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Food Irradiation : Past, Present and Future

R. C. McKinley
International Consultative Group on Food Irradiation

HISTORY

In many, if not most, countries of the world food irradiation is regarded by the general public as a new process that brings an additional dimension of risk to consumers. The truth-as scientists have long known very well-is the exact opposite on both issues. Irradiation is not a recent development and so far from adding risk to the foods the process makes the products much safer and in that and other ways is of great potential benefit to the consumer.

The history of this process dates from the previous century.

Almost 100 years ago—in 1896, radioactivity was kdiscovered and the possibility immediately began to be investigated by scientists that ionising radiation could be used to kill micro-organisms in food-those micro-organisms that can either spoil food, causing it to be wasted or that can make food dangerous to eat, resulting in sickness and even death.

Over 70 years ago—in 1921 the first use of irradiation was patented in the United States to deal with the problem of the parasite Trichinella in meat.

Over 60 years ago—in 1930, a French patent was obtained for the use of irradiation to kill spolage organisms and thus preserve food in good condition for longer.

These, then, were the developments of 50-100 years ago but in those early days radioactive sources were relatively expensive and the capacity of the available machine sources was too low for economic food irradiation so practical applications of the process were comparatively rare. However, a film recently shown on British television of emergency food supplies provided to deal with a threatened famine in Holland during the Second World War shows that some of this food-probably milk powder and dehydrated vegetables-had been preserved by irradiation. This was a little over a half a century ago.

SAFETY EVALUATION

Detailed in—depth research into the potential uses of food irradiation and the safety and wholesomeness of irradiated foods began to be taken forward in a systematic way both in the UK and the United States from about 1948. In the next few years national research programmes were started in 7 other countries and within 10 years something like 90 universities and other research organisations were actively involved in this work.

There was, however, a clear need to organise and to coordinate on an international basis all the detailed research work that was being undertaken and to have an authoritative expert evaluation of the results of the quite voluminous data that were emerging. Accordingly, the three United Nations Agencies with responsibilities respectively for safe uses of atomic energy on the one hand, and for measures to secure a safe and nutritious food supply on the other-. that is to say the International Atomic Energy Agen-

cy, the Food and Agriculture Organisation and the World Health organisation cooperated to organise from 1970 onwards the International Food Irradiation Project which sponsored and directed a co-ordinated research programme world-wide. 19 countries were involved in the project at the outset-but this subsequently grew to 24. Many hundreds of individual experiments were included within this co-ordinated programme and the data produced covered thousands of pages. The work was evaluated at a number of meetings of international experts organised into what were called Joint Expert Committees on the Wholesomeness of Food Irradiation. Ultimately, in 1980 a review by one of these Joint Expert Committees[1] reached the conclusion on the basis of the considerable volume of research undertaken, that the irradiation of food up to an overall dose of 10 kGy presented.

No toxicological hazard ;
No special nutritional problem ; and,
No special microbiological problem.

These findings amount to international expert acceptance of the safety of the process (correctly applied) and are expert endorsement of the safety and wholesomeness of foods treated by irradiation up to the overall average dose stated.

Other scientific committees have also examined the data and reached the same conclusion. In the course of the 1980s the safety and wholesomeness of irradiated food was also confirmed by the Board of the International Committee of Food Microbiology and Hygiene of the International Union of Microbiological Societies[2] and by scientific Committees in the United Kingdom,[3] the United States[4] Ireland,[5], and by the Scientific Committee for Food of the 12 nation European Economic Community.[6] A scientific committee in Australia[7] reached the same conclusion-though it should be added that a contradictory conclusion was later reached by a committee of seven politicians from the Australian House of Representatives.[8] This safety acceptance of the process by the world-wide scientific community led to consideration of the process within the Codex Alimentarius Commission and to the adoption by that organisation in 1983 of a Recommended International General Standard for Irradiated Foods and a Recommended International Code of Practice for the Operation of Radiation Facilities for the Treatment of Foods[9]. Consumers and those who claim to speak on their behalf should therefore be aware when they speak of food irradiation as a new technology-with the implication that it still requires careful assessment ;

- that they are speaking of a process that has been carefully evaluated over more than 40 years ;
- that the process was accepted by expert international scientific committees as causing no toxicological, nutritional, or microbiological problems as long as 13 years ago ; and,
- that food irradiation had international standards agreed for its proper use 10 years ago.

It is very far from new and it has received the most comprehensive assessment over a very long period indeed.

USES OF FOOD IRRADIATION

What are the purposes for which food irradiation can be useful? The process has a special value from three distinct points of view.

- it can suppress spoilage organisms and can therefore make food last longer with less wastage ;
- it can destroy pathogenic bacteria and thus make food safer, reducing the level of food-borne illness

; and,

- it can control insect infestation and thus provide an effective quarantine treatment, assisting in the movement of foodstuffs in international trade.

Any process that reduces losses of valuable food supplies needs very careful consideration. It is of great importance that the supplies available to meet the increasing needs of the expanding world population should be extended by all possible means. At the beginning of this century the world population was 1½ billion people. The current global population is over 5 billion and it is expected to reach more than 6 billion by the end of the century. Further increases are predicted for the early years of the 21st century.[10] About 90% of the population increases will take place in the developing countries of the world-and it is in these countries that food losses after harvest are the greatest. It is estimated that in the developing world where a warm climate means that spoilage organisms can grow more easily and more quickly thus speeding up the deterioration of stored food, at least 10% of the current harvest of cereals, grains and legumes is lost. Much higher losses are recorded in vegetables and fruits-estimates are that losses exceed 50%. With commodities such as dried fish, insects are reported to be the cause of losses of something like 25% of the product. All in all, the World Health Organisation believes that between ¼ and ⅓ rd of the world food supply is lost after harvest[11]. With a continually increasing world population to feed and losses of food on this scale it is obviously important to consider the part that irradiation could play in ensuring that more of the food that is harvested actually reaches the people who need it.

The second important potential benefit of food irradiation results from the effectiveness of the process in killing pathogenic micro-organisms kin food. According to the World Health Organisation, 90% of food-borne illness in the world results from two micro-organisms-Salmonella and Campylobacter[12]. Additionally, there has in recent years been concern in North America and in Western Europe about Listeria. It has been estimated that the incidence of diarrhoea in the world is about 1,400 million cases a year-with 3.5 million deaths occurring[13]. Some of this is, of course, due to contaminated water-but the World Health Organisation has suggested that the microbiological contamination of food may be responsible for up to 70% of these frightening statistics. Studies in the West show that poultrymeat products are a particularly serious cause of illness resulting from pathogenic micro-organisms. Obviously considerable efforts are being made to improve the hygienic quality of raw poultry products. But in view of the large number of ways in which these micro-organisms can infect the birds at the production stage and the considerable difficulty in avoiding cross contamination following slaughter and during further processing an independent Microbilogical Committee in the UK has reached the conclusion that whilst contamination at the production and processing stages can be reduced, there is no practicable possibility in present circumstances of it being eliminated.[14] The World Health Organisation shares this view.[15] The problem, therefore is a serious one-but the effectiveness of irradiation in attacking the micro-organisms responsible for it suggests that the process has a significant part to play in reducing the current serious incidence of illness resulting from contaminated food. Research shows that doses of between 1 and 7 kGy will result in a more than 90% reduction in the numbers of microorganisms present in poultrymeat. Treatment would therefore reduce the numbers to below the minimum infective dose. That is to say that the bacteria surviving irradiation would be at safe levels, too low to cause illness. Research

has also shown the effectiveness of irradiation in reducing pathogens in red meat, in fish and shellfish and in dried herbs and spices[16]-all products which require treatment of some sort because of the difficulty of ensuring that pathogens are kept out at the production and processing stages.

The potential value of irradiation as a quarantine treatment for fruit and vegetables is based on the effectiveness of the process for inactivating insects such as the fruit fly. The treatment could replace the use of chemicals and fumigants some of which have been phased out and some of which are under threat for environmental reasons. For example, it seems likely that it will be necessary to replace the use of methyl bromide as a result of the Montreal Protocol. This fumigant, which is widely used for controlling insect infestations is one of the ozone-depleting substances of which many countries have agreed to limit the production and consumption under the Protocol. The position of the United States-a major importer of food and agricultural products-is of considerable significance. In the US, the Clean Air Act requires that the use of chemical substances with an ozone depletion potential greater than 0.2 must be phased out by the year 2000 at the latest. The ozone depletion potential of methyl bromide is reported to be 0.7, so there would appear to be no alternative but to replace its use in exports to the US market.

FAO AND WHO

Reference has been made to the World Health Organisation, and it is appropriate to consider the position both of the Organisation and also of the United Nations' Food and Agriculture Organisation in relation to food irradiation. The organisations, after all, share a concern over the availability of a world food supply that is safe and nutritious and sufficient for the needs of the world population. The two organisations have clearly been supportive of efforts to investigate the safety of the process and to evaluate the contribution that it can make. They were involved in setting up the International Project that co-ordinated the research from 1970 onwards. Under their organisation, the Joint Expert Committees operated that evaluated the research data and assessed the toxicological, nutritional and microbilolgical safety of irradiated foods. Moreover, the international standards that have been developed for treating foodstuffs and for the operation of the premises in which the process is applied were agreed within the Codex Alimentarius Commission, which is, of course, a body sponsored by both the WHO and the FAO.

The Standard for the food sets the maximum overall average dose that may be absorbed by the food at 10 kGy and stipulates that the process shall only be carried out in facilities licensed and registered for the purpose by the competent national authority. These facilities must be designed to meet the requirements of safety, efficacy and good hygienic practice of food processing and be staffed by adequate trained and competent personnel. Control of the process within the facility must include the keeping of detailed records including quantitative dosimetry. It is a requirement that both the premises and the records shall be open to inspection by the national authorities. The food to be treated must be handled at all times in accordance with the provisions of recognised international Codes of Hygiene-and the irradiation process must only be applied when it fulfils a technological need or serves a food hygiene purpose. The standard specifically states that radiation is not to be used as a substitute for good manufacturing practices. The actual dose to be applied to each foodstuff must be commensurate with the purpose to be achieved and is required to be in accordance with good radiation processing practice. Finally, packaging materials are to be of suitable quality, acceptable

hygienic condition and appropriate for their purpose.

The recommended Code of Practice for the Operation of Irradiation Facilities sets out conditions about the radionuclide source and the way in which it shall be applied to the various foods for treatment. It is stipulated that prior to the use of the treatment certain dosimetry measurements should be made to demonstrate that the process will satisfy the regulatory requirements. The facility design must attempt to optimalize the dose uniformity ratio to ensure appropriate dose rates and, where necessary, to permit temperature control during irradiation. Examples are given in an Annex of technological conditions necessary for the irradiation of some individual food items and of the levels of dose appropriate to achieve the particular purpose of irradiating those items. For example, three acceptable technological purposes of irradiating mangoes are set out (to control insect infestation, to delay ripening and thus improve keeping quality, and to reduce the microbial load by combining irradiation and heat treatment). For all these purposes an average dose of 1 kGy is recommended. The first tow of these purposes (insect disinfestation and the delaying of ripening) apply also in the case of papaya and here again an average dose of up to 1 kGy is set down. For potatoes, the inhibition of sprouting during storage is given as the only example of an acceptable purpose for irradiation-and in this case the much smaller dose of 0.15 kGy is specified. On the other hand, reduction of pathogenic micro-organisms in dried spices and condiments and similar products may well need a dose as high as 10 kGy. The examples in the recommended Code of Practice cover also the treatment of poultry, fish and fish products, cocoa beans, dates, onions, pulses, rice, strawberries and wheat and ground wheat products.

The WHO and FAO have joined with the International Atomic Energy Agency in setting up the International Consultative group on Food Irradiation-an expert group, currently comprising 39 nations that was established in 1983 and made responsible for monitoring developments and giving advice and information on the use of the process. This group has done much valuable work in advising on precisely how irradiation should be applied to the various foods for which it is suitable and in recommending how countries should draw up detailed regulations, on the basis of the Codex Standar and Code of Practice, for the control of its use. The group also organises training courses every year to ensure both that workers operating in irradiation premises and also inspectors responsible for checking that regulations are fully met have the necessary expertise to carry out their duties effectively.

But apart from the standards that the organisations have developed through Codex and the work they have sponsored through the activities of the International Consultative Group, they have themselves taken direct action to encourage their members to consider taking up and introducing food irradiation. In 1988 they cosponsored with other United Nations agencies a major International Conference attended by representatives of 57 countries at which agreement was reached on an International Document setting out a number of important conclusions and recommendations. The Conference recognised "that food irradiation has the potential to reduce the incidence of food-borne diseases through the reduction of pathogenic contamination in foods, especially in solid foods, and can reduce postharvest food losses and make available a larger quantity and a wider variety of foodstuffs for consumers." The Conference recognised also that the process can be an effective quarantine treatment for certain foods (ie. through insect disinfestation) and thus contribute to international trade. The Conference accordingly recommended that consideration should be given to the application

of the technology where these benefits could be achieved[17]. Subsequently, in an unprecedented approach, the four Directors General of the organisations that had sponsored the Conference wrote together to the Governments of all their Member Countries to emphasise the agreements reached at the Conference and to draw their attention to the conclusions and recommendations on taking up food irradiation.

Statements from the FAO and the WHO have made clear the importance that they attach to the use of the process on a wider scale. The Director General of the FAO has issued a statement drawing attention to the steady increase in the demand for food that is to be expected in the years ahead and to the difficulty of increasing food production sufficiently to meet this. His statement went on... "A method which promises to reduce our current enormous food losses, a method which can efficiently replace certain harmful chemical treatments of food, a method which the highest responsible world authorities have declared to be safe and without health risks, should be added with proper international control to our means of adequately feeding the growing world population[18]."

The World Health Organisation has gone further in supporting the process. In a 1992 Statement issued following the completion of a further Review taking in new scientific data as well as all the data previously evaluated a WHO Press Release was issued stating that whilst food irradiation should not be seen as a panacea for all the various food safety problems faced by humanity, "Scientific research shows that this is a perfectly sound food preservation technology badly needed in a world where food-borne diseases are on the increase and where between one quarter and one third of the global food supply is lost post-harvest.[19]." Subsequently, in the Journal of Public Health Policy in the summer of 1993 the Organisation included the statement "Food irradiation may be one of the most significant contributions to public health to be made by food science and technology since the introduction of pasteurisation. Because the promotion of a safe, nutritious and adequate food supply is an essential component of its primary health care strategy, WHO is concerned that unwarranted rejection of this process may endanger public health and deprive consumers of the choice of food processed for safety.[20]" The WHO therefore regards the rejection of food irradiation as:

- contrary to the interest of public health, and
- inconsistent with the right of consumers to protect themselves and their families by choosing foods processed to ensure they are safe.

Finally, it should be emphasised that World Health Organisation has incorporated a recommendation on irradiation into its "Golden Rules for Safe Food Preparation." The first of these ten Golden Rules advises the consumer to purchase foods processed for safety and gives as an example the recommendation to select fresh of frozen poultry treated with irradiation.

COMMERCIALISATION

I think it is clear that both organisations would argue that the comercialisation of the process still falls a good way short of what they would consider desirable-even though 37 different countries have approved the use of irradiation and in aggregate these approvals cover more than 40 food items or groups of foods. But in seven of the countries food is at the present time being irradiated only for experimental, not yet for commercial purposes and in many of the countries where commercial irradiation is in practice the only items being treated are dried herbs, spices, condiments and similar products. Transfer of food irradiation technology to the food

industry through pilot scale research activities is, however, being carried out with some success in a number of countries all over the world. In the case of the Asian countries a special arrangement was financed through United Nations Agencies co-ordinating efforts under the Asian Regional Co-operative Project on Food Irradiation. Clearly however there is much potential for further development almost everywhere. Currently, of the products where irradiation would bring the greatest public health benefits, poultrymeat is known to be irradiated only at four plants (in Chile, France, South Africa and the United States-and in the latter case the development took place only in the last few months.) Irradiation of shellfish which is often contaminated with *Shigella, Vibrio* and *E. coli* is at present limited to France, Belgium, Netherlands and South Africa. Grain is irradiated only in Ukraine, and potatoes only in Chile, China, Cuba, South Africa, and Japan. Disinfestation of fruit for quarantine purposes is also at a very early stage. This is recorded in South Africa but does not otherwise appear to have yet been taken up.[21]

CONSUMER ACCEPTANCE AND MARKET TESTING

The relatively slow take up of the process is the result of fears on the part of food producers and food retailers about consumer acceptance of irradiated products. In a number of countries the existence of anti-nuclear of anti-technology lobbying groups has confused the issue. Sometimes the extremist views of the groups themselves are taken to be the views of ordinary consumers : sometimes the extremists are so active that industry fears that, whatever the original viewpoint of the consumer was, the highly professional lobbying of the anti-nuclear groups will succeed in stopping consumers trying irradiated food for themselves. And if food retailers believe that irradiated food will not sell, then clearly they will not allow it to take up valuable space on the shelves of their stores. Recent developments both in the United Kingdom and the United States give a very clear illustation of what can happen.

In the United Kingdom the government acted in 1991 to make it legal to irradiate, under licence, a range of food products including poultrymeat, shellfish, fruit and herbs and spices. To date, however, only herbs and spices have been irradiated for sale. The food retail trade in the UK is concentrated in the hands of a small number of very large companies. Each of these companies has been targetted by the antiirradiation lobby and asked to state in writing whether they will be selling irradiated food. The implication of the way the questions are phrased is that if any retailer indicates an intention to sell such food then the campaingners will use this against them in publicity and may, indeed, seek to organise boycotts of the stores involved. In the circumstances the retailers have reacted by stipulating to their suppliers that the food sold to them must not have been irradiated. The effect of this is that the policy of the government has been frustrated. Firstly, it has not been possible to combat the serious problem of Salmonella infection in the UK through having irradiated chicken on the market. Secondly, the policy of allowing consumers to choose for themselves whether or not to eat irradiated food has not been allowed to proceed. Consumers simply cannot choose for themselves because there is no irradiated food available for them to choose.

In the United States, a highly active pressure group succeeded in raising substantial funds from consumers who were not very well informed about the process and whose fears could easily be manipulated. The group used the funds in press and radio advertising that alleged that the massive and compre-

hensive research programme carried out had in fact been inadequate and-even claimed that irradiation was linked with a risk of cancer. Fortunately, an investigative television programme that is shown on a nation-wide basis did not take the claims of the group at face value but checked back with the actual researchers on the results of safety trials that the group claimed showed the process to be unsafe. In every case, this revealed that the lobbyists were misstating or distorting the results for propaganda purposes. In some cases the researchers contacted made it clear that there was no way in which their results could possibly be interpreted in the way the lobbyists were attempted to interpret them. The deeper the television programme investigation proceeded the more the impartial reporter who had previously had no special knowledge of and no particular opinion about food irradiation became convinced that the safety of the process had, indeed, been authoritatively confirmed and that the anti-nuclear campaigners were simply engaged in a propagands exercise that was totally against the interests of the public for whose benefits they were claiming to be taking action. The screening of this investigative programme did a considerable service to the cause of food irradiation in the United States though certainly the campaign of opposition is still continuing. Nevertheless, and despite the pressure of the campaignign activists, irradiated fruit has gone on sale with great success in stores in Chicago and in Florida-and in the case of the Chicago store, the quite astonishing success of the first season's marketing has been repeated in the second season. In both, the irradiated strawberries outsold non-irradiated fruit, by as much as 20 to 1. And recent reports indicate that when irradiated poultrymeat reached three stores a few months ago fears of a public reaction against the product proved entirely unfounded and sales have gone very well.

The experience with irradiated fruit and irradiated poultrymeat in the United States is further confirmation of evidence accumulated from test marketing in a number of other countries as well as previous US experience. All evidence from actual sales is that, no matter what consumers may say when they give their opinions in answer to surverys (or whatever the lobbying groups claim that surveys show) when they have the chance to buy irradiated food consumers do actually buy it. In other words, the message of the surveys and the message of the sales figures may be quite different. Survery after survey reaches the conclusion that consumers are not interested in irradiated food. But the presence of actual produce on the shelves rather than the posing of a hypothetical question shows that consumers are interested and do try the food. The results are absolutely clear. The results of opinion polls in the United Kingdom showed that in 1986 more than 50% of respondents stated that they would not buy irradiated food and in 1989 more than half considered that the process should not be allowed at all. In surveys in the United States in the period 1984 to 1987 about 40% either had concerns about the process or even considered it to represent a serious hazard. But by contrast the actual market tests that have taken place over the years reveal a different result. In the case of the United States irradiated mangoes sold well in Florida in 1986, whilst in 1987 irradiated papaya in California outsold the un-irradiated fruit by a ratio of 10 to 1. Subsequently, in Missouri, irradiated applies were placed on the market in 1990 with good results.

Outside the United States, sales of irradiated stawberries in France in 1987 went very well, despite the fact that the irradiated product was priced some 30% higher than non-irradiated strawberries. All the irradiated stocks were sold at the higher price.

Irradiated vegetables have also been successfully marketed. As long ago as 1977 Italian consumers

were offered irradiated potatoes and questioned afterwards about their reactions. A preference for the irraciated potatoes was expressed on the basis of the higher quality and better storage properties of those that had been treated. Similar tests in 1988 in Poland, which covered irradiated onions also, revealed that 97% of consumers responding to a survery would be prepared to buy irradiated produce again. Trials with onions have also been carried out Thailand where, in 1986 irradiated onions were successfully marketed at a slightly higher price than the non-irradiated variety. A similar result was achieved with irradiated onions in a pilot test in the Philippines in 1985 and in later tests with both potatoes and onions in Pakistan, with onions alone in Bangladesh, and with onions and garlic in Argentina.

Not so much information is available about the test marketing of fish or meat products. However, ham sausage sold in Thailand in a 1986 trial is stated to have outsold the non-irradiated product by a ratio of 10 to 1, meat products (of which no details are available) are reported to have sold well in Shanghai in 1991 and 1992-and earlier tests in Bangladesh with irradiated dried fish were apparently carried out successfully. In the case of animal products a very small scale trial in an American University is also of interest. Pork sandwiches were supplied to 58 students half receiving sandwiches with irradiated pork, half non-irradiated. Each group was offered the possibility of buying the other kind of product instead. 26 out of the 29 students with non-irradiated pork wanted to buy the irradiated product because of the additional safety of the meat. Only 1 student of the 29 with the irradiated product wanted to buy non-irradiated pork instead and thus avoid irradiated food. The trial is, of course, too small for valid conclusions to be drawn from it-particularly since it involved only students rather than a typical cross section of the consuming community. The results however, do indicate that a similar experiment on a larger scale and with a wider ranger of consumers might yield very interesting information. In all market tests have been carried out in 20 countries, involving 40 market trials. The results of all of them have been positive.

CONCLUSION

The history of food irradiation shows that the process is far from new. But by many consumers it is perceived to be new-and clearly a good many regard it as the ultimate high technology interference with their food-food that they think should come to them in as a natural a state as possible. This is what many consumers are saying. Food retailers, often in a highly competitive situation tend to be cautious over any initiative that they fear may not be well received by their customers and which may accordingly reduce their profitability relative to that of their competitors. In this situation, retailers are tending to be influenced by what their customers say than what consumers actually do when presented with the opportunity of buying irradiated food. Perhaps a major problem is that consumers have many more opportunities to give their opinion than they have to buy irradiated food.

All the successful marketings of irradiated food have been associated with the careful provision of well thought-out information for the public. There are certain essential elements that need to be included if the information provided is to change the public's perception of why irradiation is being used and what it is doing to the praticular food.

The first point to stress in the information to be given is a basic factor about food-ie. raw food does not stay in its natural state for very long-a wide variety of microorganisms, bacteria for example, are either present in the food or can readily enter it from

the environment. Particularly in a warm climate these will multiply rapidly and will result in the food being spoiled or made unsafe to eat.

The second point that should be placed clearly before the public is that throughout the centuries mankind has always had to cope with this problem and has therefore developed a number of ways of preserving food. In the case of liquid foods pasteurisation can be used. In solid foods the objective can be achieved by irradiation.

The third essential point to be emphasised is that irradiation is just another one of these methods.

If a well-directed educational campaign is to succeed then it must be used not in a vacuum, but in accompanying good quality irradiated produce onto the market. What products seem likely in the future to lead to growth in the market for irradiated food? The position is likely to be different in advanced and in developing countries. In the more advanced countries there is a demand for chemical treatment to be used less-so more use of irradiation in treating dried herbs and spices is to be expected. There is also a problem with pathogenic bacteria-suggesting that poultrymeat, shellfish such as shrimps (which are often eaten raw) and chilled, prepared meals might be areas in which irradiation will play a growing part. Some previously unexpected developments are already taking place. Irradiation is being used now in the treatment of liquid egg and of Camembert cheese. Until recently it was considered impossible to irradiate these items without ruining the product. Using irradiation to kill listeria means that Camembert can continue to be made in the traditional way with unpasteurised milk and thus retain its unique characteristics.

In the developing countries the areas of greatest interest are likely to be in uses of the process to reduce food losses or to increase the export of local products. This will involve increased use on dried herbs and spices and much greater use as a quarantine treatment against insects and mites on fresh fruit and vegetables and perhaps also dried fruits and nuts. Use of irradiation to reduce post harvest losses could mean a growth in the treatment, eg. of potatoes, onions and garlic.

In conlusion, then clear information on the lines described, ready acceptance of the need to answer detailed questions that the public may raise, and a bold marketing of good quality irradiated produce seem the best policies to ensure that in the future the use of the technology develops more rapidly than it has in the past. But the emphasis must be on the products themselves. The key to the acceptance of irradiated food lies inhaving high quality products readily available for the public to try.

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