ENSURING HYGIENIC QUALITY OF FOOD OF ANIMAL ORIGIN BY IRRADIATION PROCESSING

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INTRODUCTION

How safe is our food supply today? It is safer than ever before but a number of foods, especially those of animal origin are still relatively unsafe if not properly handled and prepared prior to consumption. Microorganisms and parasites can contaminate food at various stages of production, processing, storage and distribution. These biological agents, some of which are pathogenic to man and animals, may be able to survive certain preservation treatments and pose health risks to humans. Thus, it is safe to assume that food of animal origin, especially those to be consumed raw or undercooked, represent high risk for consumption and could be vehicles for foodborne diseases.

The problem of food safety is compound by the fact that immuno-compromised populations, *ie* the elderly, pregnant women, young children, organ transplant patients, and HIV positive individuals, the number of which are increasing worldwide, are more susceptible to infection by foodborne pathogens than healthy young and middle-aged adults. In addition, a number of foodborne pathogens have developed resistance to drug (Barbuti *et al*, 1992; Hatha and Lakshmanaperumalsamy, 1995; Lewis, 1995). No one is immune to foodborne diseases regardless of their professional knowledge and physical strength. Outbreaks of foodborne diseases could occur in the medical community (Palmer *et al*, 1990) and among atheletes (Hedberg *et al*, 1992). In Scotland, frequent outbreaks in hospitals attributable to contaminated chicken resulted in the removal of raw and frozen chicken from hospital meals in the late 1980' s (Yule *et al*, 1988). Cooked chicken were used instead for meal preparation in these hospitals. The severity of the outbreak of *Escherichia coli* 0157H:7 in the west coast of the USA in 1993 which caused deaths to several children and hospitalized hundreds of individuals, had resulted in a new USDA regulation which considers this pathogen an adulterant in raw and frozen ground beef (Bjerklie, 1994).

Thus, foodborne diseases continue to affect adversely the health and productivity of populations worldwide, especially those in developing countries. The Joint FAO/WHO Expert Committee on Food Safety concluded as early as 1983 that "illness due to contaminated food is perhaps the most widespread health problem in the contemporary world and is an important cause of reduced economic productivity" (WHO, 1984). Indeed, parasitic and bacterial diseases combined represented the most frequent cause of death (35%) worldwide in 1990, the majority of which occurred in developing countries (WHO, 1992). Diarrheal diseases cause about 25% of deaths in developing countries, and it is estimated that in up to 70% of cases, food is the vehicle for transmission of causative agents (Kaferstein and Moy, 1993).

ECONOMICS OF FOODBORNE DISEASES

The economic losses resulting from foodborne diseases can be considerable. For example, the US Centers for Disease Control and Prevention and the US Food and Drug Administration estimate that 6.5 to 33 million cases of foodborne diseases occur in the

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USA each year (Kvenberg and Archer, 1987). Salmonellosis alone accounts for about 2 million of these cases and is estimated to cost the US economy US$2,540 million annually (Roberts, 1988). Murrell (1991) estimated that economic losses due to animal cysticercosis in Latin America as US$ 428 million and in Africa as US$ 1.9 million. The cost of toxoplasmosis caused by *Toxoplasma gondii* in the US is estimated to be up to US$ 4,400 million a year (Roberts and Murrell, 1993). In Thailand, the annual cost of human infections with liver fluke *Opisthorchis viverrini* is estimated about US$ 99 million (Loaharanu and Sornmani, 1991).

Considerable cost saving to the society could be expected as a result of the reduction in illnesses caused by foodborne diseases. A number of studies have demonstrated that the benefit of irradiation as a public health measure to control foodborne diseases exceeds the cost of the treatment (Morrison and Roberts, 1985; Yule *et al*, 1988; Roberts and Murrell, 1993).

CONTRIBUTION OF FOOD IRRADIATION TO FOOD SAFETY

The increasing number of foodborne pathogens and the consequent outbreaks which result in illnesses and deaths of thousands of individuals each year has prompted public health officials to consider new preservation technologies such as irradiation. While several of these pathogens show resistance to drugs, other chemicals or heat treatments, many foodborne pathogens including bacteria and parasites are relatively sensitive to irradiation.

Irradiation is increasingly recognized as a "cold pasteurization precess" for solid food such as poultry, meat, seafood and spices in the same manner as thermal pasteurization is widely accepted and applied as a method to ensure hygienic quality of liquid food, *eg* milk. The latter is not suitable for solid food as it would cause significant changes in the physico-chemical characteristics of the product. Irradiation is instead a more efficeint "pasteurization" process for these food which remain essentially in the same condition as before the treatment. The energy level used for irradiation of food to achieve certain technological purposes is extremely small. The maximum absorbed energy level or dose of irradiation recommended by the Codex Alimentarius Commission for treating food,

Table 1

Sensitivity of bacteria and parasites to irradiation.

A. Bacteria	Media	D-10 value (kGy)
Non-spore formers		
Aeromonas hydrophila	Shrimp paste	0.21
Campylobacter jejuni	Ground beef	0.16-0.32
Escherichia coli	Minced chicken meat	0.26-0.39
	Minced pork	0.34-0.35
E. coli 0157H:7	Mechanically deboned chicken	0.26-0.44
	Ground beef	0.24-0.30
Listeria monocytogens	Minced pork	0.57-0.70
	Mechanically deboned chicken	0.27-0.77
Salmonella typhimurium	Ground beef	0.67
	Roast beef	0.57
Staphylococcus aureus	Roast beef	0.39
	Ground beef	0.43-0.45
Yersinia enterocolitica	Ground beef	0.1-0.21
	Minced pork	0.16-0.19
Vibrio cholerae	Surface of prawn	0.11
V. parahaemolyticus	Shrimp paste	0.44
V. vulnificus	Shrimp paste	0.30
Spore formers		
Clostridium botulinum (spores)	Cooked beef	3.45-3.6
C. perfringens (vegetative cells)	Minced pork	0.75-0.83

D-10 values of the same bacteria may vary significantly depending on the media/food products, temperature and packaging atmosphere of food at the time of irradiation.

B.Parasites	Bioassay model	Min effect dose (kGy)
Protozoa		
Toxoplasma gondii	Mice, cats	0.5
	Mice, pigs	0.7
Trematodes		
Fasciola hepatica	Mice	0.03
Clonorchis sinensis	Guinea pigs	0.2
Opisthorchis viverrini	Hamsters	0.1
Paragonimus westernami	Cats	0.1
Cestodes		
Taenia saginata	Human volunteers	0.3
Taenia solium	Hamsters	0.2-0.6
Echinococcus granulosus	Mice	0.5
Nematodes		
Trichinella spiralis	Mice	0.3
	Rats	0.3
Angiostrongylus cantonensis	Mice	2.0
Gnathostoma spinigerum	Rats	7.0*
Anisakis spp	*In vitro*	6.0

* Preliminary results

ie 10 kGy, is equivalent to the heat energy needed to increase the temperature of water by only 2.4ºC. The dose of irradiation to ensure hygienic quality of food is in the range of 2-5 kGy depending on the product and its state. Thus, the increase in heat energy of the product is in the range of 0.48 - 1.2ºC. Thus, irradiated food remains in the original natural state after the treatment.

Irradiation is unique in ensuring hygienic quality of food of animal origin, especially those often consumed raw or undercooked. The following data demonstrate the sensitivity of various pathogenic bacteria and parasites to low-dose irradiation.

Foodborne parasites in general are more sensitive to irradiation than pathogenic bacteria. Thus, radiation doses required to ensure microbiological safety of food of animal origin are normally adequate for controlling foodborne parasites as well. As most foodborne parasitic infections normally occur in rural areas, it may be difficult to demonstrate the cost-effectiveness of irradiation as a public health control measure of only parasitic infection. However, where irradiation is used to ensure microbiological safety of food, it could be demonstrated that such a measure will also be effective for controlling infectivity of foodborne parasites in general.

IRRADIATION AS A COMPLEMENTARY MEASURE TO HACCP

Hazard Analysis Critical Control Point (HACCP) is increasingly recognized as an effective method to ensure safety of food through proper analysis of hazards and control of critical points during food handling, processing and distribution. Food industries, especially those which handle and process foods of animal origin, are being encouraged or even required to incorporate HACCP into food processing systems. Contrary to processing of liquid foods such as milk which has pasteurization as the terminal critical control point, solid foods such as fresh and frozen meat, poultry and seafood, and minimally processed foods such as fruits and vegetables, have no critical end point to ensure microbiological safety at the time of marketing. Therefore, traditional HACCP system cannot be expected to ensure the safety of these food items at the market place.

Irradiation represent a new critical control point under HACCP to ensure safety of solid foods from pathogenic bacteria and parasites in the same manner as pasteurization does for liquid foods. Irradiation should be incorporated into HACCP programme as a critical end-point treatment to ensure safety from foodborne diseases, especially for food of animal origin and those to be consumed raw or semi-cooked. Regulatory authorities and the food industry should be encouraged to incorporate irradiation into the HACCP system to reduce health risks to consumers.

STATUS AND TREND IN THE APPLICATION OF FOOD IRRADIATION

Food irradiation is increasingly recognized by national authorities and food industry as a method to ensure hygienic quality of foods, especially those of animal origin. This is particularly true in the USA and especially after the outbreaks of *E. coli* 0157:H7 which caused several deaths in children and illness of hundreds of consumers who ate undercooked hamburgers in 1993. A petition has been submitted to the US Food and Drug Administration to approve the use of irradiation for red meat and their products. Earlier the US-FDA and the USDA have approved the use of irradiation for ensuring hygienic quality of fresh and frozen poultry (USDA, 1992). It is possible that these organizations will approve the use of irradiation also for red-meat during 1996.

Worldwide, some 40 countries have approved the use of food irradiation for different purposes following the recommendation of the Codex Alimentarius Commission after the adoption of a Codex General Standard for Irradiated Foods in 1983. Some 30 countries are using the process for treating several food products. Irradiation is commonly used for treating spices to ensure hygienic quality and the volume treated is increasing significantly in recent years (Fig 1). Irradiation of food of animal origin to ensure their hygienic quality has already started in some countries but the volume is still relatively small. Different products such as chicken, shrimp, frog legs, fermented pork sausages are routinely treated in some countries such as Belgium, France, the Netherlands, Thailand and USA. In Thailand in particular, there is an increasing demand for irradiated fermented pork sausages (Nham) which are almost always consumed without cooking. Irradiation has removed the risk from salmonellosis and possibly trichnellosis from the product and is the only method to do so without significantly change the characteristics of the product.

The positive conclusion of the GATT Uruguay

Round, especially the adoption of the Agreement on the application of Sanitary and Phytosanitary Measures (SPS Agreement), should add further incentives to trade in irradiated foods. Under the Agreement, governments could be required to furnish justifications for food import restrictions based on national regulations that are stricter than recognized international standards, guidelines and recommendations of the following technical organizations:

- Codex Alimentarius Commission (Food safety and human health)

- International Plant Protection Convention (Plant protection and quarantine)

- International Office of Epizootics (Animal health)

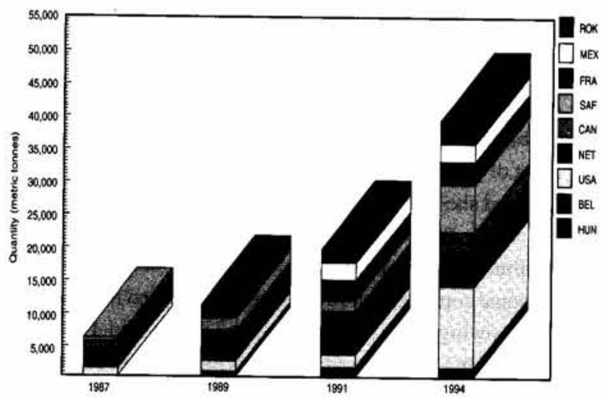

Fig 1 - Quantity of irradiated spices and vegetable seasoning in different countries.

The safety and effectiveness of irradiation as a food processing/preservation method has already been recognized by the Codex Alimentarius Commission since 1983. Thus, irradiation is likely to play an important role in overcoming non-tariff barriers to trade with regard to sanitation and phytosanitation of foods in the near future.

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