First FAO/IAEA Research Coordination Meeting (RCM) of the Coordinated Research Project on “Irradiation to Ensure the Safety and Quality of Prepared Meals”

Vienna, 10 – 14 June 2002

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First FAO/IAEA Research Co-ordination Meeting (RCM) of the Co-ordinated Research Project on “Irradiation to Ensure the Safety and Quality of Prepared Meals”

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BACKGROUND

The current trends in global food production, processing and distribution present new challenges to food safety and quality. Food produced in one area can be transported quickly to another area or regions of the world in a matter of hours or days. Changes in eating habits including a preference for fresh, minimally processed and convenience foods and the increasing interval between processing and consumption of foods could contribute to the increase in incidences of food-borne illness because of contamination by pathogenic microorganisms.

In many countries, there is a dynamic growth of market for prepared meals to meet the busy life style of populations. Such meals which offer convenience and less time for preparation are marketed in most countries either under chilled with limited shelf-life or frozen for long term sale in supermarkets. In developing countries in particular, many types of ethnic dishes are often freshly prepared and marketed at ambient conditions essentially on a day to day basis. There are growing trends to market frozen prepared meals intended for micro-waving prior to consumption in many countries.

Microbiological contamination including pathogenic bacteria (*Salmonella*, *Escherichia coli* 0157:H7; *Listeria monocytogenes*) frequently occurs during the production and processing of prepared meals which provide important vehicles to food-borne disease outbreaks. To get by microbiological problems, the food industry has to resort to freezing the meals and marketing them under frozen condition which is energy intensive and costly. Some prepared meals which are marketed either under refrigeration or at ambient conditions, have limited shelf-life. Thus, measures to ensure microbiological safety and quality of prepared meals to be marketed either under refrigeration or at ambient without compromising their organoleptic properties should be welcomed by the food industry and consumers.

Irradiation offers a potential to improve the microbiological safety and shelf-life of a number of chilled prepared meals. A number of prepared meals currently marketed under frozen condition could possibly be replaced through irradiation and chilled storage to ensure not only microbiological safety but sufficient shelf-life to meet market requirements, resulting in saving in energy and cost. As for ethnic dishes in developing countries, irradiation either alone or together with chilling could improve not only microbiological quality but could extend shelf-life of the products. However, little data are available to demonstrate the effectiveness of irradiation to improve the microbiological safety and quality of many types of prepared meals currently being marketed either under ambient, chilled or frozen conditions.

OBJECTIVE:

The overall objective of this CRP is to evaluate the effectiveness of irradiation as a method to ensure microbiological safety and extend shelf-life of prepared meals,
stored either under ambient, chilled or frozen and to evaluate the sensory quality of the treated products.

The specific objective of this CRP is to use validated methods for microbiological determination of food and validated procedures for irradiation, process control, sensory evaluation and to determine microbiological safety and quality of irradiated prepared meals or ethnic dishes.

THE MEETING

The meeting was held in the IAEA Headquarters in Vienna from 10 to 14 June 2002, and was attended by Research Contract/Agreement holders from Argentina, China, Ghana, Hungary, India, Indonesia, Israel, Korea, Malaysia, Syria, South Africa, Thailand, United Kingdom and United States of America, as well as one observer from South Africa. The list of participants is attached as Annex I.

The meeting was opened by Mr. Paisan Loaharanu, Head of the Food and Environmental Protection Section of the Joint FAO/IAEA Division for Nuclear Techniques in Food and Agriculture. He welcomed the participants to the RCM on behalf of the Directors General of FAO and IAEA.

The programme of the meeting (Annex II) included a general review on the global development of the food irradiation technology and the status of the Codex General Standard in irradiated foods, as well as analysis on methodologies used for determining pathogenic bacteria, nutritional values, sensorial evaluation of prepared meals and quality assurance procedures for radiation processing. During the meeting 3 protocols were developed: (i) Microbiological (ii) Sensorial (iii) Irradiation Process. The model of the protocols attached is as Annex III.

Dr. Joseph Farkas was elected Chairman of the Meeting with Ms Eileen Stewart as rapporteur.

All Research Contract/Agreement holders presented a report on the work they planned to carry out under this CRP as set out bellow.
REPORTS

ARGENTINA

SAFER PREPARED MEALS FOR IMMUNOCOMPROMISED PATIENTS AND THE GENERAL CONSUMER BY GAMMA IRRADIATION

Chief Scientific Investigator
Patricia Narvaiz, Food Irradiation Section, Radiation Industrial Applications, National Atomic Energy Commission- Argentina.

RATIONALE

The present life style in cities lead to little time for cooking. So, many ready-to-eat meals are available in supermarkets. Among them, canned foods do not fulfil the present preference for freshness and nutritional value the consumer show. Others are stored under frozen or refrigerated conditions, most of them being minimally processed, which enhances the probability of conveying food borne pathogens. This is of particular importance to the immunosuppressed population, whose natural defenses against diseases are low.

PRODUCT(S)

In general: Typical in the country, wide consumption and acceptability. For the first year: meat based, like empanadas, canelones, sandwiches, of adequate formulations in the case of immunosuppressed patients.

OBJECTIVE:

Overall

Increase database on the effectiveness of irradiation to improve the microbiological safety and quality of prepared meals.

Specific

- To continue with the work planned for immunosuppressed patients’ diets, widening the range of foods likely to benefit from the irradiation treatment, and improving preliminary results obtained on the formerly tested meals.
- To extend this work plan to meals for the general (“healthy”) public, especially on those which could be referred to as “ethnic” or constitute usual preference among the Argentinian consumers.
- To seek participation of prepared meals producers, retailers and catering services on these trials.
Communicate successful results of these experiences to nutritionists and physicians dealing with the immunocompromised, aiming to strengthen confidence in the method.

The local market, with the purpose of encouraging future commercial implementation of the technology.

The National Health Authorities, to afford basis for further irradiated food products approvals in the Argentinian legislation (Argentinian Alimentary Code).

Present results in scientific meetings and have them published in international journals.

WORK PLAN

1. To select producers of prepared meals, particularly for immunocompromised patients.
2. To determine microbiological profiles of these meals.
3. To determine the effectiveness of irradiation to ensure microbiological safety and shelf-life of these meals stored either at ambient, chilled or frozen conditions.
4. Evaluate sensory quality of irradiated prepared meals among immunocompromised patients and the general public.
5. Transfer results to the food industry.
6. Eventually, support the food industry on food allowances petitions to the national health regulatory agencies.

First year (2002): Selected meals: with either fish, meat or chicken base,

Present previous results at the XIV Argentine Nutrition Congress, and at the Argentine Food Science and Technology Congress, both in August, Buenos Aires.

PRELIMINARY RESULTS

Microbiological and sensory analyses on beef meat “empanadas” stored at refrigeration temperatures (5 ± 1°C) have shown promising results in reducing 4 log cycles of total bacterial counts at 3 kGy, being this dose supposed to eliminate pathogenic bacteria had they been present. The 6 kGy samples were also sensorily considered as good quality.

Sensory analyses on spinach and meat cannelloni showed good acceptance of the product irradiated either at 3 or 6 kGy.

Some out-of-panel (only two experienced panellists) evaluations on raw and cooked ham, their sandwiches, and beef meat “milanesas” showed no deleterious effects on samples irradiated at 2.5 and 5 kGy during 12 days storage.
EXPECTED OUTCOMES AFTER 5 YEARS

- Having obtained enough scientific data to support the feasibility of microbiological decontamination on a variety of prepared meals by ionizing radiations, preserving their nutritional and sensory quality.
- Having these meals sensorily evaluated by immunocompromised patients.
- Having transferred successful results to the food industry and catering services.
- Having results presented at scientific congresses and published in international journals.
CHINA

USE OF IRRADIATION TO IMPROVE THE SAFETY AND QUALITY OF CHINESE DUMPLING AND WUXI CHOP

Chief Scientific Investigator
Sun Baozhong
Institute of Animal Science
Chinese Academy of Agricultural Science

RATIONALE

In the last century, the production of two traditional prepared meals - Chinese dumpling and Wuxi chop have become industrialized through the use of fast-freezing and high temperature sterilization in vacuum packaging. The development of industrialization of Chinese dumpling and Wuxi chop need to meet the consumer’s requirement for the cooked Chinese dumpling in chilled state and Wuxi chops processed without high temperature sterilization. Such techniques are yet to be developed in China.

The following problems need to be studied:
1. Whether the use of irradiation could extend shelf-life of Chinese dumpling (cooked, chilled and ready-to-eat product)
2. Whether the high temperature sterilization procedure could be replaced by the use of irradiation for Wuxi chop product.

OBJECTIVES

Overall

To determine the feasibility and practical technique parameter of irradiation to improve the safety and quality of Chinese dumpling and Wuxi chop.

Specific

1- To get the basic scientific knowledge about the shelf-life, safety and quality of Chinese dumpling and Wuxi chop.
2- To determine the type of micro-organisms associated which influence the shelf-life, safety and quality of Chinese dumpling and Wuxi chop.
3- To determine the irradiation dose to improve the safety and quality of Chinese dumpling and Wuxi chop.
WORK PLAN

During 2002-2003:

1- Investigate the consumption patterns and preferences of Chinese dumpling and Wuxi chop to determine the product qualities and the sensory characters required by consumers and select the most popular product as research sample.

2- Determination of the safety and quality and related physical microbiological and sensory characters of Chinese dumpling and Wuxi chop to get the basic scientific knowledge of both products.

3- Irradiate both products with different doses to study the effects of irradiation on the safety, quality and related physical, microbiological and sensory characters of both products to determine the practical process parameters of irradiation.

4- Conduct consumer preference test of irradiated products to determine the acceptability and merits of irradiation treatment.

During 2004-2006

Enlarge the research range to other kinds of Chinese dumplings.

EXPECTED OUTCOME

To provide the Chinese Food Industry with the necessary scientific knowledge and practical process parameters of irradiation to improve the safety and quality of Chinese dumpling and Wuxi chop.
GHANA

IRRADIATION OF PREPARED MEALS FOR MICROBIOLOGICAL SAFETY AND SHELF-LIFE EXTENSION

Chief Scientific Investigator
Josephine Nketsia-Tabiri, (Ph.D)
Food Research Institute
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RESEARCH TEAM
Abraham Adu-Gyamfi
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RATIONALE

Prepared meals sold from homes, markets and lorry stations play a major role in the delivery of nutritious foods to majority of Ghanaians. With increasing urbanization, and its associated busy life-style, the demand for prepared meals is on the ascendancy. Although the formal and more refined prepared meals outlets such as restaurants and fast food joints are increasing, the informal alternatives, referred to as “street foods” continue to enjoy a higher patronage. A survey on the street food business revealed that many of the operators are unskilled women of low-income status with no formal training in good hygienic practices in the production and sale of prepared meals. It is note-worthy that *Staphylococcus aureus* and *Clostridium botulinum* have been isolated from *waakye* (a popular street food) on sale under ambient conditions in markets. Further studies are needed not only to substantiate these observations but also determine the impact of refrigeration and freezing on the microbiological safety and shelf-life of *waakye* and other popular street foods. Limited studies on *waakye*, indicated that the cooking applied is adequate only for eliminating vegetative bacteria but not spores. Clearly there is a need to identify procedures/processes, including irradiation, which can improve the microbiological safety and increase the shelf-life of such prepared meals without compromising product quality. These studies will be needed for the realization of the dreams of consumers who would want to buy some street foods, such as *waakye*, with better safety and quality assurance, from supermarkets or refined fast food outlets, for immediate consumption or at a later date.
PRODUCTS

1. *Waakye* (co-boiled rice & cowpeas) and
2. Jollof Rice
   Both Served with:
3. Fried fish or chicken, Gravy, Macaroni

OBJECTIVES

**Overall**
To determine the impact of irradiation on the microbiological safety and shelf-life of the prepared meals under ambient, chilled and frozen conditions.

**Specific**
- To develop protocol for the hygienic production and packaging of the prepared meals.
- To determine the microbiological shelf-life and sensory quality of the prepared meals under ambient, refrigerated and frozen storage conditions.
- To develop protocols for the irradiation of the prepared meals
- To standardize processing procedures for the delivery of high quality marketable irradiated prepared meals

WORKPLAN

**Initial 1 - 3 Years**
- Development of protocols for the hygienic preparation and packaging of one of the two prepared meals.
- Conduct shelf-life studies on the prepared meals stored under ambient, refrigeration and frozen conditions
  - Microbiological examination (guided by the suggestions of this RCM)
  - Sensory evaluation (guided by the suggestions of this RCM)
- Determination of radiation sensitivity of spoilage and pathogenic microbes on the prepared meals based on literature and actual experiments (where not available) or for verification purposes.
- Determination of protocols for irradiation processing of the prepared meals (guided by the suggestions of this RCM)
➢ Conduct shelf-life studies on irradiated prepared meals under specific storage conditions

Microbiological examination (guided by the suggestions of this RCM)
Sensory evaluation (guided by the suggestions of this RCM)

➢ Cost-benefit studies on the production of good quality and microbiologically safe prepared males.

4th and 5th Year
Repeat above for the other prepared meals.

PRELIMINARY RESULTS

Preliminary analysis indicate that the waakye, currently being offered for sale under ambient conditions, has poor microbiological quality. The current cooking conditions are adequate for the inactivation of vegetative bacteria but not spore-formers.

Microbes of public health significance that have been isolated from waakye, include Staphylococcus aureus and Clostridium perfringens.

EXPECTED OUTCOME

- Protocols for the hygienic preparation and packaging of the prepared meals.
- Protocols for the production of irradiated prepared meals
- Validated protocols for the microbiological examination of the prepared meals.
- Validated protocols for the sensory evaluation of the prepared meals
- Cost-benefit data for the production of quality and safe prepared meals
HUNGARY

IMPROVEMENT OF MICROBIOLOGICAL SAFETY AND SHELF-LIFE OF SELECTED CHILLED READY MEALS

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Dept. of Refrigeration & Livestock Technology
Szent István University, Budapest, Hungary

RATIONALE

There is a growing interest to market semi-prepared and prepared meals packaged in modified atmosphere packaging (MAP) and distribute under chilled conditions. Such products are less energy-demanding and more attractive for the consumers than frozen meals. However, they are non-sterile and potential survival of pathogenic microorganisms and post-processing contamination before packaging create microbiological risks and much limitation of shelf-life, especially under abusive temperature conditions, frequently occurring during retail display period and home storage.

OBJECTIVE

Demonstration of the feasibility of preventing the above risk in products by gamma radiation in such products as reconstituted breaded turkey breast meat with cheese and ham filling (“Cordon Bleu”) and intermediate moisture filled pasta products (“Tortellini” and “Ravioli”).

WORK PLAN

Year 1

- literature survey on the microbiological ecology of the above products;
- identifying critical spoilage and pathogenic bacteria which are capable of growing in these products;
- testing microbiological quality and shelf-life of unirradiated products under intended marketing conditions;
- testing the role of MAP gas-composition conditions in the storability and quality maintenance;
- initial studies on the effect of irradiation on the microbiota and sensorial quality;
- estimation of maximal acceptable radiation dose from the point of view of sensorial quality.
Working plan for additional years of the project duration

- challenge testing (inoculated pack studies):
  - with Cordon Bleu, using *Listeria monocytogenes* and psychrotrophic *Bacillus cereus* spores;
  - with pasta products using *Staphylococcus aureus* as inoculum;
  - estimating lethality values of the target organisms at selected radiation doses;
  - studies on shelf-life of irradiated products under proper and abusive temperature conditions;
  - testing lipid oxidation and thiamin retention during storage studies;
  - checking the advantage of using radiation decontamination of critical ingredients before production of the meals.

PRELIMINARY RESULTS

- microbiological shelf-life of unirradiated products at 4°C and 8°C storage temperatures, respectively;
- determining maximal sensorially acceptable radiation doses;
- estimation of irradiation effect on the main components of the native microbiota.

EXPECTED OUTCOME

- demonstration of technological feasibility of radiation processing for assuring microbiological safety and improving storage stabilities of the chilled (semi-) prepared meals.
USE OF RADIATION TO IMPROVE THE SAFETY AND QUALITY OF PREPARED MEALS

Chief Scientific Investigator: Dr. A.K. Sharma
Head, Food Technology Division, Bhabha Atomic Research Centre

Co-Investigators: Dr. Ramesh Chander, Dr. S. Chawla, Ms. Sweetie Kanatt, Ms. Siddhi Jadhav

RATIONALE

The Indian unleavened bread (chapati) is a low water activity product like bread. On storage it is prone to fungal spoilage. The origin of fungal contamination could be air or the packaging material. Radiation processing of freshly made packed chapatti could control fungal spoilage and extend its shelf-life. Packed chapattis are already available in retail markets in India. Slightly tempered dry vegetables/pulses (or sprouted pulse) are consumed regularly in India. It is prone to spoilage on prolonged storage primarily due to bacterial activity. It will be endeavored to extend the safety and shelf-life of such a preparation at low temperatures using gamma radiation. Rice dish pulav or biryani, containing both vegetables and meat are commonly consumed as complete meal especially in cities. Shelf-life and microbiological safety are major concerns in retailing these products through super markets. Radiation processing would be used to extend the shelf-life of this product under low temperature (chilled storage).

Many of the Indian sweet meets prepared from milk have been found to have contamination of pathogens, especially Staphylococcus aureus. It is planned to use radiation processing to eliminate this contamination and ensure the safety of the product, and make it ambient stable.

It is planned to standardize the preparation of recipes for the above products for making them amenable for radiation processing. Packaging material and radiation processing parameters, and post-processing storage regimes would be standardized for the above products. Storage and consumer acceptance studies would be conducted for developing the final protocols for product development.

WORK PLAN FOR THE FIRST YEAR

- Identification of meal menus
  The meal menus will be identified with the help of collaborators. The recipes and conditions for preparation of the meal menus will be standardized.
• **Identification of suitable packaging material**
  The packaging material would be identified with a molding device. Appropriate molding would be done to accommodate the meal menus. The cover and secondary packaging would be designed.

• **Base line studies**
  Base-line studies would be carried out with each of the items in the meal menus to evaluate:
  - Microbiological parameters
  - Chemical parameters
  - Sensory attributes

• **Study of the effect of process parameters on the items of the meal menus**
  The effect of process parameters such as dose and temperature during irradiation on the microbiological, chemical and sensory quality of the items of the meal menus would be studied.

**WORK ALREADY DONE**

Though extensive work has been done in the area of preservation of primary foods by radiation processing in this institute, the work on prepared meals is rather limited. However, some work has already been initiated at FTD, BARC, on radiation preservation of intermediate moisture meat products under an IAEA-CRP. The experience gained under this CRP would be useful in the new CRP.


**The milestones for the first year**

- Identification of meal menus and packaging materials (August 2002)
- Base-line studies on individual items of the meal menus (December 2002)
- Study on the effect of process parameters on the quality parameters (June 2002)

**FUTURE WORK**

Standardization of the process parameters and sensory evaluation and acceptability studies would be carried out.
INDONESIA

IRRADIATION TO ENSURE THE SAFETY AND QUALITY OF HOME STYLE PREPARED MEALS

Chief Scientific Investigator
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RATIONALE

a) Microbiological profiles of traditionally prepared meals e.g. black soup, ox-tail soup, chicken and vegetable soup and chicken sweet corn soup
b) Effects of irradiation of these prepared meals in terms of microbial reduction, and shelf-life extension either under refrigeration or chilled condition
c) Sensory quality of irradiated prepared meals

PRODUCT

Home style prepared meals e.g. black soup, ox-tail soup, chicken and vegetable soup and chicken sweet corn soup

OBJECTIVE

To evaluate the effectiveness of irradiation as a method to ensure microbiological safety and extend the shelf-life of traditionally prepared meals stored under refrigeration and chilled condition

WORK PLAN

Year 1
• To conduct survey on microbiological evaluation of control and irradiated commercial prepared home style frozen foods and some chemical characteristic evaluation of the products.

Year 2
• Self-making home style prepared meals, selecting proper packaging material, irradiation in order to get information on the threshold radiation dose and optimum radiation condition, microbiological assessment and chemical characteristic evaluation on the products.

Year 3-4
• Continuation of the activity, sensory evaluation, and data compilation.
Year 5

- Applying the finding proper irradiation condition, packaging both in contact and secondary packaging materials and propose a new brand name into safe and convenience home style prepared meals ready for consumer with the dose below 10 kGy.

EXPECTED OUTCOMES

- This study will support and give more valuable information on the food security and food safety of home style prepared meals in particular for traditional produce for local government approval for irradiated foods in Indonesia.
HACCP AND SACCP PROTOCOLS FOR READY-TO-EAT MEALS PASTEURISED WITH IONISING RADIATION

Chief Scientific Investigator
Dr. Yair Haruvy
Soreq Nuclear Research Centre
Israel Atomic Energy Commission

RATIONALE
Necessity to identify, *ab-initio*, critical potential failure modes: Hazardous, Sensory, as well as Economic, and assign Critical Control Points to detect and/or eliminate them in due time and course.

PRODUCT
All current RCM types of Ready-to-Eat Meals Pasteurised with Ionising Radiation

OBJECTIVES
To assist in structuring effective (H-S-E) ACCP for all other RCM projects;
To structure a general comprehensive yet effective (H-S-E) ACCP protocol for Ready-to-Eat Meals Pasteurised with Ionising Radiation

PRELIMINARY RESULTS
Preliminary SACCP could be orchestrated along the existing HACCP lines with relatively minor modifications. Care should be taken to avoid overlooking of high-risk failure modes, as well as to avoid overdoing the analysis to yield numerous CCPs with small marginal value. A combined H-S-E ACCP protocol should allow for a facile analytical tool of the objective projects.

Primary fields of failure modes seem to be non-uniformity of ingredients, processing and testing.
WORK PLAN (1st year)

Receive preliminary process protocols from all other RCM projects and structure effective (H-S-E)ACCP preliminary documents for them. Further, accumulate an inventory of common CCPs in the field of Ready-to-Eat Meals Pasteurised with Ionising Radiation.
KOREA

MICROBIOLOGICAL SAFETY AND SHELF-LIFE EXTENSION OF KOREAN TRADITIONAL PREPARED MEAT PRODUCTS, BULGOGI AND GALBI USING IRRADIATION

Chief Scientific Investigator:
Cheorun Jo
Radiation Food Science and Biotechnology
Korea Atomic Energy Research Institute,

RATIONALE
Series of outbreaks of food borne diseases in Korea makes industry more careful about the food safety and quality of the products. The most popular prepared meat products in Korea, Bulgogi and Galbi are getting more commercially available in the market including catering services. However, the proper shelf-life and microbiological safety of the commercial products are not well understood.

PRODUCTS

Bulgogi: Korean traditional shredded and marinated beef
Galbi: Korean traditional barbecued rib with pork or beef

OBJECTIVES

• Evaluation and development of optimum irradiation processing procedure
• Assurance of the safety of Korean traditional prepared meat products, Bulgogi and Galbi by irradiation with proper sensory requirement to meet the consumer’s satisfaction
• Development of HACCP protocol including irradiation process

WORK PLAN

1. Obtaining background information about microbiological problem from raw and fresh materials and conducting the sauce pasteurisation by irradiation to control the pathogen and spoilage bacteria with shelf-life extension.
2. Irradiation application to marinated Bulgogi and Galbi products at chilled conditions.
3. Irradiation application to fully cooked and ready-to-eat Bulgogi and Galbi at chilled and frozen conditions
4. Optimization of the processing procedures and development of HACCP and SACCP protocols.

PRELIMINARY RESULTS

- Initial contamination of raw materials for Bulgogi sauce making was quite high, especially in fresh vegetables such as garlic, onion, and green onion.
- Irradiation at 2.5, 5.0, and 10 kGy was effective to control the spoilage or pathogenic bacteria.
- Irradiating the Bulgogi sauce was better in terms of preserving the relative protease activity than that of heat-treated.
- No significant difference was found in pH and electron donating ability in Bulgogi sauce among the irradiated with different doses and heat-treated samples.

EXPECTED OUTCOMES

- Processing procedures using irradiation to produce the Korean traditional meat products, Bulgogi and Galbi, with proper consumer’s quality standard.
- HACCP and SACCP protocol for the Korean traditional meat products, Bulgogi and Galbi.
MALAYSIA

USE OF IRRADIATION TO IMPROVE THE SAFETY AND QUALITY OF PREPARED MEALS

Chief Scientific Investigator:  
Dr. Noraini Mohd Khalid,  
Food Technology Research Centre, Malaysian Agricultural Research and Development Institute (MARDI)

RATIONALE

Very limited data is available to indicate the effectiveness of irradiation to improve the microbiological safety, quality and shelf life of prepared meals, whether they are stored at ambient, chilled or frozen temperature.

Irradiation has been successfully applied to various foods aimed at improving food safety and reducing food spoilage. Irradiation process, however, is not suitable for all products. Food high in fat develop off-odours and tastes due to accelerated development of rancidity, even at relatively low doses. High protein foods also undergo changes in flavour and odour after irradiation. These effects could be minimized by irradiating food at chilled or frozen temperatures.

In 1997, a Study Group convened by the Joint FAO/IAEA/WHO discussed the safety and nutritional consequences of using high dose irradiation to treat foods. The Study group concluded that high dose irradiation, following both GMP and Good Irradiation Practices (GIP) could be applied to pre-packaged pre-cooked foods to make them shelf stable for extended periods. Irradiation, therefore, offers a potential to improve the microbiological safety and shelf life of chilled prepared meals.

PRODUCTS

The most promising category of chilled and frozen foods are prepared meals and ethnic frozen foods which have double digit growth in the past few years in Malaysia. Prepared or ready-to-serve meals are complete meals that can be served and consumed with little or no preliminary preparation other than reheating, garnishing and plating to increase their palatability and acceptance. Ready-to-serve meals comprise of primary and complementary dishes. Primary dishes would include rice, meat or fish. Complementary dishes could be vegetables, sauce or side dish.

In this study, the products to be developed are:

i) Beriani rice } primary dish

ii) Chicken kurma }
iii) Fruit chutney  } complementary dish

OBJECTIVES

Overall

- To evaluate the effectiveness of irradiation technology, either exclusively or in combination with chilling or freezing, as a method to ensure microbiological safety and extend the shelf-life of prepared meals, stored either under ambient, chilled or frozen conditions
- To evaluate the sensory quality of treated products to detect changes in flavour, odour, taste and acceptability after irradiation

Specific

- To develop a complete meal comprising of rice, meat and side dish
- To use validated procedures for irradiation of pre-cooked, pre-packaged chilled meals
- To use validated methods for microbiological evaluation of irradiated prepared meals stored at chilled temperatures to determine the effectiveness of irradiation as a process to ensure microbiological safety
- To evaluate the sensory qualities of treated products and determine their shelf life.

WORK PLAN (5 Years)

A) Development of pre-cooked chilled meals packed in suitable packaging materials
   a. Trials to develop optimum formulation for beriani rice, chicken kurma and fruit chutney
   b. Establish processing parameters for chilled preservation of these products
   c. Microbiological evaluations of the chilled products – total viable counts, coliforms, yeast & molds
   d. Sensory evaluation of chilled products – 9 point hedonic scale
   e. Reformulation of products based on results of sensory evaluation and to suit chilling process

B) Irradiation of chilled foods
   a. Determine irradiation dose for optimum product quality – 0,1,2,3 kGy
   b. Sensory evaluation of products immediately after irradiation
c. Reformulation of products based on results of sensory evaluation to suit irradiation process

d. Sensory, microbiological and physical evaluation of products immediately after irradiation

C) Shelf life and storage studies

a. Quality evaluation of products after chilling and irradiation
   - Physical analysis
   - Microbiological analysis
   - Organoleptic analysis using a 9-point Hedonic scale for odour, flavour, texture, colour, taste, overall acceptability

b. Determination of shelf life of irradiated products
   - At weekly intervals for 4 weeks – samples will be analysed for microbiological, physical and sensory qualities

D) Optimization studies based on data collected from chilling and irradiation steps

PRELIMINARY RESULTS

Formulation trials have been conducted on the development of our pre-cooked frozen TV-dinners, each combination comprising of rice, vegetable and meat items. These complete dinners were packed in 3-compartment aluminium trays, frozen cryogenically to an internal food temperature of –18°C.

EXPECTED OUTCOME

Pre-cooked chilled irradiated meal with extended shelf life or 3-4 weeks stored at below 4°C.
SOUTH AFRICA

USE OF IRRADIATION TO IMPROVE THE SAFETY AND QUALITY OF ETHNIC SOUTH AFRICAN FOODS

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University of Pretoria

Co-investigators
Ms Sue Pinches
FSTP programme
CSIR – Bio/Chemtek

RATIONALE

South Africa is a multi-cultural country with different eating habits and food preferences. Traditional African foods such as beef and chicken tripe form a part of the diet of black South Africans. These foods are laborious to prepare, not generally available commercially, and have limited shelf life. Other popular ethnic foods in South Africa include meat products such as “biltong” (intermediate moisture dried meat) and “boerewors” (spicy sausage) consumed by all population groups. These foods have the potential to cause food poisoning. Very limited information is available on the microbial ecology of these ethnic foods. Moreover, no significant research has been conducted on the use of irradiation to improve the microbiological safety and increase shelf life without adversely affecting sensory quality.

PRODUCT

Tripe, “boerewors”, “biltong”, Malaysian curried meals

OBJECTIVES

Overall

To determine the effect of irradiation, alone and in combination with other processing technologies, on the microbiological and sensory quality of selected, refrigerated, ethnic South African foods and/or meals.

Specific

To determine the potential pathogenic and spoilage micro-organisms on the basis of intrinsic and extrinsic factors of selected foods.
To establish the irradiation processing parameters to be used to render the foods safe.
To determine the threshold irradiation dose levels to retain sensory quality characteristics.
To determine the effect of irradiation in combination with other processing hurdles on the microbiological safety, shelf life and sensory quality of foods.
WORK PLAN

Years 1 and 2: Tripe

To extend the shelf life of refrigerated cooked tripe using irradiation processing

- Determine and optimise the unit operations involved in preparation of conventionally cooked tripe.

- Determine the intrinsic properties of raw and cooked tripe (i.e. pH, aw) and identify potential pathogenic and spoilage microorganisms associated with the food product at normal (5 °C) and abusive chilled stored conditions (15 °C).

- Determine the irradiation dose needed to render the product safe from pathogens (e.g. *E. coli* 0157) and to reduce spoilage microorganisms to acceptable levels.

- Determine the effect of the pre-determined irradiation dose on the sensory characteristics and/or acceptability of the prepared product.

- Select appropriate irradiation doses based on steps 3 and 4 together with other hurdles (e.g. packaging, use of antimicrobials) to render the product safe.

- Verify the process by challenge testing with appropriate organisms (e.g. *E. coli* 0157).

- Determine the shelf life of the irradiated samples at normal and abusive chilled storage temperatures.

- Determine the consumer sensory acceptance of the irradiated tripe samples.

Years 3 to 5

The principles of previous work will be applied to the other selected ethnic South African foods

EXPECTED OUTCOMES

To provide the South African food industry with the necessary scientific information to ensure the safety and to improve shelf life of selected chilled, ethnic South African foods using food irradiation.
SYRIA

EFFECT OF GAMMA IRRADIATION ON MICROBIAL LOAD, CHEMICAL, AND SENSORY CHARACTERISTICS OF SYRIAN PREPARED MEALS

Chief Scientific Investigator
Dr. M. Al- Bachir
Dept. Of Radiation Technology
Syrian Atomic Energy Commission

RATIONALE

The Syrian consumers have recently started using prepared meals that are prepared and marketed in local super markets. Since the shelf stability of such meals is limited, the gamma irradiation treatment may solve the above problem, including improving the storability quality and safety.

PRODUCT

Syrian prepared meals including Kobba and Borak.

OBJECTIVE

The main objective of the project are to investigate the effect of low doses of gamma irradiation on improving the storability and safety of prepared meals and evaluate the effect of the treatment on microbial, chemical and sensory characteristics of Syrian prepared meals.

WORK PLAN

2002
Participated in the first co-ordination meeting to discuss the subject with other participating counties, this would enable use to develop sound objectives, experimental design and the techniques to be employed as well as definitions of equipments and materials to be used for the coming years.

2003
Literature survey on the use of irradiation for reducing microbial load and improving quality of prepared meals.
Identifying the kinds of prepared meals used in the experiments.
Determine the microbiology quality, chemical and sensory properties of the selected meals.
Estimation of the maximum acceptable radiation dose from the point of view of sensory quality.
2004
Kobba will be used in the experiment

2005
Borak will be used in the experiment.

2006
Final report of the project

EXPECTED OUTCOME

Ensure the microbiological safety and shelf-life extension of Syrian prepared meals namely Kobba and Borak.
THAILAND

USE OF IRRADIATION TO IMPROVE THE SAFETY AND QUALITY OF THAI PREPARED MEAL

Chief Scientific Investigator
Prof. Athapol Noomhorm
Food Engineering and Bioprocess Technology
Asian Institute of Technology, Thailand

RATIONALE

There is a dynamic growth of market for chilled prepared meals in Thailand because of the growth of food services in supermarkets and convenient stores. However, the shelf life of this food is short furthermore it is implicated in a number of serious foodborne disease outbreaks.

Irradiation could provide a potential to improve the microbiological safety and extend the shelf life of chilled prepared meals. It is possibly used alone or together with chilling. With the combination of irradiation and chilling, frozen condition could be replaced resulting to saving in energy and cost. However, there is a limitation of information about the application of irradiation on chilled prepared meals. Also, information relevant to the application of food safety control system like Hazard Analysis and Critical Control Point (HACCP) should be gathered to ensure more safety of the irradiated prepared meals.

For Thai dishes, they are normally composed of herb and spicy with different types of meat. All dishes are eaten along with rice. Both Thai aromatic rice and herb are susceptible to deterioration in quality by processing factors. Therefore, the study of the effect of irradiation on Thai dishes, which compose of these two components, is necessary

PRODUCT

Thai spicy basil rice with chicken

OBJECTIVES

Overall
- To investigate the use of irradiation for extending shelf life;
- To ensure microbiological safety of chilled prepared meal
- To enhance collaboration with local industry
Specific

1. To determine the effect of low dose irradiation to ensure microbiological safety of Thai spicy basil rice stored under chilled conditions.

2. To evaluate the quality (physical, chemical quality and palatability) of chilled Thai spicy basil rice after irradiation to determine optimum doses

3. To determine the shelf life of irradiated chilled Thai spicy basil rice under chilled condition

4. To gather information relevant to the application of Hazard Analysis and Critical Control Point (HACCP) system in the process of Thai spicy basil rice

**WORK PLAN: (5 yrs)**

Phase I:

1). To identify the Thai traditional dish with different combination of cooked rice, meat i.e. chicken, Thai herb (basil leaf), ingredient, gravy

2). To investigate the pre-treatment of each composition such as precooking method of cooked rice and packaging material

3). To find the appropriate dose for each composition

4). To identify the technique of microbiological analysis for each composition

5). To evaluate the quality (physical, chemical quality and sensory) of the product

6). To find information for feasibility of commercial production

Phase II:

1). To follow up the above procedures with the appropriate dose processed

2). To investigate on the shelf life of irradiated product under chilled condition

Phase III

1) To gather information on the application of HACCP in the process

2) To compare the irradiated chilled Thai dish with the frozen product in term of quality and cost of production
PRELIMINARY RESULTS

Irradiation (1 to 4 kGy) causes significant changes in qualities of cooked rice and spicy chicken basil. It could significantly reduce microbial population. However the applied dose should be limited to be accepted by consumers. Dose of 1 and 3 kGy was found as optimum dose for cooked rice and spicy chicken basil. During storage under chilled condition, the qualities of cooked rice and spicy chicken basil changed. Based on microbial quality, irradiated samples could be kept for much longer than 4 weeks. However, sensory quality was adversely affected by both irradiation and storage time. Cooked rice was rejected at not more than 3 weeks for both irradiated and non-irradiated sample. The spicy chicken basil was rejected sooner with shelf life around 7 days of storage.

EXPECTED RESULTS

To come up with the irradiated chilled Thai dish prepared meal with the shelf life of at least 4 weeks and to apply HACCP system in the process
UNITED KINGDOM

USE OF LOW-DOSE IRRADIATION TO ENHANCE THE SAFETY AND QUALITY OF CHILLED READY MEALS

Chief Investigator
Eileen M Stewart
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Queen’s University Belfast (QUB)

Co-investigator
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(DARD) Newforge Lane,
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RATIONALE

The market for ‘cook-chill’ ready meals has expanded significantly during the past ten years. This specific category of food has been defined as a catering system based on the full cooking of food followed by fast chilling and storage in controlled temperature conditions (0-3ºC) and subsequent thorough re-heating before consumption. Such meals cover a wide range of commodities including meat, poultry, fish, vegetables, pasta and desserts and are used at home by consumers and by the catering industry for use, for example, as hospital meals or meals-on-wheels. These products have a relatively short shelf-life with a recommended maximum shelf-life of 5 days at 0-3ºC including the day of cooking. In addition, there are other concerns with regard to microbiological quality, reduced sensory quality and decreased nutritive value. It has been suggested that low-dose irradiation could be used to extend the shelf-life of these products while at the same time reducing the risk of food poisoning.

OBJECTIVES

Research carried out at QUB and DARD has readily demonstrated that the safety and shelf-life of chilled ready meals consisting of meat (chicken, beef or pork) and certain vegetables (e.g. broccoli, carrots and roast potatoes) can be enhanced by irradiation doses of 2 or 3 kGy without having a detrimental effect on sensory or nutritional quality. To date, investigations have been limited to such traditional meals with no research being carried out on the more popular ready meals such as lasagna, cottage pies, curries, etc. which have a relatively short shelf-life upon purchase. It is therefore the objective of this work program to investigate the effect of low-dose irradiation (1-5 kGy) on the microbiological, sensory and nutritional quality of these meals and to determine if their overall quality can be enhanced.
WORK PLAN

Year 1

- Select type of ready meals for investigation in consultation with a local processor in Northern Ireland. Initially, one meal will be selected for analysis.
- Calculate $D_{10}$ values for pathogenic bacteria such as *E. coli* and *Salmonella* spp. using standard methods. The irradiation temperature will be 4°C and there will be a standard inoculation procedure.
- Determine the microbiological quality of the selected meal (irradiated and unirradiated) stored at 3°C and 10°C for up to 14 days. Lipid oxidation studies will be carried out in parallel using selected tests. Time permitting, the effect of the processing treatments on the vitamin content of the meals (e.g. thiamin and ascorbic acid) will be investigated.

FUTURE WORK

- Select further meals for treatment and carry out tests as outlined for Year 1.
- Carry out sensory testing of the meals determined to be most appropriate for radiation processing.

PRELIMINARY RESULTS

At present no research has been carried out on this project.

EXPECTED OUTCOME (after 5 years)

To have determined the usefulness of low-dose irradiation on the microbiological safety, shelf-life, sensory quality and nutritional quality of a range of popular chilled ready meals. It is also anticipated that the optimum radiation processing conditions for such products will be established.
UNITED STATES

CONSUMERS’ WILLINGNESS TO PAY FOR IRRADIATED PREPARED FOODS

Chief Scientific Investigator
Dr. Rodolfo M. Nayga
Professor, Department of Agricultural Economics
Texas A&M University

RATIONALE

Assessing the marketing and economic feasibility of irradiated prepared foods

PRODUCT

Irradiated prepared meat product (e.g., rotisserie chicken or one of HEB Supermarket’s newest pre-cooked vacuum packed convenience meat product)

OBJECTIVES

Overall

To evaluate and assess consumers’ willingness to pay for irradiated prepared meat products

Specific

(1) To examine the factors affecting consumers’ willingness to pay for irradiated prepared meat products

(2) To determine a profile of consumers who are most likely to pay for irradiated prepared meat products

(3) To segment consumers according to whether they are strong buyers, interested, doubters, or rejecters and to determine change in their position/segmentation before or after presentation of information about food irradiation.

WORKPLAN

Year 1

- Develop survey instrument
- Pre-test survey instrument
- Conduct survey – personal intercept interviews in HEB supermarkets in selected Texas cities
- Code data
Year 2

- Conduct statistical and econometric analysis of survey data
- Write paper(s) for scholarly journal(s)

Years 3-5

- Present findings of study conducted in years 1-2 to HEB executives and work with them on follow-up marketing study if they decide to develop and sell irradiated prepared meat products in their supermarkets
- Guide or help conduct marketing and economic feasibility studies of selected products being studied by other RCM participants

EXPECTED OUTCOMES:

- Study will be able to help assess and evaluate economic and marketing feasibility of irradiated prepared meat products

Segmentation of consumers willing to pay a premium for irradiated prepared meat products
Annex I

First Research Co-ordination Meeting on
“Irradiation to Ensure the Safety and Quality of Prepared Meals”

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Annex II

First RCM on Irradiation to Ensure the Safety and Quality of Prepared Meals

Programme

Monday, 10 June

9.00 Opening

9.30-17.00 Workshops

- Global development on food irradiation. P. Loaharanu (FAO/IAEA)
- Methodologies for determining pathogenic bacteria in irradiated prepared meals. J. Farkas (Hungary)
- Methodologies for determining shelf-life of irradiated prepared meals. A. Minaar (South Africa)
- Methodologies for determining nutritional values of irradiated prepared meals. E. Stewart (UK)
- Determining consumer acceptance of irradiated prepared meals. R. Nayga (USA)
- Quality assurance procedures for radiation processing of prepared meals. Y. Haruvy (Israel)

Tuesday, 11 June

9.00-12.00 Session I: Microbiological Safety

- Improvement of the microbiological safety and shelf-life of selected chilled meals by gamma irradiation. J. Farkas (Hungary)
- Irradiation of prepared meals for microbiological safety and shelf-life extension. J. Nketsia-Tabiri (Ghana)
- Irradiation to ensure the safety and quality of prepared meals. A. Sharma (India)
- Use of irradiation to improve the safety and quality of prepared meals. N. Khalid (Malaysia)

12.00-13.30 Lunch
13.30-17.00 Session II: Irradiation of Traditionally Prepared Meals
- Use of irradiation to improve the safety and quality of ethnic South African foods. A. Minnaar (S. Africa)
- Irradiation to ensure the safety and quality of home-style frozen foods. I. Koenari (Indonesia)
- Use of irradiation to improve the safety and quality of Wuxi and Chinese dumplings. B. Sun (China)
- Microbiological safety and prolonged shelf-life of Korean traditional prepared meals, Bulgogi and Galb, by irradiation. C. Jo (Rep. of Korea)
- Use of irradiation to improve the safety and quality of prepared meals in Syria. M. Al-Bachir (Syria)

Wednesday, 12 June
9.00-12.00 Session III: Quality Enhancement and other Special Considerations
- Use of low-dose irradiation to enhance the quality and safety of chilled ready meals. E. Stewart (N. Ireland)
- Safer prepared meals for immunocompromised patients and the general consumer, by gamma irradiation. P. Narvaiz (Argentina)
- Use of irradiation to improve the safety and quality of prepared meals. A. Noomhorm (Thailand)
- Consumers’ willingness to purchase irradiated prepared meals. R. Nayga (USA)
- HACCP and SACCP protocols for ready to eat meals pasteurised with ionising radiation. Y. Haruvy (Israel)

12.00-13.30 Lunch
13.30-17.00 Group Discussions on Work Plans for the next 5 years:
I. Inactivation of pathogenic bacteria in irradiated, chilled-prepared meals
II. Shelf-life extension of irradiated traditionally prepared meals
III. Quality control/quality assurance of irradiated prepared meals
IV Acceptance of irradiated prepared meals

Thursday, 13 June
9.00-17.00 Group Discussions – Report Preparation
Friday, 14 June

9.00-12.00  Review of reports of Working Groups
12.00-13.30  Lunch
13.30-16.00  Adoption of RCM report

*Closing*
ANNEX III – PROTOCOLS

PROTOCOLS FOR SENSORY QUALITY OF IRRADIATED FOODS AND/OR MEALS

1. USE OF ANALYTICAL SENSORY EVALUATION TESTS (using trained panellists)

Analytical discrimination sensory tests (using 30-50 panellists trained for the task) should be used to determine whether there are significant differences between irradiated and non-irradiated samples. The degree of difference could also be measured. Descriptive sensory tests may be used to describe the perceived sensory characteristics of irradiated and non-irradiated foods and/or meals. Ten to twelve panellists trained in generic descriptive analysis are required to do this.

These analytical sensory techniques will provide useful information during (a) Product optimisation and/or development and (b) Shelf life testing of irradiated foods and/or meals. Microbiological safety of samples must be 100% guaranteed before commencing with any sensory analysis tests.

2. USE OF CONSUMER SENSORY EVALUATION TESTS (using target consumers)

Consumer sensory evaluation tests should be used to determine whether the irradiated foods and/or meals are considered to be acceptable by the target consumers. These tests are used when one needs to answer question relating to (a) like or dislike and/or (b) preference of samples. At least 50 target consumers should be used. These tests should be conducted only after microbiological safety and shelf life studies have been conducted.

2.1 How much do consumers like the samples? (using e.g. a 9-point hedonic scale)

Example of score sheet:

Consumer sensory evaluation of tripe

<table>
<thead>
<tr>
<th>Set number:</th>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age:</th>
<th>Male / Female:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education:</th>
<th>Ethnicity:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Instructions: You have received 3 samples of tripe. Please evaluate the samples from left to right. Please indicate with an “X” in the appropriate block, how much you like or dislike the odour / appearance / colour / texture / taste of the following samples? How much do you like the samples overall? Drink some water and eat a carrot slice between samples to cleanse the palate.
<table>
<thead>
<tr>
<th>AROMA:</th>
<th>Sample codes</th>
<th>Decoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like extremely</td>
<td>395</td>
<td>9</td>
</tr>
<tr>
<td>Like very much</td>
<td>297</td>
<td>8</td>
</tr>
<tr>
<td>Like moderately</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Like slightly</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Neither like nor dislike</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Dislike slightly</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Dislike moderately</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Dislike very much</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Dislike extremely</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

### 2.2 Preference testing:

2 samples only: Which of the two samples do you prefer and why? (i.e. paired preference test)

More than 2 samples: Please rank the following samples according to preference (i.e. ranking test)

```
most liked             least liked
```

Marketing and economic research protocols should be adopted to compliment consumer sensory evaluation results. It is recommended that the protocol should be presented and discussed during the next RCM meeting.

### 3. GOOD SENSORY PRACTICES

Good Sensory Practices (GSP) should be used regardless of whether analytical and/or consumer sensory evaluation tests are conducted.

Standardised procedures should be used in terms of

- Preparation equipment and sample preparation
- Use of appropriate dilutions and carriers, where applicable
- Serving temperatures
- Serving utensils
- Quantities served
- Number of samples presented per session
- Coding (use only 3-digit codes) of samples
- Random order of presentation
- Rinsing or neutralising
- Time of testing

It is recommended that the reference sample to be used during the shelf life storage testing should be a freshly prepared sample (i.e. the conventionally prepared control)
sample). It is also advised, from an ethical point of view, that panellists should be informed that samples to be evaluated, may have been irradiated.

Appropriate statistics should be used to analyse sensory data. This depends on the type of sensory data obtained. If data follow a normal distribution, parametric statistical tests can be used (e.g. ANOVA, t test). If data do not have a normal distribution, non-parametric statistics should be used (e.g. Wilcoxon test).

Consult appropriate sensory analysis statistical textbooks, sensory reference books as well as statisticians.

Finally, it is advisable to consult sensory experts if you are unsure about any procedures or protocols. Food Science departments at Universities might be able to help in this regard.

4. OTHER MEASUREMENTS FOR EVALUATING QUALITY

- Texture or rheological measurements using appropriate instruments, e.g. Instron, Brookfield viscometer.
- Colour measurements using tri-stimulus colorimeters.
- HPLC measurements for vitamins B1 and Vitamin C.
- Chemical analyses for lipid oxidation, e.g. peroxide values, TBARS.
- Other appropriate physical and chemical assays, e.g. pH, titratable acidity, nitrogen basic volatiles.

5. RECOMMENDED LITERATURE


MICROBIOLOGICAL PROTOCOLS FOR IRRADIATED PREPARED MEALS

1. ASSESSMENT OF THE PRODUCT FROM THE MICROBIOLOGICAL PERSPECTIVE:

Define the product concept and description including conditions of handling and target population

Consider:

*Intrinsic properties* (inherent properties of the food and food components)
- pH
- Water activity
- Redox potential

*Extrinsic properties* (product environment)
- Recontamination routes
- Storage temperature
- Packaging atmosphere
- Irradiation temperature

The intrinsic properties of the product and the way in which it is stored (extrinsic properties - product environment) predict the microbiological hazard (potential pathogens) present in the system. (Ref. 9)

In the case of combination processes such as pre-cooking and frying combined with irradiation, proper process control of these steps should be exercised and GMP adhered to at all times.

We need to determine and list the pathogenic bacteria that may occur and select those that may present the greatest risk, from the intrinsic and extrinsic factors (basic risk assessment) (Refs. 9 and 2) This information is the preliminary concept for microbiological safety.

It is important to do a literature survey in relation to our product concept, conditions of storage and for epidemiological information (Refs. 9, 1 and 2). In order to assess if identified organisms are an actual hazard in the foodstuff, computerized predictive model systems may be useful. These include the FoodMicroModel (UK) and the USDA predictive modelling system. These systems allow predictions of how targeted organisms are likely to behave under optimal conditions of nutrient availability (independent of the food matrix) under various parameters such as pH, water activity, gas concentration (MAP) and in the presence of various anti-microbials. The use of Predictive Models is useful at the product conceptualisation stage, during product development and for assessment.
2. SHELF-LIFE AND SAFETY DETERMINATION

For the intended irradiation processing, the effects of irradiation on the spoilage micro-flora, as well as the target pathogens selected according to the previous considerations, need to be investigated. The food safety objective and performance criteria (how many log cycle reductions of the relevant micro-organisms are required) need to be defined. The acceptability of the treatment from a sensory perspective needs to be evaluated.

Shelf life determination.

Determine at laboratory scale the shelf life according to the conditions of expected marketing. We need to do this under:

a. Nominal temperature of storage and/or display
b. Potential abuse temperature

For the shelf life studies, the total viable cell counts for both psychrotrophic and mesophilic micro-organisms need to be assessed, to indicate the permissible time of storage to a prescribed viable cell count level. From this the microbiological shelf life can be determined.

Challenge testing for safety assessment

Having obtained shelf life information we need to consider if the identified potential pathogens can grow and/or form toxin within that period. We need to assess the effects of treatment and storage on the targeted potential pathogenic organisms. To do this challenge tests need to be performed (Refs. 3 and 4).

3. METHODOLOGY FOR MICROBIOLOGICAL ANALYSIS

For this work recorded standard and validated methods should be used. Individual laboratories should verify that staff members are competent to perform analysis according to the validated methodology. If out-sourcing of microbiological analysis is necessary, it is preferable to out-source to accredited laboratories (Refs. 5 to 8)

Verification of the process by challenge testing

This is dependent on the facilities of the laboratory. Out-sourcing of challenge testing may be necessary if facilities are limited. Non-virulent strains of the identified pathogens, and indicator organisms should be used for the challenge tests. Do not use highly virulent organisms for challenge testing (Refs. 3 and 4).
4. RECOMMENDED LITERATURE:

**Microbiological ecology:**


**Challenge testing:**


**Methodologies:**


**General and Comprehensive:**
RECOMMENDED PROTOCOL FOR IRRADIATED MEALS AND/OR FOODS

A. Parameters

Source: Gamma sources. E-beam adaptation can be carried out at a later stage if desired.

Dose Rate: No specific recommendation for gamma sources, as long as desired temperature can be maintained throughout radiation processing.

Dose: 0, 1, 2, 3, 4 kGy for products to be consumed. Higher doses to be used for comparison purposes only. Note: Bio-burden reduction may be required for several ingredients to meet the combined safety and shelf-life goals.

Dosimetry: Accurate dosimetry calibrated to a national or international standard should be carried out at the actual conditions of irradiating the product, e.g. cooling chamber. The overdose ratio may also be reported.

Sensitivity: The minimum dose should be determined for assuring microbiological safety as well as the maximum dose acceptable for sensory quality.

Atmosphere: Minimizing oxygen levels as much as possible (oxygen data is needed).

Temperature: Preferably 0-4°C for chilled products, below -18°C for frozen products, where applicable.

Packaging: Polystyrene (PS) containers and lids which are heat-sealable.

Note: Laminated materials that comprise PS lining on both surfaces are also suitable.

Note: PS-Aluminium-PS laminates are available, but are forbidden for use in microwave ovens!

Note: Cling film wrapping is suitable for irradiation only if comprised of polyethylene-poly-acrylic-acid copolymer, but NOT poly-vinylidene-chloride.

Packaging heating testing: Should be carried out prior to irradiation experiments, under the re-heating conditions destined for the meal: microwave, oven, boiling water.

Food filling: Special care must be practiced to keep the sealing areas free from food.

Sealing: Three sealing lines are recommended to ensure leak-proof packaging.

Recommended: Up to 30 days for the product, up to 24 days after shelving, and up to 16 days for shelf-life: the consumer. Products should be labelled with “best before dd/mm/yy”.

B. Operation Steps

1. Lower bio-burden to allow for estimated safe shelf-life at doses up to 4 kGy.
2. Prepare ingredients (Steps 1 and 2 can be combined).
3. Prepare pouches or containers for packaging.
4. It is recommended that each ingredient should be filled separately while hot (>70°C).
5. Seal pouches three times.
6. Place in ice, using an insulated box equipped with drainage, to allow for fast cooling to 0-4°C. The internal temperature of the food should be verified employing dummy packages.
7. Irradiate while ensuring temperature of 0-4°C throughout the radiation processing.
8. Store at a secure location, ensuring temperature of 0-4°C throughout the storage.