International Journal of New Technology and Research (IJNTR)
ISSN: 2454-4116, Volume-1, Issue-5, September 2015 Pages 05-12

Radiation Processing of Meat and Meat Products – An Overview

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Abstract- **More than three decades of research and development work on technological aspects of food irradiation have clearly demonstrated the practicability and efficacy of this technology. Radiation processing of food has now been recognised as an effective and safe process as compared to the conventional methods. Today nearly 60 different commodities are being radiation processed in more than 40 countries. The microbiological safety of irradiated meat and meat products is one of the major considerations. It is well known that the macro nutrients are not significantly altered; however certain vitamins may be affected. As a whole, irradiation of meat does not lead to nutrient losses to the extent that there is an adverse effect on the nutritional status of the individuals consuming these foods. After decades of research, development, public debate and consumer acceptance trials in many countries, irradiation has emerged as a safe and viable technology for ensuring the safety and quality of food as well as for combating food borne diseases. Indeed it is currently the best available technology suitable for treating raw and pre-cooked meat products and the countries which adopt it will be benefited greatly in both domestic and international trade.**

Index Terms : **Lipid oxidation, Meat irradiation, Meat quality, Nutritional Changes**

I. INTRODUCTION

Radiation processing of food is an emerging, promising, new food safety technology for improving hygiene and increasing storage and distribution life. Irradiation is a process of exposing foods to very high-energy electrons, which are similar to light waves or microwaves. This process is sometimes referred to as ionizing radiation, electron beam pasteurization, or e-beam sterilization. The radiation energy causes changes in molecules by breaking chemical bonds. At small doses, irradiation inhibits or modifies food spoilage problems, such as sprouting and ripening. Medium doses will kill or genetically alter microorganisms so they can't reproduce, which means they can no longer cause spoilage or human illness. High doses will sterilize foods and are commonly used to decontaminate herbs and spices. Ionizing radiation can be used to bring about beneficial changes in food stuffs and it has been suggested as a method of ensuring the safety of meat products [1].

Despite substantial efforts in avoidance of contamination, an upward trend in the number of outbreaks of food-borne illnesses caused by non-spore forming pathogenic bacteria are reported in many countries. Good hygienic practices can reduce the level of contamination but the most important pathogens cannot be eliminated from most farms nor is it possible to eliminate them by primary processing, particularly from those foods which are sold raw. Several decontamination methods exist but the most versatile treatment among them is processing with ionizing radiation. Decontamination of food by ionizing radiation is a safe, efficient, environmentally clean and energy efficient process. Irradiation is particularly valuable as an end product decontamination procedure. Radiation treatment at doses of 2–7 kGy, depending on condition of irradiation can effectively eliminate potentially pathogenic bacteria such as *Salmonella*, *Staphylococcus aureus*, *Campylobacter*, *Listeria monocytogenes* and *Escherichia coli* O157:H7 from suspected food products without affecting its nutritional and noticeable changes like the taste, texture, or appearance of food [2].

It is a unique feature of radiation decontamination that it can also be performed when the food is in a frozen state. With today's demand for high-quality convenience foods, irradiation in combination with other processes holds a promise for enhancing the safety of many minimally processed foods. Radiation decontamination of dry ingredients, herbs and enzyme preparations with doses of 3–10 kGy proved to be a viable alternative to fumigation with microbicidal gases. Radiation treatment at doses of 0.15–0.7 kGy under specific conditions appears to be feasible also for control of many food borne parasites, thereby making foods safe for human consumption [3]. Microorganisms surviving low and medium-dose radiation treatment are more sensitive to environmental stresses or subsequent food processing treatments than the microflora of unirradiated products.

Radiation treatment is an emerging technology in an increasing number of countries and more-and-more clearances on radiation decontaminated foods are issued or expected to be granted in the near future. Acceptance of the process in different parts of the world is not uniform. In USA and in some other countries where health authorities actively encourage the use of this technology, commercial application has greatly advanced in recent years. In contrast, progress in the European Union is still slow. The recent advancement in the applications of radioisotopes and radiation technologies in various areas like medicines, industry, agriculture and research have enhanced the peaceful uses of atomic energy and improved the quality of life in many spheres. Radiation

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sterilization of medical products and food preservation by irradiation are two most important application of nuclear energy. However, many people are still unaware of these developments and unfortunately, quite a number of people also have misconceptions and apprehensions regarding the use of radiation. It is absolutely necessary to create awareness among the general public about the beneficial application of the radioisotopes and radiation technology. It is expected that through increased public education, food irradiation will emerge as a viable commercial industry.

II. Irradiation Processes

The irradiation technology implies the exposure of meat products to ionizing radiation to decontaminate food products. Ionizing radiation occurs when one or more electrons are removed from the electronic orbital of the atom. It can be produced by three different techniques, gamma ray processing, high energy electron called e-beam and X-ray processing. Radioisotopes such as Cobalt-60 and Cesium-137 emit gamma rays while electrons and X-rays are generated by machines sources. Packaged meat is exposed to effective doses of ionizing radiation so that pathogens and spoilage organisms can be destroyed. Ionizing radiations inactivate microbes by damaging nucleic acids. This damage occurs directly as a result of electron and photon contact with DNA and RNA as well as indirectly through the action of charged ions, further reacting with the nucleic acid. The radiation effects on biological materials are direct and indirect. Ionization radiation interacts with an irradiated material by transferring energy to electrons and ionizing molecules by creating positive and negative ions. The irradiation process involves exposing the food, either pre-packaged or in bulk, to a predetermined level of ionizing radiation. A typical model of gamma irradiation facility is shown in Fig.1.

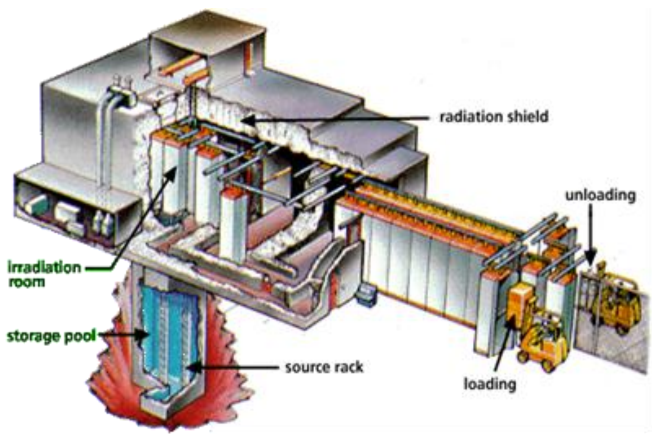

Fig. 1 Gamma Irradiation facility

III. Effects of Radiation on Biological Materials

The radiation effects on biological materials are direct and indirect

A. *Direct effect*

In direct action, the chemical events occur as a result of energy deposition by the radiation in the target molecule. Since atomic bonds are shared electron orbital, direct effect of ionising energy results in the fracture of bonds that hold the pathogen's DNA together resulting in breaking of DNA strands (Fig.2).

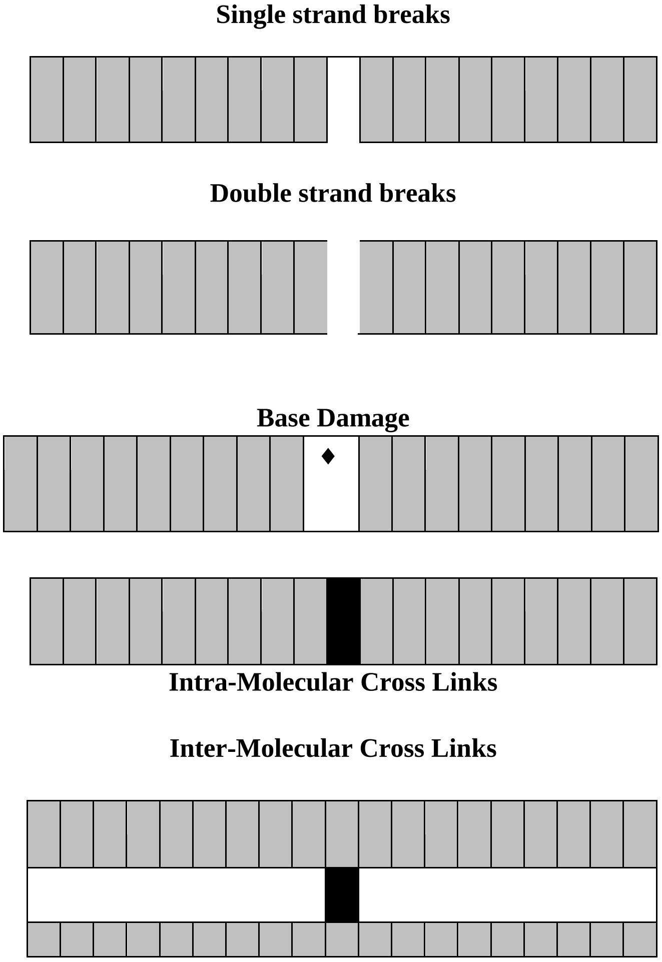

Fig-2. Diagrammatic representation of major types of damage to the isolated DNA after irradiation

There could be single strand breaks that occur in the sugar phosphate backbone of the individual polynucleotide strand or double strand breaks in adjacent or near adjacent in both the polynucleotide strands. Base damage or intermolecular cross-links are also observed when isolated DNA is exposed to gamma radiation.

B. *Indirect effect*

Indirect effect is caused by secondary electrons and free radicals formed due to interaction of radiation with water and other cell constituents. Radiolysis of water also plays an equally important role in the destruction of bacteria. Radiolysis of water results in a number of products such as hydroxyl radicals ($.OH^{-}$), hydrated electron (e^{-}_{aq}), hydrogen atoms, hydrogen molecule (H_2), Hydrogen peroxide (H_2O_2) and hydrated protons (H_3O^{+}). Hydrogen peroxide is a strong oxidizing agent and a poison to biological systems, while the hydroxyl radical is a strong oxidising agent and the hydrogen radical a strong reducing agent. These two radicals can cause several changes in the molecular structure of organic matter [4].

Damage to DNA caused by the interaction of these species disables the organism to grow or multiply. Like other food preservation methods such as cooking and canning, the loss of electrons from atoms also creates charged ions or "free radicals". These ions are highly reactive and will react with the DNA strands, thereby further damaging the nucleic acid and rendering the expression of complete DNA impossible. All of the free ions and electrons created by the process react with other atoms very quickly and do not remain in the product. The sensitivity/resistance of micro organisms to gamma radiation depends upon the environmental conditions. Oxygen enhances the radio sensitivity of bacterial cell. Radio sensitivity of bacteria also depends upon the dose rate, the water content, medium and temperature. It also depends upon the type of bacterium and its phase of growth [5].

IV. MEAT IRRADIATION

Radiation processing of meat is a novel alternative to traditional preservation methods such as salting, curing, smoking, drying, canning, cooking, refrigeration, freezing, modified atmosphere packaging and high-pressure. Some of the advantages of this technology are that it is a physical, cold and non-additive process that causes minimal changes in food. It is also an ecofriendly process. It can be applied to pre-packaged food and is highly effective compared to chemicals and fumigants. It does not leave harmful residues in food. It is one of the best emerging technologies to ensure the microbiological safety of meat. In developed as well as developing countries an increase in the incidence of food -borne diseases especially of animal origin has been noticed [6]. In USA, the US FDA (1997) and USDA (1999) approved radiation processing of meat. Radiation processed ground beef and poultry have appeared since on the market shelves of several states in the US. Meat and meat products pasteurised by radiation have been successfully marketed in Belgium, France, China, Indonesia, Netherlands, South Africa and Thailand for a number of years. In India, the Ministry of Health and Family Welfare approved meat and meat products including chicken for radiation preservation under FSSAI regulations in 2009.

V. POULTRY IRRADIATION

The presence of pathogenic bacteria such as *Salmonella* and *Campylobacter* in poultry is a world-wide phenomenon. The contamination problem is aggravated by modern mass rearing practices. Poultry-borne Salmonellosis and Campylobacteriosis occur mainly as a result of under-cooking, time-temperature abuse leading to survival and growth of the pathogens, or recontamination after cooking due to contact with surfaces, hands or utensils which have been previously contaminated with raw chicken [6]. Poultry-borne Salmonellosis or Campylobacteriosis account for a heavy toll in human disease and associated suffering, including death [7]. Economic losses associated with these problems were estimated by Buzby and Roberts [8] to be in the thousands of millions of US dollars. According to the Centre for Disease Control and Prevention, 2009, Salmonella causes an estimated 1.2 million cases of acute gastroenteritis, including 23,000 hospitalizations and 450 deaths, in the United States each year [7].

VI. IRRADIATION AND MEAT QUALITY

A. Changes in Lipids

Oxidative lipid degradation is associated with many meat-processing technologies including meat irradiation. Irradiation may result in the formation of free radicals and possible development of off-odour. Hydroxyl radicals generated by the interaction of ionising energy with water molecules can cause initiation of lipid oxidation in muscle tissues or in meat products [9]. Oxygen dissolved in meat tissue or surrounding the product is subjected to activation by ionising radiation [10] and may generate reactive oxygen species [11]. Hydroxyl radicals and other reactive oxygen species interact with lipids in meat and form lipid hydro peroxides. Subsequent breakdown of such hydro peroxides aldehydes, ketones and various other products that generates volatiles, which may partially contribute to off odours in irradiated meat. Free radicals may interact with heme pigments in meat and change meat colour. Thus free radicals generated by irradiation can destroy antioxidants in muscle, reduce storage stability and increase off flavour production in meat [12]. The susceptibility of irradiated meat to oxidative rancidity is related to the nature, proportion, packaging, storage, and degree of saturation in fatty acids and the composition of phospholipids in cell membranes [13], [14].

Lipid peroxidation in muscle foods is one of the major degradative processes responsible for loss of meat quality. It leads to the formation of warmed over flavors, destruction of essential fatty acids and some of the fat soluble vitamins [15]. It would be good to note that the path of by-product formation from lipids followed by ionizing radiation induced autoxidation is the same that as natural autoxidation [16]. Minor changes were noted when increasing the dose up to 10 kGy. As per the literature available, lipids irradiated under conditions anticipated for commercial food processing (≤7 kGy), does not result in significant loss of nutritional value [17].

Irradiation treatment is not effective in stopping the changes in meat that diversely affect consumer acceptance, such as oxidation of pigment to yield brown or grey discolouration, drip loss from the cut surface of lean tissue, and oxidation of meat lipids which causes off-flavours, by atmospheric oxygen [18].

Oxidative rancidity in irradiated meat can be minimised/retarded by various means. The most obvious precaution to take against oxidative deterioration is removal of air. Vacuum packaging and modified atmosphere packaging (MAP) of meat are very effective in controlling oxidative rancidity [19, 20]. However, the usefulness of vacuum packing is limited by the product characteristics. Also meat packed in modified atmosphere increases the pack volume and different gas formulations are required for each product [21]. Freezing of meat can considerably slow down the rate of oxidative rancidity. However freeze thawing, temperature abuse in handling and distribution and/or prolonged storage can accelerate lipid oxidation. Antioxidants are one of the principal ingredients that protect meat quality by preventing oxidative deterioration of lipids [22, 23]. They can interfere with the oxidation process by reacting with free radicals, chelating catalytic metals and also by acting as oxygen scavengers. There is an increasing demand for naturally occurring antioxidants because they are presumed to be safe since they occur naturally in food.

Effect of natural antioxidants like chitosan [14], mint [24] and tocopherol in combination with sesamol [25] were evaluated on lamb and pork meats during radiation processing and storage to establish the antioxidant potential and found to give positive effects in controlling the oxidation of lipids. MRPs formed through a reaction of amino acids or peptides with reducing sugars are known to have antioxidative effects in food systems [26]. Some of the early MRPs produced from glucose and lysine are known to have antioxidative properties in methyl linoleate model systems and meat products [27, 28]. One of the naturally occurring antioxidants most widely used in the food industries is ascorbic acid with a varied chemistry. Ascorbic acid and its esters function as antioxidants by protecting double bonds and scavenging oxygen [29, 30]. Effects of lactic acid and irradiation on the quality profile of hurdle processed chicken products were studied by Jayathilakan et al [31] and found the protective effects of lactic acid in controlling the quality deterioration during irradiation and storage.

B. Changes in Proteins

Because of the importance of proteins to human health, the effect of irradiation on this food constituent is of interest. Similar to lipids, protein damage due to irradiation is catalyzed by free radicals formed by the radiolysis of water. Damage caused to protein by ionizing radiation include deamination (resulting in the production pyruvic and propionic acids), decarboxylation (resulting in a production of ethylamine and acetaldehyde) [32], reduction of disulfide linkages, oxidation of sulfydryl groups, breakage of peptide bonds and changes of valency states of the coordinated metal ions in enzymes [32]. The prevalence of ammonia and pyruvic acid production indicate that deamination plays a greater role than decarboxylation [32]. These possible chemical and physical changes are similar to that seen with other treatments of food material [15]. Major products formed by the interaction of radiation with protein material are carbonyl groups, ammonia, free amino acids, hydrogen peroxide and organic peroxides. At high doses, some cross links can occur leading to the formation of new proteins by the bonding of free amino acids to proteins and protein to protein aggregation [34, 35]. Protein to lipid cross-linking can also be seen [15]. These chemical changes are all affected by the structure and state of the protein and by the conditions of irradiation such as the dose, dose rate, temperature and presence of oxygen. Changes stated here mostly affect the primary structure of the protein but many studies indicate that irradiation is a major process by which the secondary and tertiary structures are affected. The folding pattern changes are brought about by aggregation due to cross-linking among peptide chains or denaturation through the breaking of hydrogen bonds and other linkages involved in the foldings. To some extent, the particular effect of radiation is related to the protein structure, composition, whether native or denatured, whether dry or in solution, whether liquid or frozen, and to the presence or absence of other substances [36].

C. Oxidation of amino acids by irradiation

Amino acids inside a protein are less labile to irradiation than free amino acids. The effect of irradiation on aliphatic and aromatic amino acids differs. For aliphatic amino acids, irradiation in the presence of oxygen will lead to the formation of ammonia and alpha-ketoacids, or to the formation of ammonia, carbon dioxide and an aldehyde or a carboxylic acid. The yield of expected oxidation products decreases linearly as a function of the number of carbon atoms present in the aliphatic side chains. This is explained by the fact that the more carbon atoms are present, the more sites for attack by an OH^- radical are available. If oxygen is not present, this may suppress the generation of peroxy radicals and thus favor deamination or combination interactions forming some amino dicarboxylic acid derivatives [33].

Sulfur containing amino acids along with aromatic amino acids are the most susceptible to irradiation damage. The products formed from sulfur-containing amino acids in proteins include methyl or ethyl mercaptan, dimethyl disulfide, carbonyl sulfide or hydrogen sulfide. When sulfur compounds are submitted to radiation in the absence of oxygen, hydrogen sulfide and sulfide are formed in large amounts. In the presence of oxygen, the amount of ammonia and sulfuric acid produced increases [32]. The typical odor of irradiated meat is related to the formation of sulfuric compounds. The most radiation sensitive amino acids are in fact the ones bearing sulfur notably cystine, methionine and tryptophan. Desulfuration must thus be considered as one of the principal effect of ionizing radiation on amino acids and proteins [15].

D. Oxidation of proteins by irradiation

In the case of proteins, the presence or absence of oxygen has a large effect on the products recovered. The major player in irradiation damage to proteins is $.OH^-$. In the presence of oxygen, little or no aggregation occurs but fragmentation of the polypeptide chain is basically the rule. When gamma irradiation is conducted under ambient conditions, proteins are seen to fragment with increasing dose showing that even 20% oxygen is enough to produce fragmentation reactions. Exposure to OH^- in the presence of oxygen generally produces a dispersed pattern of lower molecular weight protein fragmentation products. Fragmentation appears to occur predominantly at the alpha carbon rather than at the peptide bond [33]. Fragmentation is again the result of the action of oxygen free radicals and of secondary reactions leading to the formation of alkyl peroxides or hydroxy derivatives. Myosin is one of the most important proteins in muscles. Yook et al., [37] showed that protein solubility increased slightly for irradiated beef with dose. Zabielsky et al., [38] suggest that myosin solubility goes down with increasing irradiation dose up to 10 kGy, resulting in reduced water holding capacity. Lee et al, [39] studied the electrophoretic patterns of irradiated beef and demonstrated that muscle proteins are structurally changed rather than destructured and broken down by gamma irradiation with the dose between 3 and 10 kGy. Gamma irradiation caused conformational changes to the major contractile muscle protein, myosin with the dose between 3 and 10kGy [39]. Lacroix et al., [40] demonstrated that meat irradiated at 6 kGy, under vacuum and at low dose rate (2 kGy h^{-1}), seemed less affected by the treatment and remained more stable during storage. The emulsifying capacity of the irradiated proteins was higher than the control product. The hydrolysis of proteins in smaller fractions of lower molecular weights could be at the origin of this emulsifying capacity increase.

E. Changes in Vitamins

Meat is a great source of water-soluble B complex vitamins. The amount of these vitamins is largely influenced by the fatness of the meat, being principally found in lean portions due to their lipid insolubility. Age of the animal also has an effect on the water-soluble vitamin content. The B vitamins in meat include thiamine (B_1), riboflavin (B_2), niacin (B_5), pyridoxine (B_6), biotin (B_{10}), cobalamine (B_{12}), choline, folic acid and pantothenic acid. There are little fat-soluble vitamins in meat. Beef contains around 1 microgram of vitamin A per gram of fat, some ascorbic acid and negligible amounts of vitamins D, E and K [41].

In the case of vitamin radiolysis, the types of possible free radical reactions are determined by the medium in which the vitamins are present. The fat-soluble vitamins would thus be exposed to radicals produced by the direct action of radiation on lipids and the water-soluble vitamins to radicals formed by water irradiation. In the case of fat-soluble vitamins, the free radical-mediated reactions are negligible since they will mostly recombine with positive lipid ions. For water-soluble vitamins, some may react with hydrated electrons directly or acquire an electron from the other radicals produced in the aqueous medium. The fate of the reaction is determined by the electron reduction potential of the vitamin and the weakness of its H bonds [15]. Since vitamins are in quite low amounts in most foods, the $.OH^-$ radicals will mostly react with other major food components like lipids, proteins and carbohydrates, before reacting with vitamins. The vitamins are thus more affected by the secondary radicals formed by the interactions with the major components which are mostly hydroperoxides [42]. The effect of irradiation on nutritional content of cooked chicken is shown in Table 1. From the table, it can be interpreted that the major vitamins which are significantly reduced with irradiation were vitamin E and Thiamine [43].

F. Irradiation and the fat-soluble vitamins

Since these vitamins are not readily present in meat but more in dairy, fruit and vegetable products, they are of minor concern. Vitamin E (α-tocopherol) is the most irradiation sensitive fat-soluble vitamin. Vitamin D is mostly found in fish and has a high stability to irradiation. Finally, vitamin K being synthesized by bacteria in the human gut is of no concern although the vitamin K originating from meat is sensitive to high irradiation doses [42].

G. The water soluble B vitamins

This group of vitamins is of greater importance in meat. The sensitivity of many B vitamins seems to vary between meat cuts and also from meat to meat [45].

1. Thiamine

Meat can be a significant source of thiamine. It has been shown that thiamine is the most irradiation labile water-soluble vitamin. However, this vitamin is even more labile to heat [44]. It is also been shown that the temperature of the meat sample during irradiation as a major effect on the rate of thiamine loss [46]. Oxidative damage to thiamine is responsible for its loss. When thiamine is irradiated, a decrease in spectrophotometric absorbency indicates the destruction of its pyrimidine ring. Loss of the amino group is observed and this reaction generates ammonia in function of the irradiation dose.

2. Riboflavin & Niacin

This vitamin is relatively stable to irradiation. No loss was found in pork chops and chicken breasts irradiated at temperatures between -20 and 20°C at doses up to 6.6 kGy. Some irradiated samples even showed an increased in riboflavin concentration of up to 25% [44].

Niacin is the most abundant B complex vitamin in meat. Pork chops irradiated at different temperatures with doses up to 5 kGy showed no loss in niacin. A loss of 15% was observed with a dose of 7 kGy when irradiation was done at 0°C [45]. No significant effect was seen with chicken breasts under the same conditions [45].

3. Pyridoxine, biotin and cobalamin

Sensitivity of pyridoxine to gamma irradiation is less than that of thiamine. The sensitivity of pyridoxine is closer to that of riboflavin at doses higher than 10 kGy. Villavicencio et al., [47] stated that losses appeared to be low at doses <10 kGy. Gallien et al., [48] found that it was not significantly affected at these doses (<10 kGy). Work at sterilization doses (20-40 kGy), showed no significant losses in biotin. No loss in cobalamin was observed when pork was irradiated at 7 kGy, 0°C [45].

4. Choline, folic acid and pantothenic acid

No losses due to irradiation have been reported for choline [49]. There are indications that some components of folic acid are sensitive at a dose of 25 kGy while others not [42]. In the case of pantothenic acid, studies showed that there is no loss in many foods irradiated at doses of ≥10 kGy [43]. Heat sterilization reduces the vitamin content of meat more than any other method including gamma irradiation, electron treatment and frozen storage.

VII. LABELLING AND MONITORING

To ensure that the consumer is informed that irradiation has been used, the FDA requires that foods that have been irradiated bear a logo, the Radura logo, and a statement that the food has been irradiated. Additional labelling may be included by the manufacture to inform the consumer why the food has been irradiated, and how to store the food to maintain the quality, provided such statements are truthful and not misleading.

The Radura logo was also included in the Codex Alimentarius standards on irradiated food as an option to label irradiated food [50].

The use of the Radura-logo is voluntary according to the Codex Alimentarius standard [50]. However, a few countries (namely the USA) make its use compulsory; a few countries allow the optional use; others, in particular the European Union, do not provide for the use of this international logo. In the Codex standard the symbol is in green with all elements filled; some countries allow for different designs and even varying colours.

In order to develop monitoring methods to ensure compliance, an extensive research effort has been undertaken to develop methods which can be used to identify foods that have been treated with ionizing radiation. As a result of this effort, a range of methods using a wide variety of chemical, physical and biological techniques exist that can be used to identify many different food commodities that have been irradiated. Some of these methods act as screening methods, while others can provide more definitive information. None of the current methods will work equally well on all foods. Most of the methods have been developed for a particular food commodity, although many have been shown to also be applicable to other foods as well. Each method has its strengths and weaknesses, and further research will continue to refine these methods, and develop new ones.

VIII. STATUS OF LEGISLATION AND FUTURE NEEDS

Although food irradiation cannot provide the sole answer to food borne illnesses, analogous with heat pasteurization of milk, it would prevent a lot of infections from specific solid foods, and thereby, would enhance the microbial safety of important segments of food supply with relatively low costs compared to the costs caused by food borne disease. Therefore, being a feasible technology serving the fight against food borne illness, the practical implementation of radiation processing should not be blocked. Food exporting countries find it frequently, difficult to permit the radiation decontamination of foods even for inland use as long as their main trading partners do not accept such commodities. Nevertheless, today nearly 60 different commodities are being radiation processed in more than 40 countries [51]. Proper information about the safety and benefits of irradiated foods could increase the level of understanding and acceptance of irradiated products by consumers [52]. It is important that the WHO [53] and several respected non-profit organizations such as the American Medical Association [54], American Dietetic Association [55], Institute of Food Technologists, and the Council for Agricultural Science and Technology in the USA have a positive attitude towards processing of food by irradiation for safety. At the same time, it has to be always emphasized that, like other intervention strategies, irradiation must be applied as part of a total sanitation program. The benefits of irradiation should never be considered as an excuse for poor handling and storage conditions, i.e., as a substitute for good manufacturing and hygienic practices.

Future R & D efforts may be aimed at the multi hurdle approach including irradiation, specificity of different dosages on pathogenic bacteria and to evaluate the effect on colour and flavour with respect to meat/poultry products.

IX. COMMUNITY CONCERNS

Irradiation of food products invites lot of concerns with regard to the radioactivity of the irradiated food. Extensive testing and evaluation have demonstrated that irradiated foods are safe like canned, pasteurised and frozen food items. As per the U.S. Food & Drug Administration's (FDA) rules food that has been irradiated, or food that contains irradiated ingredients or components, must be labelled or have a label displayed on or close to it stating that it has been treated with ionising radiation. This will facilitate consumers to express their choice of selecting both types of food items. Concerns have been raised regarding the less stringent and food hygiene practices if irradiation is adopted as preservation technique. In practice irradiation cannot be considered as a substitute for good hygienic practices. Sometimes irradiation may lead to the elimination of natural warning signals like smell etc which make it difficult to tell if food are old or have gone 'off'. In addition to this there is a concern that food irradiation is driven purely by market needs, rather than consumer demand. The industry should emphasize the impact of food irradiation on safety, taste and nutritional value in their advertising efforts.

X. TECHNOLOGICAL PROBLEMS AND LIMITATION OF IRRADIATION

Irradiation has high capital costs and requires a critical minimum capacity and product volume for economic operation although irradiation has low operating cost and requires low energy. Contemporary designs of food irradiation plants are often more suited to the conditions and needs of developed countries. Designs that keep capital costs to a minimum and make it effective will be more suitable for developing countries. Studies carried out since the 1940s demonstrating the benefits of food irradiation have also identified its limitations and some problems.

Food irradiation is not a panacea for all food problems. Besides economic and logistic factors, and opposition based on psychological perception problems due to lack of public knowledge on wholesomeness of irradiated food [56], sensory changes frequently constitute a dose limitation [57]. Irradiation at sub freezing temperatures can reduce off-flavour formation; for either technical or economic reasons, however, some foods cannot be frozen. Certain results cannot be secured through irradiation, and in these circumstances it is inapplicable. For example, at doses within the practical limits, irradiation does not inactivate viruses, enzymes and microbial toxins. Irradiation has no persistent effect, thus, post irradiation contamination must be prevented to secure the microbial benefit of the radiation treatment.

XI. SUMMARY

The wholesomeness and acceptability of irradiated foods have been evaluated by various expert committees (JECFI/IAEA/WHO/FAO) and after reviewing all the data it was recommended that the irradiation of any food commodity up to an overall average dose of 10 kGy, presents no toxicological hazard as well as no nutritional or microbiological problem. Radiation doses greater than 10 kGy can lead to sterilised products, as is the case with meat products prepared for the NASA space flight programme. Sterilized foods are useful in hospitals for patients with severely impaired immune systems.

There is evidence that the interest in irradiation preservation of foods will continue to grow. In future greater numbers of food items are expected to have the approval for being irradiated. The recently created international council on food irradiation (www.icfi.org) can play a greater role in familiarizing food companies with the benefits of irradiation.

While all possible efforts should be made to decrease in the long term level of contamination at the production stage, the potential of food irradiation to contribute to diminish the rising incidence of food borne diseases and to contribute to their prevention should not be undermined.

By adopting an HACCP-based approach to risk management, it can be clearly demonstrated that application of a technology such as food irradiation is essential for ensuring the safety of raw meat and meat products. Such an intervention should be considered as a CCP in the food chain, much as milk pasteurization is today recognized as necessary for ensuring the safety of milk and milk products. Therefore, the potential benefits of irradiation, which is endorsed by national and international bodies such as the World Health Organization, the Food and Agriculture Organization of the United Nations, surely merit serious consideration by public health authorities, industry, and consumer groups world-wide.

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