The development of food irradiation to-date in Asia Pacific, the Americas, Europe and Africa

Catherine M. Deeley[1], Meixu Gao[2], Richard Hunter[3], Dieter A.E. Ehlermann[4]
[1]International Marketing Manager for REVISS® Services (UK) Ltd. 6 Chiltern Court, Asheridge Road, CHESHAM, Buckinghamshire, HP5 2PX UK
cathie.deeley@reviss.co.uk
[2]Associate Professor, Institute of Agro-food Science and Technology, Chinese Academy of Agricultural Sciences, P.O. Box 5109, Beijing, 100094 China
[3] President and CEO, Food Technology Service, Inc., 502 Prairie Mine Road, Mulberry, FL 33860 USA
[4] Consultant, LINAC Technologies, Orsay, France

This report summarises the content of a tutorial on the development of food irradiation to-date with respect to legislation, volumes treated, plant development and market opportunities, presented at the 14th International Meeting on Radiation Processing in Kuala Lumpur in February 2006.

1. Background

a. Legislative history

Food irradiation is not a new technology; first patents were applied for more than 100 years ago. Under the jurisdiction of the Food and Agriculture Organization (FAO) of the United Nations, the World Health Organisation (WHO) and the International Atomic Energy Agency (IAEA), there has been almost continuous research and review of the safety and nutritional adequacy of irradiated food for more than 40 years. The first Codex[1] Alimentarius General Standard and Code of Practice for the control of commercial food irradiation were published in 1979. Since this date Codex has been widely adopted as the standard for the control of commercial food irradiation facilities. The General Standard was revised in 1983 and 2003 and the Code of Practice in 2003. Most recently a FAO/WHO/IAEA[2] study group on high dose food irradiation reported, "…food irradiated to ANY dose to achieve the technological objective is both safe to consume and nutritionally adequate..". This report was adopted in 2003 in the revised Codex Code of Practice, which permits irradiation to any dose if the application is technologically justified. However, the Codex terminology of, " an overall average dose of 10 kGy" was replaced by, "a maximum dose of 10 kGy". This was introduced in response to market forces which misguidedly call for control over the maximum dose instead of the minimum dose, which is currently only specified for quarantine applications (US-FDA[3]: 400 Gy for unspecified pests, 150 Gy for fruit flies).

b. Why now?

The need for food irradiation is three fold: Sanitary applications for the protection of consumers from food borne illness; phytosanitary applications, to replace fumigation and pesticides in the removal of agricultural pests; commercial applications to slow the ripening process for extension of shelf life and the reduction of food spoilage. On the one hand these applications are being driven by declining home-skills, which increase the

[1] The Codex Alimentarius Commission is a joint body of the Food and Agriculture Organization (FAO) of the United Nations and the World Health Organisation (WHO) representing 130 countries worldwide
[2] High-dose Irradiation: Wholesomeness of Food Irradiated with Doses above 10 kGy, WHO, Geneva, 1999
[3] US-FDA: United States Food and Drug Administration

level of third party intervention in the provision of prepared foods and ready-to-eat meals. The consequent increased risk of large-scale pathogen adulteration and wide ranging out-breaks of food borne illness can be offset by irradiation as part of a routine HACCP[4] programme. This is evident in the USA by the steady growth in irradiation of ground beef to help combat E-coli O157:H7 adulteration. On the other hand "healthy eating" and international trade combine to drive phytosanitary applications. We eat more fresh fruit and vegetables from a wider market than ever before. Developing countries often have less advanced food hygiene and basic sanitation. Use of polluted irrigation water and untreated organic fertilizers is common, risking pathogen adulteration of the crop. According to FAO, spoilage after harvesting accounts for at least 25% of world food production. In developing countries, where climatic conditions hasten deterioration of stored product, losses of vegetables and fruits can be up to 50%. Current treatments to reduce spoilage include the use of fumigants, chemical washes and pesticides. These are surface treatments that leave chemical residues on the skins, albeit at trace levels. Some of these, including ethylene dibromide, ethylene dichloride and ethylene oxide, are potentially harmful and have been banned for food treatment by Japan, UK and many countries in Europe. Although highly controversial, the fact is that irradiation would be a most helpful treatment for the extension of shelf life of organic produce!

Methyl Bromide (MeBr) is the most widely used fumigant for removal of quarantine pests such as fruit fly, to avoid their introduction into non-infested regions. It is often applied to bulk crops in transit and allowed to vent to the atmosphere unchecked. MeBr is a Class I carcinogen and is highly ozone depleting. It has been banned from agricultural use in developed countries since 2005[5]; a ban is pending by 2015 in developing countries. Quarantine applications are exempt until a good alternative is found, but reduced production levels of MeBr have caused costs to more than double since 1999. The US Department of Agriculture has spent $146M on researching alternatives and supports the use of irradiation as the most effective alternative.

Finally, irradiation could provide food producers with a premium brand identity, synonymous with wholesomeness and safety. Consumers in high-risk groups such as the elderly, mothers with young families and people with immune-compromised diseases could benefit from availability of irradiated staple foods such as chicken and ground meats. Expectant mothers could choose to eat irradiated soft cheese during pregnancy without risking foetal deformity or stillbirth, caused by listeria in unpasteurised cheese. Uncooked foods such as steak tartar and shellfish could be consumed by any of us without fear of sickness.

c. Restrictive legislation

40 years of research[6] have concluded that food irradiation, "…does not introduce changes in the composition of food which can produce, from a toxicological point of view, an adverse effect on human health", and "…will not introduce changes in the micro flora of food which might increase the microbiological risk of consumers..", and "…will not introduce nutrient losses which will impose an adverse effect on the nutritional status of individuals and populations..". Despite this, legislation demands irradiated foods to be labelled for the "protection" of the consumer. Yet there is no equivalent legal requirement to label foods treated with chemicals and pesticides and as such, consumers are deprived

---

[4] Hazard Analysis Critical Control Point

[5] Montreal Protocol

[6] 1992- New Expert Committee WHO - updated report on the Safety and Nutritional Adequacy of Irradiated Food

from making an informed choice. Such inequality in the legislation is surely prejudicial against a technology that is not only proven safe, but also offers consumers valuable benefits in the safety, quality and purity of food. For example, spices irradiated to remove harmful pathogens, retain more aromatic efficacy and have better colour than those treated with steam or ethylene oxide. Nevertheless, fumigated spices are still to be found in our stores, despite these fumigants having been banned for food treatment by many importing countries! The fear of consumer reprisal has led retail outlets to discriminate against irradiated spices in favour of inferior, illegal, chemically treated spices, which need not be labelled and will therefore not alarm the unwitting consumer.

d. Growing use of irradiation

Since 1999 the market for irradiated fresh and frozen meat in the USA has grown significantly; irradiated brands of ground beef and hamburgers are available in thousands of major retail outlets and restaurants across the country. Irradiation of raw oysters is set to increase since USDA approval was given in 2005.

In spite of the inequality in labelling legislation there are clear signs of growth in phytosanitary applications. New irradiation plants are being built in Asia Pacific and South American countries for the irradiation of exotic fruits for export to remove quarantine pests. Approximately 2 million pounds (1,000 metric tonnes) of labelled irradiated fruits and vegetables are sold annually in the USA, with growing interest in the irradiation of other highly perishable products such as blueberries, raspberries and cherries. The Asia Pacific countries reported a significant increase in the volume of food processed by irradiation in 2005. Compared with 2002, Vietnam reported an increase of 180%, Malaysia 70%, India 50%, China and Indonesia 40%. In contrast to this, food irradiation in Europe is in decline, blocked by political and bureaucratic constraints.

e. Outlook

It is important that a clear understanding of legislative requirements is developed between exporting and importing regions in support of market growth for irradiated food. The following three sections aim to provide insight into these requirements along with current estimates of the volumes of food irradiated, the number of plants under development and the opportunities for market development in Asia Pacific countries, the Americas, Europe and Africa.

2. Asia Pacific Region

a. Legislation

Since 2001 there has been a Regional Cooperation Agreement (RCA) on food irradiation supported by FAO and the IAEA. Under this project, 11 member countries in the Asia Pacific region have initiated collaboration on the harmonisation of national regulations governing food irradiation. Australia and New Zealand have recently unified their whole regulatory system relating to food, including radiation processing.

Most countries in the region have already adopted the Codex General Standard and the Codex Code of Practice for the control of commercial food irradiation. Approval to irradiate foods is given by class or item [1]. China approved irradiated foods by item in the 1980s, then by class in the 1990s. Now the existing 9 standards include 3 items approved in 1994 (sweet potato wine, pollen, hog carcasses); 6 classes approved in 1997 (dried nuts and preserved fruits; dried spices; fresh fruits and vegetables; frozen packaged raw meat of livestock and poultry; beans, grains and their products; cooked meat food of livestock and poultry). A standard for the irradiation of seafood is currently under development. Pakistan, the Philippines and Vietnam approved 7 food classes for irradiation in 1996, 2004 and 2005, respectively. India approved the use of irradiation in 1994 and reviewed the legislation in 1998 and 2001; as of now 21 items of food have been approved for radiation processing. Thailand has approved 17 food items, Korea has approved 13 food items and Japan has approved irradiation of potatoes to inhibit sprouting. Australia and New Zealand have approved irradiation of dry vegetables and 9 fruits. Malaysia issued a draft regulation on food irradiation for public comment in 2005; the outcome is under review. Sri Lanka finalised regulation of food irradiation in 2005. Singapore has approved the importation of food irradiated in accordance with Codex Standards.

Legislation pertaining to irradiation for phytosanitary applications is at an early stage in the Asia Pacific region. In 2006 New Zealand adopted a protocol for import of irradiated papaya from Australia. Thailand is the first country in the region to have irradiation approved by the USDA[7] for phytosanitary treatment of exotic fruits for export to the USA in early 2006. India is in the early stages of developing a framework equivalency agreement with the USDA for the export of Mangos to the USA.

There is no legislation governing the verification of irradiated food in the regions, but some countries are developing analytical methods for after-the-fact identification of irradiated food in the market place. Most countries in the region comply with the Codex requirements for labelling but the implementation of the standards on labelling need to be strengthen in some of the member countries; this might explain why there have been recent incidences of unlabelled irradiated foods exported from China, identified and consequently banned in member states of the European Union.

b. Volumes treated

The volumes and commodities irradiated in 2005 as reported in the RCA Final review meeting of coordinators of the project on the application of irradiation for improving food safety, security and trade[6]are listed in Table 2.1. Roughly one hundred and eighty thousand metric tonnes of foodstuff were irradiated in this region in 2005.

From Table 2.1, we can see that there are three main classes of irradiated food in this region: dried plant products including spices and vegetables irradiated for the purpose of decontamination; garlic, potato and onion irradiated for the purpose of sprout inhibition; frozen foods mainly seafood irradiated for the purpose of pathogen reduction.

[7] USDA: United States Department of Agriculture

Table 2.1 Volumes and food commodities irradiated in 2005

Country	Quantity (metric tonnes)	Main Commodities Processed
China	140,000	garlic, spices, dry vegetables
India	1,500	spices, dried vegetables, onion
Indonesia	7,000	frozen foods, baby food, spices
Japan	8,000	potato
Korea	3,500	dried agricultural products
Malaysia	850	spices, dried vegetables, honey
Pakistan	50	dried meat and vegetables, spices
Philippines	103	spices, dried products, frozen foods
Thailand	3,000	spices, fermented sausage, frozen seafood
Vietnam	14,200	frozen shrimps and seafood, spices

Table 2.2 shows the number of existing facilities in the region and the number of new irradiation facilities proposed for construction over the next three years, reported at the RCA meeting in 2005[6]. Most of the facilities listed use gamma radiation from cobalt-60 sources. EB is Electron Beam.

Table 2.2. Number of irradiation facility in Asia Pacific Regions

Country	Operational facilities in 2005	Proposed facilities
Australia	3	1EB
China	78	13 and 1EB
India	5	3
Indonesia	3	1
Korea	2	1
Malaysia	1 and 1EB	1
Pakistan	1	5
Philippines	1	1
Sri Lanka		1
Thailand	1	1EB
Vietnam	2	1

c. Market development

For the application of irradiation as a sanitary treatment, the facilities and basic regulations are well established in most countries. There is little or no consumer opposition to irradiated foods sold in the region and the domestic markets will continue to grow in-line with product need. The development of export markets will ultimately demand equivalency in the legislative frameworks in place; most importantly, the labelling requirements of the importing country must be observed. The growth of export markets for irradiated foods from the Asia Pacific region will ultimately be dictated by the attitude of the western consumer to food irradiation.

Irradiation as a phytosanitary treatment of fresh produce is an export opportunity driven by consumer demand for high quality exotic fruits and all season vegetables. Continuing legislative harmonisation will strengthen growth in this application in the short to medium term, as is evident from the recent approvals for the export of fruits to the USA from Thailand and India.

3. The Americas

a. Legislation

The primary regulatory agency for irradiated foods in the United States of America. is the Food and Drug Administration (FDA). Regulations are laid-out in the Code of Federal Regulations: 21 CFR 179 [2] and irradiated foods may be imported for sale and use if they comply with the FDA requirements. In addition, imported irradiated fresh fruits and vegetables must be processed in a facility having a compliance agreement and operating in a country that has signed a Framework Equivalency Work Plan. These later regulations are imposed by the U.S. Department of Agriculture and are found in 7 CFR 305 [3]. FDA requirements limit energy sources to gamma rays from cobalt-60 or cesium-137; electrons from machines not exceeding 10 MeV and X-rays from machines not exceeding 7.5 MeV. Classes of foods must be specifically approved for irradiation and this process involves submittal of a petition to the FDA. Because irradiation is classified as a food additive, review of this petition is especially rigorous and may take years. Approved food items are listed in Table 3.1

Table 3.1 Food items approved for irradiation in the USA

Item	Purpose	Dmax (kGy)	Dmin (kGy)	Date of Clearance
Pork	Decontamination	1		7-22-85
Spices	Decontamination	30		4-18-86
Vegetable Seasonings (dried)	Decontamination	30		4-18-86
Vegetables (fresh)	Disinfestation	1		4-18-86
Enzymes	Decontamination	10		4-18-86
Fruit	Disinfestation	1		4-18-86
Herbs	Decontamination	30		4-18-86
Poultry (fresh or frozen)	Decontamination	3	1.5	9-21-92
Poultry meat (mechanically separated)	Decontamination	3	1.5	9-21-92
Red meat (fresh)*	Decontamination	4.5		12-2-97
Red meat (frozen)*	Decontamination	7		12-2-97
Shell eggs	Decontamination	3		7-21-00
Sprout seeds	Decontamination	8		10-30-00
Animal Feed/Pet Food	Decontamination	50		3-31-01
Molluscan Shellfish	Decontamination	5.5		8-11-05

Packaging for irradiated, pre-packaged foods must also be approved by the FDA [4]. Irradiated foods must be labelled with the international radura symbol and the statement “treated by or with irradiation.” The placement of the label differs for retail and bulk items and no label is required if the food only contains irradiated ingredients.

The Canadian approval system is similar to the US. Onions, potatoes, wheat, flour, whole or ground spices, dehydrated seasonings are currently approved (see CFDR Section 1094 [5]). Canadian authorities are currently evaluating approval of fresh and frozen ground beef, fresh and frozen poultry, pre-packaged fresh, frozen, prepared and dried shrimp and prawns, and mangoes.

Most Central and South America countries have liberal regulations regarding irradiated food. The number of food items and doses often exceed those allowed by the USA. A few countries, such as Brazil, have adopted the Codex Alimentarius standard that any food may be irradiated with the dose to be based on the technological need.

b. Volumes treated

US food irradiation is primarily spices, ingredients and meats. 3 facilities currently irradiating meats are in Florida, Texas and Iowa. Approximately 6 other facilities located throughout the USA irradiate spices, ingredients and garlic, and there is a small amount of fruit irradiated for intra-state quarantine. There is a growing interest in the irradiation of untreated imported produce but regulations limit the geographical location of these facilities to the colder, northern states. The Minnesota Beef Council estimates that 8,200 metric tonnes of meat, 910 metric tonnes of fruit and vegetables and 79,400 metric tonnes of spices were irradiated in the USA in 2004.

Canada has at least 3 facilities irradiating food and no new facilities are currently planned. Central America has about 8 facilities irradiating spices with at least one new facility planned for fruit in Mexico. South America has approximately 10 facilities performing fruit and spice irradiation with several new facilities planned for fruits and vegetables. Both regions have significant interest in phytosanitary irradiation for export.

c. Market development

There is a small but vocal anti-food irradiation movement in the US. However, most US consumers are neutral to positive about purchasing irradiated foods and appear especially accepting of irradiated fruits and vegetables. Many US food processors are reluctant to use irradiation due to the transport distances to the relatively few food irradiation facilities in the country. The awaited FDA approval of the petition to irradiate Ready-to-Eat food items should increase the interest of US food processors. There is growing interest in the US in irradiation of raw molluscan shellfish, such as oysters, and this market is set to expand. The USDA is in the process of approving the import of irradiated mangoes, mangosteen, pineapple, rambutan, lichi and longan from Thailand and mangoes from India on the basis of signed Framework Equivalency Work Plans. South and Central America should find that irradiated fresh produce sells well in the USA. Canada appears likely to approve some new food items for irradiation in the near future.

4. Europe and Africa

a. Legislation

Directives for a European Framework Agreement (1999/2/EC) [6] and a Unified Positive list of foods approved for irradiation (1999/3/EC) were adopted in a joint action of the European Parliament and the European Council and became applicable in September 2000 [6]. The unified positive list currently contains only 'dried aromatic herbs, spices and vegetables seasonings'. Any amendment or addition to the positive list needs a unanimous decision from both these bodies[8]. As all Member States have the right of veto, Green Party representation effectively prohibits the extension of the positive list. As a result there, is in effect, a dual system of approvals in operation. The unified list adopted by all 25 member-states of the European Union and a system of national clearances maintained by a few individual Member States. Belgium, France, Italy, Netherlands, United Kingdom, have maintained clearances for specific food items and categories, which were approved nationally before the EC-directives came into force. However, this does not imply that all the clearances maintained are in current use: Italy and the UK make no commercial use of their maintained clearances.

[8] EU = European Union, consisting of the EC = European Communities; the administration is in the hands of the CEC = Commission of the European Communities; the European Council consist of the heads of the member governments, respectively the ministers of the department concerned; the European Parliament is the counterpart to the European Council

In May 2004 the 10 new member states, namely Slovenia, Slovakia, Latvia, Lithuania, Estonia, Malta, Cyprus and Czech Republic, Hungary, Poland surrendered their national clearances and now comply with the European unified positive list, despite the latter 3 having specific national clearances in active use at the time.

The EC ‘single market’ stipulates free trade within the Community. As a consequence, member states, in compliance with the unified positive list, must permit the sale of any irradiated food item from maintained approvals in another member state. This has recently (15^{th} June 2006) resulted in a specific ordinance allowing irradiated deep-frozen frog legs originating from Belgium, France or the Netherlands to be sold in Germany.

Export of irradiated food to the EC is possible by two routes: for ‘spices’ the irradiation facility in the exporting country must be approved by the EC (the procedure and the inspection is free of costs to the applicant). At present, facilities in the following countries (numbers in parenthesis) hold EC-approval: South Africa (3), Turkey (1), Switzerland (1). For other products not on the unified list but where national clearances are still in place [6] a bilateral agreement is required. For example, the UK maintains a clearance for irradiated fruit. A producer in India, say, might legitimately petition the UK competent authority (The Food Standards Agency, FSA) for approval to import irradiated fruits.

A further requirement of the EC-directives is to establish standardized analytical methods for identification of irradiated food in the market place, in order to enforce correct labelling. European legislation demands labelling of all food with irradiated ingredients, even present at seasoning concentrations or less. It is therefore vital that exporters of irradiated food ingredients comply with European labelling legislation or risk building consumer resistance to the acceptance of irradiated products in the European markets.

The non-EU countries (Bulgaria, Romania and Norway) have adopted the EC-restrictions on food irradiation and permit only irradiated spices. The new Russian Federation and Ukraine have maintained the regulations of the former Soviet Union. Croatia has re-implemented regulations of the former Yugoslavia and the Federation of Serbia and Montenegro appears to have maintained former clearances. Turkey, which is awaiting membership of the EU, maintains a wide range of national clearances for food irradiation.

On the Arabic rim of Africa: Egypt, Iran, Israel, Libya, Saudi Arabia, Syria and Tunisia maintain varying clearances for food irradiation. South Africa and other countries in the South, Ghana and Zambia hold a range of clearances.

b. Volumes treated

The Commission of the European Communities provides detailed information on food irradiation, including reports on amounts irradiated in the Member States [6]. This website reflects the status in 2002 and is the most up-to-date data available. The reports due from the EC-members for the years 2003 and 2004 are not yet available; publications need translation into 20 languages and subsequent unanimous approval by the 25 Member States.

In 2002, from official audit of irradiation facilities by the individual Member States of the European Union (still 15 at that time); the amount of food processed by ionizing radiation is reproduced below in Table 4.1.

Table 4.1 Food irradiated in the EU in 2002

	Total Volume / Metric Tonnes	Spices / Metric Tonnes
Belgium	6,613	570
Germany	795.3	635
Denmark	0	0
Spain	No Report submitted	
France	5,129	1,275
Netherlands	7,114.4	1,706
United Kingdom	0	0

The consistency of the data in table 4.1 is poor. Some countries include amounts irradiated for export or traded within the EC; others omit export quantities. In 2002, Austria, Finland, Greece, Ireland, Italy, Luxembourg, Portugal, Sweden had no EC-approved food irradiation facilities. Consequently, there were no reports submitted by these Member States. In the remaining EU-countries, a total of 23 facilities (isotope and machine sources) are approved for food irradiation.

The total amount of spices and aromatic herbs irradiated within the EU is roughly 4,186 metric tonnes; however, except for marginal quantities of labelled spices sold in the retail market in Belgium, it is unclear where the majority of this volume is used.

In total, about 20,000 metric tonnes of food was reportedly irradiated in 2002. Assuming an average consumption of 1 metric tonne of food per year per person and a population in the EU of about 450 million people, the ratio of irradiated product to the total food consumption is less than one ten-thousandth of a percent; virtually nothing!

No figures are available for the amount of irradiated food imported to EU-countries.

The grain irradiator at the Odessa port (Ukraine) is reported to irradiate some 400,000 metric tonnes per year since 1980. Up to 1991 the facility was operated exclusively for imported grain, it is currently also used for exports and the total amount irradiated is reported to be 200,00 metric tonnes annually. In Croatia for 2004 about 18,000 metric tonnes of food were irradiated, of which about 30% was spices. In Turkey the amount irradiated annually is about 2000 metric tonnes, 60 - 70% being spices, herbs and dry vegetables.

On the Arabic rim of Africa (Egypt, Iran, Israel, Libya, Saudi Arabia, Syria and Tunisia) and in Ghana and Zambia there is no data available. South Africa reports about 15,000 metric tonnes of spices and about 3,300 metric tonnes of other products irradiated annually.

c. Market development

Market growth in Europe seems unlikely in the short to medium term. The EU legislative requirement for unanimous Member State approval of any application for addition to the positive list and the labelling of food with irradiated ingredients present even at trace levels, severely limits the potential for market growth. Such constraining legislation is not only unjustified by scientific research but also contravenes the recommendations of the FAO and the WHO and might be seen by some as a breach of accepted trade agreements. For this reason, the only realistic route for increasing trade in irradiated foods with Europe is through bilateral trade agreement with the five EU-Member States with maintained national clearances (Belgium, France, Italy, Netherlands, UK). Countries with interest in exporting irradiated produce to Europe could legitimately use these States as the gateway to the wider market.

In contrast, the countries of the Arabic rim of Africa (Egypt, Iran, Israel, Libya, Saudi Arabia, Syria and Tunisia) and Ghana, Zambia and South Africa have provisions for import of irradiated food, but details about the legal requirements and procedures are not easily available. The potential market for imported irradiated food in these areas is likely to be limited. There is, however, potential for this region to export to Europe.

5. Conclusion and Outlook

Consumers in the USA are found to be neutral to positive about purchasing brands of irradiated ground beef and hamburgers. From this reality, food producers and processors should conclude that the so-called consumer resistance to irradiated food evaporates once a need has been established and a product made available. The real barriers to trade in irradiated foods in western markets are in protracted legislative procedures and the power of the retail giants who refuse to stock irradiated food for fear of falling market share from consumer reprisal. Until consumers understand the benefits of food irradiation and demand free choice, these barriers will continue to prevent significant market growth for irradiated foods.

In spite of the inequality in legislation applied to the labelling of irradiated produce compared with chemically treated produce, there are clear signs of growth in phytosanitary irradiation applications. New irradiation plants are being built in Asia Pacific and South American countries for the irradiation of tropical fruits. The USA is in the process of approving the import of irradiated mangoes, mangosteen, pineapple, rambutan, lichi and longan from Thailand and mangoes from India. From here it is a short step to envisaging increasing demand in the UK for better tasting, tree-ripened mangoes from India or Pakistan. This consumer demand could be met, in full compliance with EU legislation, under UK maintained clearances for the use of irradiation to slow the ripening process after harvesting. In the short term, development of phytosanitary applications may be the only opportunity for increasing international trade in irradiated food products.

References

[1]: Regional Cooperation Agreement: Daejeon, Republic of Korea, 21-25 February 2005. Working report, reproduced by the IAEA, Vienna, Austria, 2005

[2]: http://www.cfsan.fda.gov/~lrd/FCF179.html - USA Code of Federal Regulations Governing Food Irradiation

[3]: http://www.washingtonwatchdog.org/documents/cfr/title7/part305.html - USA Phytosanitary Legislation and Frame Work Equivalency Plan

[4]: http://www.gpoaccess.gov/cfr/index.html - Search for 21CFR179.45 - USA Packaging Legislation

[5]: http://canadagazette.gc.ca/partI/2002/20021123/html/regle1-e.html - Canadian legislation

[6]: http://ec.europa.eu/food/food/biosafety/irradiation/index_en.htm - European Community Home Page for Food Irradiation with links to Legislation, Consultation and Communication and Annual Reports