spoiled	109.32	0	157.12	0
2. Sprouted, shriveled, soft	127.12	635.6	321.94	1609.7
3. Good	1352.57	29756.54	466.17	10255.74
TOTAL	1589.01 kg	30392.14 Pesos	945.23 kg	11865.44 Pesos
Average proceeds from sales (P/kg)*		19.13/kg		12.55/kg

*P40 = 1$US

3.2. Consumer response

Consumers purchased irradiated onions labeled irradiated. The commodity sold better than non-irradiated onions in supermarkets frequented by high income shoppers.

Consumer response to the technology was evaluated in a survey of 210 “educated” consumers and 36 consumers from the Food Development Center (FDC). Of the 22 educated consumers interviewed, 67% did not know what food irradiation was and 11% thought it was something that would make food unsafe (Table III). Of the 36 FDC consumers interviewed 92% had heard of food irradiation but 53% were still uncertain if they would purchase irradiated foods (Table IV). There was poor awareness of the technology outside of FDC and even where there was awareness, this did not automatically translate into acceptance of the technology.

TABLE II. EFFECT OF IRRADIATION ON SPROUT INHIBITION IN ONIONS STORED IN COMMERCIAL COLD STORAGE

ONION VARIETY	PERCENTAGE OF ORIGINAL VOLUME OF GOOD BULBS AFTER STORAGE	
a) Red Creole Stored 2–3°C, 7 months	Original Volume = 56 tons	Original Volume = 3 tons
Irradiated Non-Irradiated Difference	76% 50% 26%	85% 49% 36%
b) Yellow Granex Stored 2–3°C, 4 months	Original Volume = 20 tons	Original Volume = 2.5 tons
Irradiated Non-Irradiated Difference	60% 30% 30%	80% 46% 34%
c) Shallots Stored 15–20°C, 4 months	Original Volume = 14 tons	Original Volume = 14 tons
Irradiated Non-Irradiated Difference	90% 21% 69%	61% 14% 47%

Irradiation was also preferred over chemicals to prevent sprouting of onions and to control pathogens. Several information materials for consumers were developed in the course of preparing for the survey.

Information dissemination was an important factor in the acceptance of the technology by the consumer (Table IV). Prior to information dissemination, only 15% of the consumers were willing to buy irradiated foods. After information dissemination this increased to 79%. Sixteen percent (16%) however remained uncertain while 5% indicated they would still refuse to buy the irradiated products. Of the consumers who were uncertain one thought irradiation made a food radioactive while the others felt they needed more information. FDC consumers (97%) were convinced to buy irradiated foods after information dissemination. However 3% remained unwilling to purchase even after information dissemination.

TABLE III. SURVEY OF CONSUMER RESPONSE TO FOOD IRRADIATION

ITEMS SURVEYED	RESPONSE	
	Educated Consumer (%)	FDC Consumer (%)
Knowledge of food irradiation: Have you heard about food irradiation? Yes No	 33 67	 92 8
Perception of Food Irradiation: When you hear the term food irradiation what do you think it does to food? a. Improve its quality/safety • Makes it better • Makes it safer • Both	24	69
b. Makes food unsafe/radioactive? • Unsafe • Radioactive • Better quality but unsafe • Better quality but unsafe and radioactive	11	8
c. No idea	65	22
Which process would you prefer to prevent sprouting of onions? • irradiation • maleic hydrazide • don't know, need more information	 72 0 28	 94 0 6
Is there a difference between irradiated and non-irradiated onions that you see? • Yes • No • Uncertain	 92 7 1	 97 3 0
If, yes, what is causing the difference? • appearance • texture • color • smell • combination of the above	 45 6 3 1 45	 53 0 6 0 41

TABLE IV. EFFECT OF INFORMATION DISSEMINATION ON CHANGES IN CONSUMER RESPONSE TO FOOD IRRADIATION

QUESTION	RESPONSE			
	Prior to the Dissemination of Information		After the Dissemination of Information	
	Educated Consumer (%)	FDC Consumer (%)	Educated Consumer (%)	FDC Consumer (%)
1. Will you buy irradiated foods/onions?				
Yes	15	36	79	97
No	18	0	5	0
Uncertain	67	53	16	3
2. Will you eat irradiated foods/onions?				
Yes	13	47	78	97
No	21	0	9	0
Uncertain	66	53	13	3

4. CONCLUSIONS

The results of commercial scale trials confirmed predictions which FDC had obtained in the past using small scale trials, that irradiation effectively controlled storage and post storage losses in onions. There were higher financial returns from the sale of irradiated onions due to the lower magnitude of commodity deterioration during storage. However investment in a plant will not be profitable on the basis of onion irradiation alone because of the high capital cost of an irradiator. Although there was greater profit from sales and greater consumer satisfaction in the availability of good quality commodities late in the storage season, feasibility will depend on other applications. The industry was searching for ways to increase applications in other areas.

Economic feasibility will also depend on the opening of markets for other products for which irradiation offers a marketing advantage. Although as shown in this study, information dissemination to the consumer is essential, this will likely not be a limiting factor to commercialization as only a small percentage of consumers 3–5%, will remain unwilling to purchase irradiated foods after information on the nature of the technology and its benefits is provided. The opening of markets and product acceptance by consumers in the markets opened is important to facilitating trade and needs to be pursued.

PUBLIC ACCEPTANCE AND TRADE DEVELOPMENT OF IRRADIATED FOOD IN SRI LANKA WITH SPECIAL REFERENCE TO SPICES AND ONIONS

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Abstract. Sri Lankan spices, onion, shallots and dried chillies suffer considerable storage losses due to inadequate preservation method. Irradiation to a dose 7 kGy was found to be effective technique to reduce storage losses and improve quality of different spices. Preliminary results showed prospect of using irradiation for large scale preservation of dried chillis. But, due to lack of irradiation facility scaled- up irradiation and storage trials could not be undertaken. Based on study conducted by the Ceylon Institute of Scientific and Industrial Research a report was submitted to the Atomic Energy Authority of Sri Lanka on the current demand for a multi-purpose irradiation facility. The food items identified for irradiation processing include spices, desiccated coconut, shrimps for export; and onions, chillies and dried fish products, foliage plants and medical products for local trade. The volume of products for commercial processing has also been indicated in the survey report. Steps for approval of the Harmonised Regulations on Food Irradiation as adopted in the RCA Workshop in Seoul, 1998 are at the processing level for submission as a parliamentary bill. A consumer acceptance survey was carried out in 1997; the outcome showed a low acceptance for irradiated spices. About 200 participants comprising private exporters, govt. officials and students were made aware of the irradiation process and benefits of irradiation treatment through the training programmes on post-harvest management at the CISIR.

1. INTRODUCTION

Sri Lankan spices including pepper, cloves and cardamom are gaining increasing importance in export markets. The majority of spice production is concentrated around the mid-country where microbial contamination and damp climate conditions make storage and the maintenance of quality difficult, particularly with regard to standards stipulated by export markets.

Onions, shallots and dried chillis are also important crops in Sri Lanka. Being seasonal, gluts occur during the harvest season leading to sharp fluctuations in price. The perishable nature of these commodities particularly onions and shallots make storage risky. In Sri Lanka losses could range between 40–60% of the harvested crop over a considerably short period of time.

2. OBJECTIVES

The objectives of the programe therefore were as follows:

- To treat at least one commercial batch of onions, shallots and chillies for intra and inter country test marketing.
- To treat at least one commercial batch of selected spices i.e. pepper, cloves and cardomom for inter and intra country test marketing.
- Collect and analyze test marketing data on local and imported products mentioned above.
- Prepare and distribute resource material for educating the public on the advantages of using irradiation technology for maintaining quality and minimizing post harvest loss.
- Conduct a series of public lectures on food irradiation technology to promote consumer awareness of the use and advantages of this technology in Sri Lanka.

3. RESULTS

Preliminary laboratory scale studies conducted by the Post Harvest Technology Group at the Ceylon Institute of Scientific and Industrial Research (CISIR) under Phase III of this RCA project on food irradiation provided favorable results with regard to the application of irradiation technology as a means of reducing post harvest losses and improving the quality of pepper, cloves and cardamom. This study indicated that a dose of 7 kGy resulted in complete decontamination of the spices.

Studies conducted on dried chillis produced favorable results. However, it was not possible due to the lack of facilities, to scale up these trials to commercial levels. A major reason was the lack of adequate resources to cover the costs associated with the trials. Discussions were held with various prospective sponsors for such activities from the government and the private sector but met with no success. While a food irradiation facility is yet to be established in Sri Lanka, a private irradiation facility has now been installed for the treatment of non food products manufactured for export markets.

Meanwhile, a report was submitted to the Atomic Energy Authority of Sri Lanka on the current demand for a multi-purpose food irradiation facility. The demand for irradiation services in Sri Lanka arises mainly with respect to the various food items such as spices, desiccated coconut, fruits & vegetables, shrimps, prawns and locally traded food items such as onions, chillies and dried fish products, foliage plants and for some of the medical items such as surgical gloves. The demand for irradiation services from each of the above mentioned commodity was assessed. The study showed that the total annual demand for irradiation services would be about 350,000 metric tons or more of different commodities.

Clarification of national regulations for the use of irradiation for the treatment of food items was sought from the Director Environment and Occupational Health following discussions with exporters and other prospective users of a food irradiation facility in Sri Lanka. Steps were also taken to initiate the formulation of guidelines for the use of irradiation technology for disinfection of food commodities in collaboration with the Sri Lanka Standards Institute.

The revised regulations on harmonization of food irradiation standards based on guidelines adopted at the RCA Workshop on “Harmonization of Procedures and Regulations on Food Irradiation for Asia and the Pacific” in Seoul, Republic of Korea in April 1998 was presented to a committee comprising representatives from the Atomic Energy Authority and the Ministry i.e. Chief Food Authority. Steps will be taken to publish the regulation in the form of a parliamentary bill in the near future.

A consumer acceptance survey was conducted in 1997 for irradiated pepper. Small consumer groups were used to evaluate consumer behavior towards irradiated foods such as spices. A consumer group consisted of 5–10 participants. Each participant was given a questionnaire. The results indicate that only 16.6% of the population showed willingness to purchase irradiated spices.

Education and public awareness programs were very successfully held together with training programs on post harvest management conducted at the C.I.S.I.R. Ten such programs were conducted during the period under review for up to two hundred participants i.e., students, private exporters and government. Education on the usefulness of irradiation to the food industry was also included in post harvest technology course lectures at under graduate and post graduate levels at Sri Lankan Universities.

Present studies include the Control of Thelaviopsis rot in pineapples by adopting gamma irradiation technology and Control of Glocephlotrichum microchlamidosporum in Rambutan Malwana special selection by adopting gamma irradiation technology.

A national seminar on nuclear techniques for better agricultural productivity was organized and conducted by the Atomic Energy Authority of Sri Lanka. Our group participated successfully in this programme to disseminate information on research findings to the learned community.

MARKET TESTING AND CONSUMER ACCEPTANCE OF IRRADIATED RICE (*Oryza sativa indica* Linn.)

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Abstract. Special grade A fragrant rice (Jasmine rice) of 13% moisture content was obtained from a local miller in Bangkok. Low density polyethylene, 29.5 cm in width × 45 cm in length and 200 micron in thickness, was used to pack the rice with a net weight of 5 kg. The irradiated food label was printed on one side of the bag to comply with food control regulations. The color and the ink for marking, were tested for gamma radiation compatibility. A total of 800 bags of rice, with a total gross weight of 4,000 kg, were irradiated at a minimum absorbed dose at 0.5 kGy for insect disinfestation. Radiation treatment was carried out using a multi-purpose, carrier type gamma irradiator, Model JS-8900, Serial No. IR-155, located at the Thai Irradiation Center.

Irradiated rice was distributed on a weekly basis to food stores in Bangkok and Pathum Thani, as well as to various governmental organizations and interested individuals. The product was sold at 60 bahts per bag (approx. US$ 2.4) to retailers. Various commercial brands of non-irradiated rice of 5 kg size, were available in the market at 52 to 78 bahts per bag (approx. US $ 2.08 to 3.12), depending on quality and brand name. During the distribution, a leaflet of educational information was given to the consumer. A simple questionnaire used in the marketing trial indicated that 72% of the consumers bought irradiated rice because of the good quality of the product based on visual inspection, and 28% of them were willing to try the new product. Most consumers preferred irradiated rice to chemical treatment (fumigation) for insect disinfestation. However, most consumers were not sure if they would like to buy irradiated rice again unless its cooking quality was acceptable. Market testing of irradiated rice in the upper-class market or supermarket was unsuccessful because of limitations in the sale and service conditions. To meet the requirement of the supermarket retailer, irradiated rice had to be supplied on a monthly basis, with the term of payment after 30 days.

1. INTRODUCTION

Rice is a major economic crop and main food for the Thai people. In 1996, Thailand produced 22.016 million tons of rice with a total farm value of 104,384.020 million bahts (estimated 4,175.368 million US$) [1]. Rice is among the top ten export commodities [2]. In 1996, six (6) million tons of rice and rice products were exported with a total value of 50,403 million bahts (estimated 2,016.12 million US$) [3].

Milled rice or white rice is susceptible to attack by many common stored grain insects. These are the rice weevil, maize weevil, the rice moth, red flour beetle, confused flour beetle and saw-toothed grain beetle [4]. In a tropical climate, these insects multiply rapidly and can cause severe damage during storage within a short period of time. Fumigants such as methyl bromide and phosphine are commonly used to control infestation. To be effective, the rice packaging must be opened or punctured to allow the penetration of the chemical into the rice package. Therefore, after fumigation and during the storage, the opening of the rice package will allow the reinfestation by insects. Apart from this fumigants are highly toxic to the user and to the environment, and difficult to handle, causing toxic chemical residue in the commodity. Methyl bromide is also known as an ozone depleter [5] and harmful to the environment. Ionizing radiation, namely, gamma rays from cobalt-60 or cesium-137 (≤5 MeV), X-rays (≤5 MeV) from X-rays generated machine and electron beams (≤10 MeV) from an electron accelerator, is recommended as an alternative mean for insect disinfestation [10]. A minimum radiation absorbed dose of 0.5 kGy can control the insect infestation [6–10]. A minimum dose of 0.16 kGy was recommended for controlling rice weevil in industrial application [4]. The appropriate and acceptable dose treatment for the cereal ranged from 0.5 to 1.0 kGy [11–13].

Since 1994, at least 37 countries have approved irradiated food and about 225 kinds of food and agricultural products have been approved. Presently, there are 13 countries that have approved irradiated rice [5].

Previous work on the "Control of Rice and Mungbean Irradiation Processing and Marketing Trial", established that irradiated rice was accepted by the consumer. A regular packaging size of 5 kg was recommended. [12]. This work was a continuation of the latter project and aimed to scale-up the volume tested under project "Market Testing and Consumer Acceptance of Irradiated Rice". All important factors involved in marketing rice, i.e. packaging material, the label, consumer groups, consumer information and consumer attitude toward irradiated rice were also determined.

This research work was part of the IAEA/OAEP Research Agreement No.8173/CF which forms part of the IAEA co-ordinated program of research under the IAEA Project No. RAS/0/022 entitled "Public Acceptance and Trade of Irradiated Food".

2. MATERIALS AND METHODS

2.1. Rice used

Export quality, special grade A white rice (Jasmine rice) of 13% moisture content was obtained from a local miller in Bangkok in 100 kg or 50 kg bags. The rice used was newly milled, unfumigated, and free from contaminants and live infestation based on visual inspection. A total volume of 4,000 kg was obtained from the factory.

2.2. Packaging material

The plastic bag used for a 5 kg package of rice was a low density polyethylene bag, 25.5 cm in width × 45 cm in length and 200 micron in thickness. Two different types of ink markings (printings) on the polyethylene bags were obtained from the plastic bag factory. One type was a regular surface coating ink and the other was laminated surface coating ink. The bags were pre-tested for radiation compatibility of the ink markings at a minimum dose of 1.0 kGy to observe if the color and the tensile strength were affected by radiation.

2.3. Design of packaging material label

The Office of the Food and Drugs Administration (OFDA) approved irradiated rice and the use of the irradiated rice label for market testing purposes. The design of the product label, in compliance with regulations, included the international logo of irradiated food, the name of the product, the purpose of irradiation, irradiation date, license number, date of irradiation, the name and the address of the rice producer and the name and the address of the contract irradiator. Apart from the details required, the color of the marking and the size of the label were not restricted. In this test, the size of the label was 23 cm. in width × 30 cm in length and the printing was in green, except for the yellow dot in the middle of the international irradiated food logo. The design of the label was part of the consumer education and marketing aspect It was attractive and informative, giving the consumer a choice. The specific name of the rice, "Jasmine Rice" was largest in print and was located on the top of the package above other information details.

2.4. Preparation of the consumer pack of rice

The rice from item 2.1 was repacked in the designed polyethylene bag of 5 kg net weight. The preparation of a total of 800 bag of 5 kg each (4,000 kg) was handled by the TIC.

2.5. Rice irradiation

An aluminum tote box, size: 59 cm × 122 cm × 128 cm was used to contain the 5 kg packages of rice for irradiation following the loading pattern and the process control previously studied [13]. Two batches of rice, 400 bags each, were treated at a minimum absorbed dose of 0.5 kGy to control insect infestation [6–11], using a commercial scale, carrier-type gamma irradiator located at TIC. The total of 800 bags with a net weight of 5 kg, were irradiated.

2.6. Consumer target groups

Each batch of irradiated rice was distributed on a weekly basis to local food shops in Donmuang District, Bangkok and Klong Luang Distric, Pathum Thani Province, housewives, and various government institutions and hospital. A supermarket, namely Foodland Supermarket Company was also approached. Most of the target groups were acquainted with irradiated fermented pork sausage, therefore, it was not difficult to introduce a new irradiated product to them.

2.7. Consumer education

Detailed information was provided on the label of the package of rice and represented the major information source for consumers. Additional information was given in the form of leaflets (Fig.1) distributed to the consumers who purchased the rice.

2.8. Price of rice

The irradiated rice was sold at 60 bahts per bag of 5 kg (estimated US $2.4 each), while various varieties of non-irradiated rice were available in the market at a price ranging from 52 to 78 bahts. The availability of various kinds of rice in the market provided wide choices for the consumers.

2.9. Collection of information on consumer attitude

Along with the distribution of irradiated rice, a simple questionnaire was randomly given to 100 consumers. The results are shown in Table I. Other information was also obtained from consumer remarks, such as competitive price, confidence in the distributor and confidence in the OFDA license.

TABLE I. CONSUMER RESPONSE TO QUESTIONNAIRE ON IRRADIATED RICE

Question	Answer	Percentage of answer
Why do you buy irradiated rice?	• To try it out	28
	• Good quality based on appearance	72
Rice has to be fumigated for disinfestation before marketing. Between the use of toxic chemicals and radiation (no residue) which one will you choose?	• Toxic chemical	0
	• Radiation	100
Will you buy irradiated rice again?	• Yes	0
	• No	0
	• Not sure	100

3. RESULTS AND DISCUSSION

The 5 kg package of irradiated rice was acceptable to the consumers. The attractive and informative label caught the attention of the consumers. It took about 12 weeks to sell a batch of 400 bags of 5 kg each. The leaflet of educational information on irradiated rice was also of interest to the consumers. It was found that 72% of the consumers bought irradiated rice because of the high quality of the product based on visual inspection, and 28% of them were willing to try out the new product. Most consumers preferred irradiation treatment to toxic fumigants since radiation treatment does not result in a toxic residue [14]. However, they were not sure if they would buy irradiated rice again unless cooking quality of irradiated rice was acceptable. This study revealed that high quality of the rice was the most important factor for consumer acceptance. Other important factors involved were the size of the package, the quality of the bag, the attractive marking of the label and the educational information provided.

Market testing of irradiated rice in the supermarket was not undertaken due to the service requirements set up by the private sector. The TIC had to supply irradiated rice to a supermarket, namely, Foodland Supermarket, on a monthly basis with one month for the term of payment. The TIC is a non-profit government owned organization which is not authorized to handle research work as a full-scale commercial undertaking. In addition, considerable time, budget, and manpower were required to supply the rice on a monthly basis. The large volume of production of rice for irradiation also required a large space for production and storage, including manpower and transportation.

4. CONCLUSION

High quality fragrant rice was prepared in good quality packaging material with an attractive marking of the irradiated food label. The rice was contained in a 5 kg package and irradiated at a minimum dose of 0.5 kGy for insect disinfestation. Four tons (800 bags) of irradiated fragrant rice were distributed to various consumer target groups. The consumers accepted irradiated rice because of the high quality of the product, its attractive packaging and informative irradiated food label. There was no consumer resistance to irradiated rice. However, most consumers were not sure if they would buy irradiated rice again unless its cooking quality was acceptable. The achievements of this research work were as follows:

- Identification of a suitable packaging material for rice, including a suitable irradiated food label.
- Identification of rice quality acceptable to the consumer and of the acceptability of the 5 kg size consumer package, as recommended.
- Identification of procedure for the commercial radiation processing of rice.
- Identification of consumer target groups who were acquainted with irradiated food in the local market, namely, irradiated fermented pork sausage (Nham).
- Dissemination of educational information for irradiated rice and other irradiated food products by various means.
- Collection of consumer attitudes on irradiated rice.
- Identification of no consumer resistance to irradiated rice.
- Large-scale market testing of irradiated rice was not found feasible due to the limitations of service conditions required by the private sector.

Thai Irradiation Center Office of Atomic Energy for Peace Ministry of Science, Technology and Environment • Irradiated rice for insect disinfestation • Clean and Hygienic • No fumigant used • Long storage life in good packing condition • No re-infestation problem

Fig 1. A leaflet of consumer information on irradiated rice.

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MARKET TESTING OF IRRADIATED FOOD

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Abstract. Viet Nam has emerged as one of the three top producers and exporters of rice in the world. Tropical climate and poor infrastructure of preservation and storage lead to huge losses of food grains, onions, dried fish and fishery products. Based on demonstration irradiation facility pilot scale studies and marketing of irradiated rice, onions, mushrooms and litchi were successfully undertaken in Viet Nam during 1992–1998. Irradiation technology is being used commercially in Viet Nam since 1991 for insect control of imported tobacco and mould control of national traditional medicinal herbs by both government and private sectors. About 30 tons of tobacco and 25 tons of herbs are irradiated annually. Hanoi Irradiation Centre have been continuing open house practices for visitors from school, universities and various different organizations and thus contributed in improved public education. Consumers were found to prefer irradiated rice, onions, litchi and mushrooms over those non-irradiated.

1. INTRODUCTION

Less than a decade ago, Viet Nam was one of the poorest countries in Asia, facing the prospect of famine. Following the renovation of policy, not only has the basic domestic food demand been met but Viet Nam has leapfrogged from being a net importer of rice to one of the worlds top three rice exporters. With more than 80% of the population earning a living off the land, Viet Nam has emerged as an agricultural power capable of feeding the region. The nation last year recorded a rice output of more than 25 million tons.

Tropical climate and poor infrastructure of storage lead to huge post-harvest losses of food, especially for onions, grains, dry fish and fishery products. The annual loss of paddy rice in the Mekong Delta, the biggest rice producing area in Viet Nam, is about 2 millions tons (valued at 2,000 billions VND).

Food irradiation technology has been introduced in Viet Nam since the late 80's to reduce food losses. The demonstration gamma facility provided by the IAEA was put into operation in July 1991. The first loading of a Co-60 source was 107 kCi. Current activity is more than 40 kCi.

Changes in circumstances from a planning, government-controlled economy to a market economy affected the development of food irradiation in the country. When construction of part of the gamma facility started in 1987, several state companies expressed their willingness to use the irradiator for sprout inhibition (potatoes, onions) and insect disinfestation (rice, green grams, dried fish, dried tobacco leaves, etc.). However, upon the completion of the irradiation facility and when it became operational, some of these companies had been dissolved while others existed with fragile activities. Moreover, control of the food supply in the country by government companies was drastically reduced from 85% to the current 10%.

The important problem for food irradiation at the present time is to involve both the government and the private sector in realizing the benefits of the process. Market testing and public education on food irradiation could encourage businessmen to use the technology for commercial purposes.

2. MARKET TESTING OF IRRADIATED FOOD

2.1. Market testing of onions

The first appearance of irradiated food in the market was in August 1992. At that time we retailed the irradiated onions ourselves on a special holiday, the 15th July by the lunar calendar. Housewives prepared special dishes on this day for the market testing of treated onions that were 5 months in storage. People from Viet Nam television were invited to conduct interviews to gauge buyer response. A large sign showing the international logo on food irradiation was installed with an explanation in Viet Namese indicating that irradiation of onions inhibited sprouting. Copies of the clearance for seven irradiated food items given by the Minister of Health were also provided. The price of irradiated onions was set with a little discount of 3,500 VND/kg against a market price of 3,600VND/kg. Within two hours more than 300 kg of irradiated onions were sold out. The total sold in two days was 500 kg. The interview shown later on TV produced a positive opinion about food irradiation. After that event, two videotapes on food irradiation (IAEA and BBC tapes) were provided to Viet Nam television which were shown several times on the central channel.

The second introduction of irradiated onions to the market lasted from July to September, 1993. Eight tons of irradiated product was distributed through the Fruit & Vegetable Corporation of Viet Nam (a state company) and private traders. We priced our products as market. Questionnaires with a stick on stamp and our address on the reverse side were provided to consumers. About 20% of them returned to our office with no adverse comments from buyers.

2.2. Market testing of rice

A close collaboration was established with the Hanoi Union of rice companies (HURC) on insect disinfestation of rice. Based on experiments, an irradiation dose of 0.5 kGy and a packaging material of jute/woven bag lined with polyethylene were chosen. The first trial consisting of 5 tons of irradiated rice was conducted in 1993. After 6 months of storage, irradiated and non-irradiated rice were distributed through the network of HURC. The price of irradiated rice was the same as market price. Consumers preferred irradiated rice due to the absence of insects, non-irradiated rice had to be sold as animal feed. In 1994, 20 tons of irradiated rice were retailed with the questionnaires. The same trial of 25 tons of irradiated rice was conducted in 1997. No negative comment was received from consumers.

2.3. Market testing of mushrooms

Mushroom is a clean and delicious vegetable with a very short shelf-life. Within a day at 10°C, the cap opens, the stem elongates, and the gills darken. Research showed that mushroom irradiated at a dose of 1.5 to 2.0 kGy soon after harvest had a shelf-life at 5° C of 11 days, and at 10°C, of 7 days. Most investigations show that sensory quality of mushroom is unaffected by irradiation.

In 1998, 500 kg of mushrooms were treated by radiation for market testing. More than 400 kg were sold with a questionnaire. Almost all customers accepted irradiated mushrooms, although they were 2-3 times higher in price than the non-irradiated mushrooms.

2.4. Market testing of litchi

Litchi is a special agriculture product of Bacgiang province. The harvest season of litchi takes place only annually in June. Preservation of the fruit is therefore an important problem in horticulture. Extended self-life of litchi will help horticulturists sell their products to different places of the country at a higher price.

The research showed that, irradiated litchi had a smaller percentage of damage caused by stem borer than the non-irradiated or chemically treated litchi. This difference increases when litchi is collected in the middle of the season. Irradiation at doses of 0.2 to 0.4 kGy extended the shelf-life of litchi to 3 weeks at 12°C. Furthermore, the sugar content of the fruit increased after irradiation. In 1998, 530 kg of litchi were treated by radiation for market-testing. The economic evaluation showed that 1 ton of irradiated litchi can produce a profit of about 1 million VND in the off-season.

3. COMMERCIALIZATION

Irradiation technology has been used in commercial scale since 1991 for insect control of imported tobacco and for insect and mould control of national traditional medicinal herbs, by both the government and private sectors. About 30 tons of tobacco and 25 tons of herbs are irradiated annually.

4. PUBLIC EDUCATION

To increase public awareness of irradiation technology and food irradiation, the Hanoi Irradiation Centre continued to open for visitors from schools, universities and other organizations. Occasionally, transportation is provided by the Centre to students. Through this program, information on food irradiation are disseminated to the public.

5. CONCLUSIONS

Consumers prefer irradiated onions, rice, litchi and mushrooms over those not irradiated. No adverse statements regarding quality of irradiated food were received from consumers. The fear of irradiation existed but proper explanation and information dissemination should resolve this problem.

The price of irradiated products must be the same as market price. The irradiation/transportation costs for treated products could not be added because the Viet Namese buyers always look at price first. Expenses could be covered during the off-season when prices for onions, mushrooms and litchi could be raised 2-5 times higher, or through the use of a stabilizing factor, as in the case of irradiated rice.

Telecast of BBC and IAEA Videos on food irradiation in the Central Television Program was very useful in promoting public education.

Active participation of trade partners either state or private, plays a crucial role for the commercial development of food irradiation in Viet Nam.

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