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INTERNATIONAL CONSULTATIVE GROUP ON FOOD IRRADIATION

CONSULTATION ON MICROBIOLOGICAL CRITERIA FOR FOODS TO BE FURTHER PROCESSED INCLUDING BY IRRADIATION

29 May - 2 June 1989
WHO, Geneva

Held under the joint sponsorship of the

Food and Agriculture Organization of the United Nations,

International Atomic Energy Agency,

World Health Organization

WORLD HEALTH ORGANIZATION, GENEVA, 1989

INTERNATIONAL CONSULTATIVE GROUP ON FOOD IRRADIATION (ICGFI)

The International Consultative Group on Food Irradiation was established on 9 May 1984 under the aegis of FAO, IAEA and WHO. ICGFI is composed of experts and other representatives designated by governments which have accepted the terms of the "Declaration" establishing ICGFI and have pledged to make voluntary contributions, in cash or in kind, to carry out the activities of ICGFI.

The functions of the ICGFI are as follows:

a) to evaluate global developments in the field of food irradiation;

b) to provide a focal point of advice on the application of food irradiation to Member states and the Organizations; and

c) to furnish information as required, through the Organizations, to the Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food, and the Codex Alimentarius Commission.

At the time of the Consultation on Microbiological Criteria for Foods to be further processed including by irradiation, Geneva, 29 May - 2 June 1989, the following governments had become members of ICGFI:

Argentina, Australia, Bangladesh, Belgium, Canada, Chile, Côte d'Ivoire, Egypt, France, Federal Republic of Germany, Ghana, Hungary, India, Iraq, Israel, Italy, Malaysia, Mexico, the Netherlands, New Zealand, Pakistan, the Philippines, Poland, Syria, Thailand, Turkey, United Kingdom, the United States of America and Yugoslavia.

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1. INTRODUCTION

Dr W. Kreisel, Director, Division of Environmental Health, World Health Organization, welcomed the participants on behalf of the three parent Organizations of the International Consultative Group on Food Irradiation, FAO, IAEA and WHO. He emphasized that this consultation was not concerned with food irradiation _per se_, although its title might suggest this. Its objective was to define microbiological indicators for good manufacturing practices and its outcome would therefore be of interest to all concerned with food processing, and not just to those who are involved with food irradiation.

He reminded the participants that the more traditional food processing technologies such as pasteurization and other preservation methods were today fully accepted by consumers and regulatory agencies alike. But the fact that these traditional technologies could also be misused to clean-up "dirty" food, i.e. food that was not produced according to good manufacturing practice, did not seem to cause great concern. It was understandable, however, that a new technology does generate concern, particularly in the case of a so far undetectable process such as food irradiation, which leaves the food so treated almost unchanged.

It was because of the possibility of misuse that WHO had proposed to the International Consultative Group on Food Irradiation (IGCFI) in September 1988 that a consultation of this nature should be held. Holding it at this time was particularly opportune, bearing in mind that in December 1988 the Geneva Conference on Food Irradiation had adopted the DOCUMENT ON FOOD IRRADIATION[1]. This document recommended that governments ensure, as a prerequisite to any processing of food by irradiation or any sale of irradiated food, that regulatory procedures for control are introduced. The employment of good manufacturing practices was spelled out as one of the key principles for control. Dr Kreisel hoped that this consultation would arrive at some definition of microbiological criteria for use by both food control authorities and food processors and particularly by food irradiation plants.

This hope was expressed despite the results of earlier joint FAO/WHO consultations and working groups on microbiological criteria for food[2], which found that no public health benefit could be derived from defining microbiological criteria for raw foods.

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(1) Proceedings of the Joint FAO/IAEA/WHO/ITC-UNCTAD/GATT International Conference on the Acceptance, Control of and Trade in Irradiated Food, Geneva, 12-16 December 1988. IAEA, Vienna 1989

(2) Christian, J.H.B., Microbiological Criteria for Foods. Summary of Recommendations of FAO/WHO Expert Consultations and Working Groups 1975-1981, Unpublished WHO Document VPH 83.54.

As the consultation had been prepared with close collaboration between the joint FAO/IAEA/WHO secretariat and Dr Christian from Australia, Dr Kreisel asked for the agreement of the participants to request Dr Christian to act as Chairman of the consultation. He also proposed that Dr Roberts from the UK act as rapporteur. The participants concurred with these proposals.

The FAO Joint Secretary, Mr R. Dawson, felt that the consultation should not limit its deliberations to arrive at microbiological criteria for only those foods which would be further processed by irradiation. He pointed out that such criteria, if developed, should apply to all types of food processing whether it be freezing, pasteurization, irradiation or any other process. Also, such criteria should not differ for foods to be irradiated from those developed for foods to be further processed by other means. The importance of following good manufacturing practice was stressed. Mr Dawson also referred to the Codex Alimentarius Commission and proposed that the outcome of this consultation should be presented to the Codex Committee on Food Hygiene for further elaboration.

2. CONCERN REGARDING FOODBORNE DISEASES

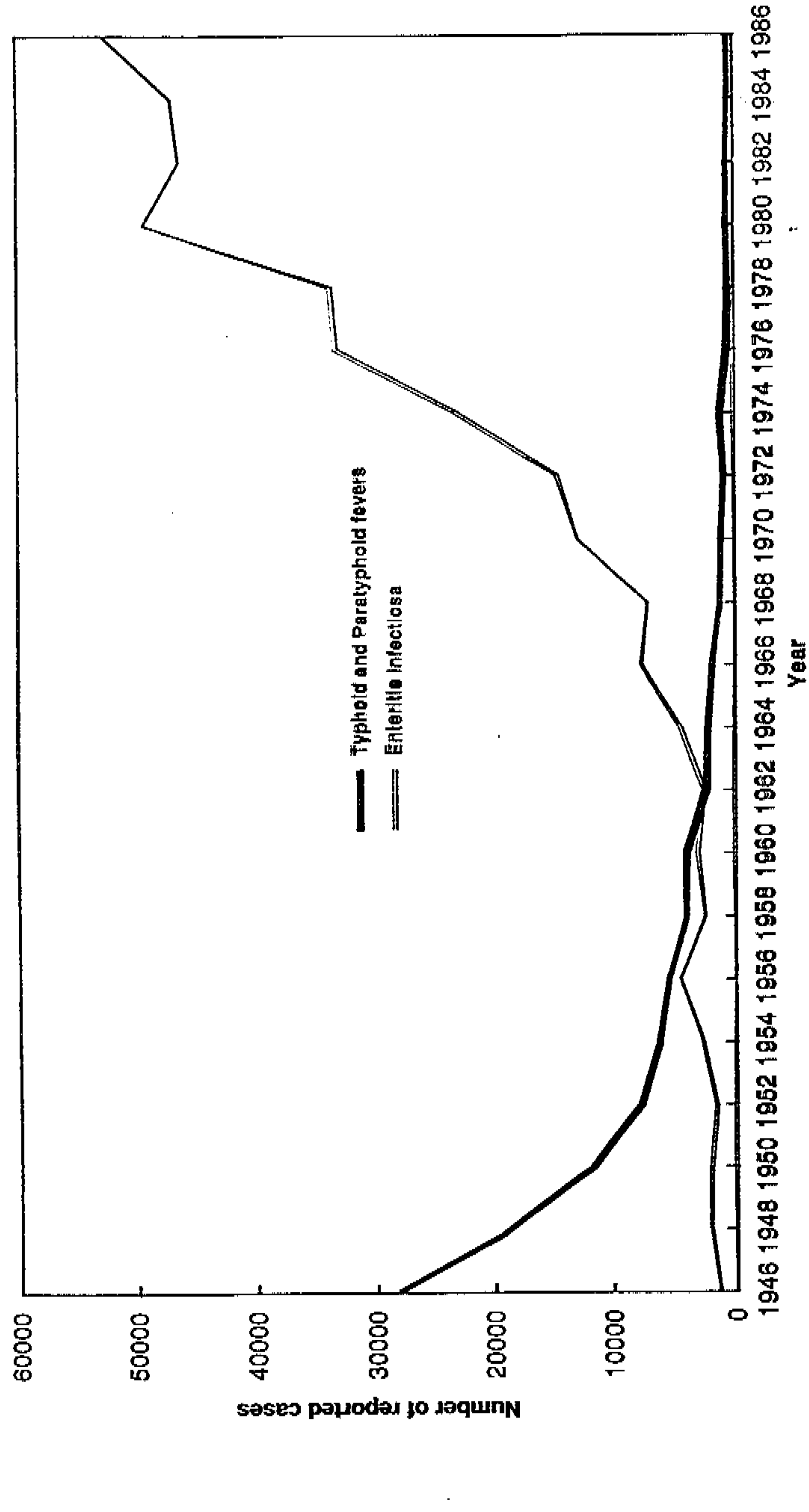
The World Health Organization regards illness due to contaminated food as one of the most widespread health problems in the contemporary world. Contrary to the beliefs and fears of many consumers, particularly in industrialized countries, most foodborne diseases are caused by microbiologically contaminated foods and not by chemicals in food. Reports from several countries indicate that foodborne morbidity is increasing rather than decreasing. These reports also show that the so-called "sporadic" outbreaks have been responsible for the dramatic rise in cases per annum in recent years.

The exact reason for this development is not known, but it parallels a remarkable change in eating habits away from traditional well-cooked family meals, where thorough cooking would inactivate any pathogenic bacteria remaining, to convenience foods, fast-food outlets, snacks and ready-to-eat products where the final heat treatment may often be less severe.

The following two graphs from Germany (period 1910-1944) and the Federal Republic of Germany (period 1946-1986), where foodborne diseases (here called Enteritis infectiosa) are compared with typhoid and paratyphoid fevers, are typical of the situation in many industrialized countries as can also be seen from the third graph depicting the situation related to some foodborne diseases in England, Wales and Northern Ireland (period 1980-1988).

In several countries, poultry meat has meanwhile been identified as the vehicle mainly responsible for human salmonellosis. As will be explained later in this report, poultry meat, even if produced under good manufacturing practices, often harbours Salmonella and other foodborne pathogens. It may thus be less prudent than in the past to rely solely on cooking to render contaminated foods safe. Such foods also provide opportunities for cross-contamination of prepared foods with pathogens, thus increasing the chances for foodborne disease to occur.

Enteritis infectiosa, Typhoid fever and Paratyphoid fever (A, B and C),
Geographic area of the Federal Republic of Germany, 1946 - 1986



Source: Statistisches Bundesamt Wiesbaden, Meldepflichtige Krankheiten 1987

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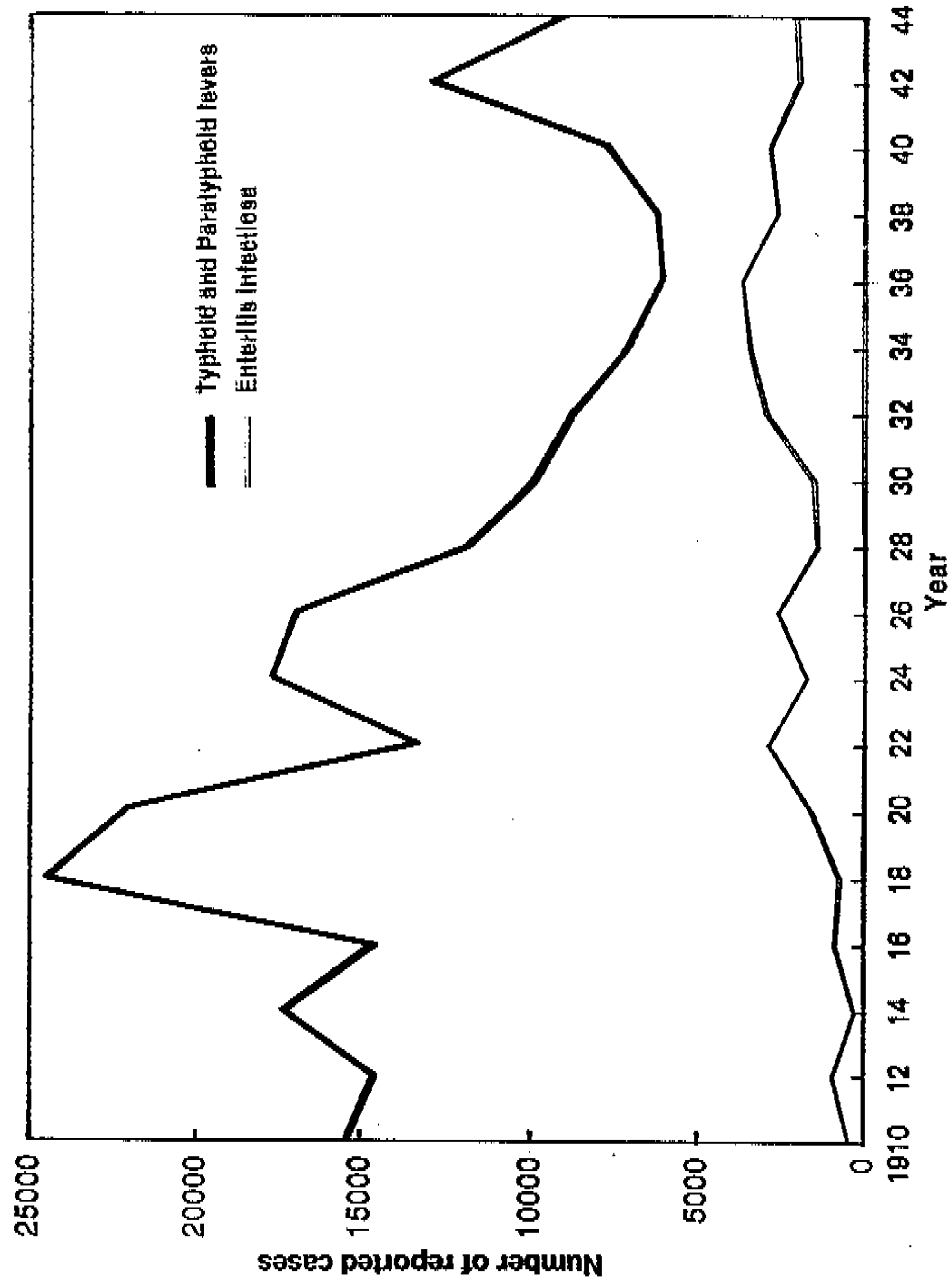
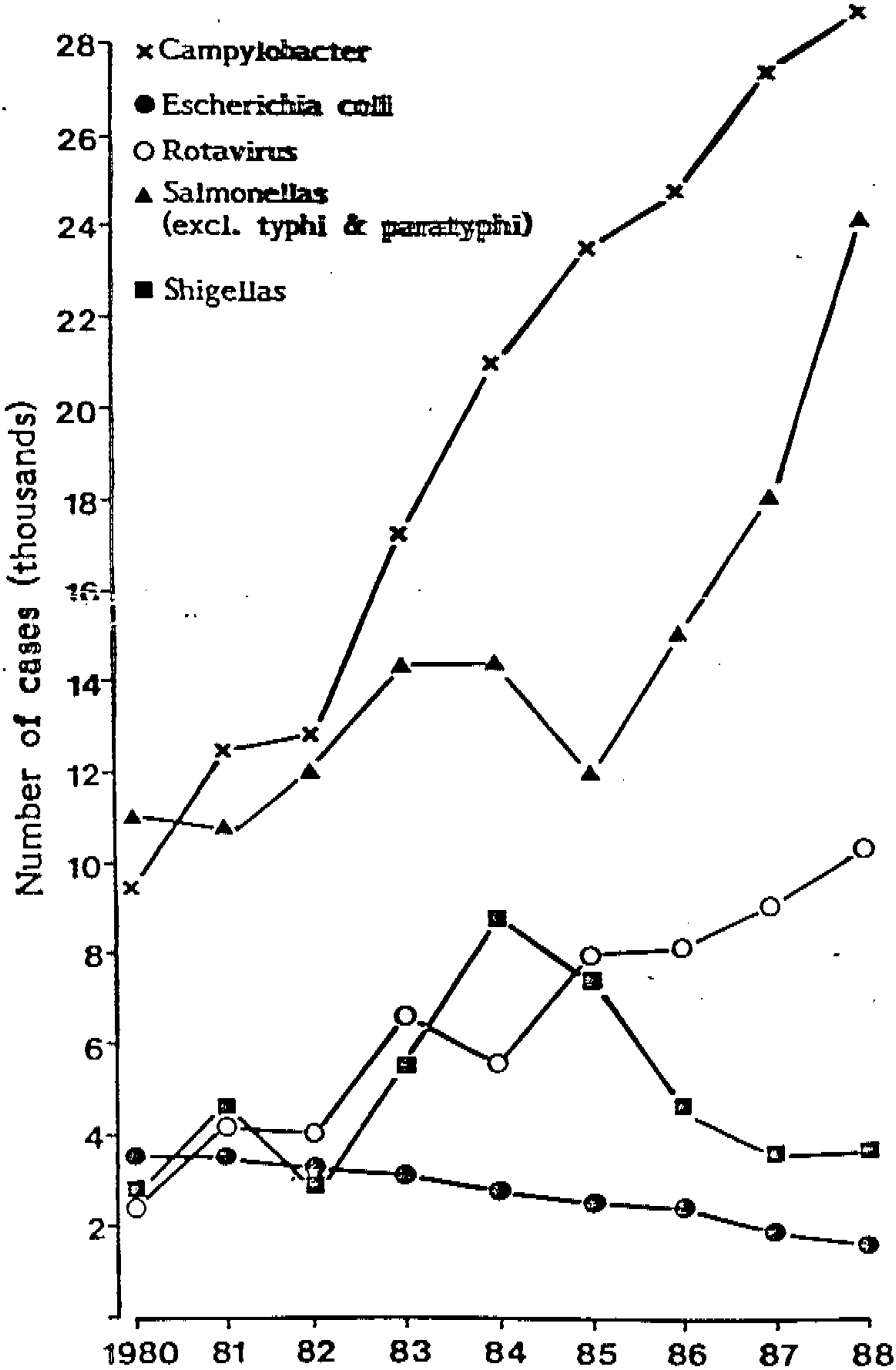
Enteritis infectiosa, Typhoid fever and Paratyphoid fever (A, B and C), Germany, 1910 - 1944



Source: Statistisches Bundesamt Wiesbaden, Meldepflichtige Krankheiten 1987
WHO 89300

SURVEILLANCE OF GASTROINTESTINAL INFECTIONS : 1980-88. ENGLAND, WALES, NORTHERN IRELAND



Source: PHLS Communicable Disease Surveillance Centre

3. MICROBIOLOGICAL CRITERIA FOR FOODS AS INDICATORS FOR GOOD MANUFACTURING PRACTICE (GMP)

3.1 The nature of the problem

Certain microorganisms that can reduce the safety or utility of food are currently inactivated by physical processes, and particularly by heat. It is also possible to inactivate many such types of microbes by irradiation at doses and under conditions that cause minimal chemical, physical and organoleptic changes in the food. Following the conclusion of the Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food in 1980[1] that irradiation of any food commodity up to 10 kGy would not introduce any specific toxicological, nutritional and microbiological hazard, the Codex Alimentarius Commission adopted in 1983 the Codex General Standard for Irradiated Foods[2]. Doses within this range can be used to inactivate pathogenic bacteria of importance in foods (e.g. Salmonella, Campylobacter, Listeria, Vibrio spp), as well as specific spoilage organisms.

Microorganisms vary greatly in their susceptibility to irradiation. Irradiation doses in the range of 2-7 kGy will inactivate much larger populations of vegetative bacterial pathogens than are likely to be present in hygienically produced foods. An irradiation dose that kills such bacteria will coincidentally destroy many types of vegetative spoilage bacteria and inactivate most parasites. A dose that inactivates bacterial spores will inactivate very large populations of vegetative pathogenic and spoilage bacteria as well. Thus irradiation treatments that improve the safety and quality of food in respect of particular organisms will significantly reduce the overall microbial population.

While reduction may have beneficial effects on shelf-life if the food is perishable, concern has been expressed that it may disguise the fact that a food has been improperly handled. Thus attempts might be made to use the process to substitute for good manufacturing practices (GMP). It was considered that this concern might be overcome if, before irradiation, the food was required to meet appropriate microbiological criteria.

Indeed, consumer organizations have expressed many concerns about food irradiation, one of which is that the process might be misused as a method of "cleaning up" food which might otherwise be of inferior microbiological quality or even unfit for human consumption. For consumers to accept irradiated food, irradiation must be seen to be a genuine consumer protection measure, not a consumer deception device. Therefore, it should only be used as an additional safeguard when GMP has been met.

It was suggested that microbiological criteria are a way of strengthening consumer confidence in the use of the process. Clearly, this view is too narrow. Microbiological criteria, in isolation, are inadequate to achieve the objectives of ensuring consumer confidence. While microbiological criteria have a role in confirming that GMP has been observed, they cannot ensure safety to the consumers.

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(1) Report on the Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food. WHO Tech. Rep. Series No. 659 (1981)

(2) Codex General Standard for Irradiated Food. Vol. XV of the Codex Alimentarius, FAO, Rome (1984)

For genuine reassurance, consumers need a comprehensive framework of regulations, proper enforcement and control, and an open dialogue on the effectiveness of such a system. Thus the objective of this consultation is to recommend microbiological criteria for foods to be further processed that will serve the purpose of ensuring that only hygienically handled foods will be so treated. Such criteria would not include currently unavoidable foodborne pathogens for which the food is intended to be irradiated (for example Salmonella and Campylobacter in frozen poultry meat).

It was agreed that, as food for all types of further processing should have been handled hygienically, consideration should not be confined to irradiation treatments. Thus discussion concentrated on the establishment of microbiological criteria related to GMP for all such processes, while acknowledging that in some instances pasteurization by heat or irradiation might be the only technologies available by which to achieve the desired objective.

3.2 Good Manufacturing Practice

Food laws apply equally to all food processors, whether they are canners, dryers, freezers, warehouses or food irradiators, and any such processor is obliged under these laws to ensure that the foods they receive and process are safe and of good quality. This involves the establishment of adequate quality control systems within the food processing premises, and also requires necessary systems and purchasing contracts with suppliers to ensure that raw foods are of the best possible quality when harvested, transported and delivered; that farming or fishing systems are adequate to ensure quality and control of chemical and microbiological problems; that inspection to judge the product against purchasing standards is routinely performed at receiving stations; and that a good knowledge of pesticide usage, heavy metal or industrial chemical contamination problems, possibilities of bacterial and mould growth in susceptible crops, etc., are all taken into account to ensure the products are acceptable. Therefore, the concept of GMP is to initiate a thorough and pervasive system to control all food quality and safety problems, from growing and harvesting through final sale. An example of such a quality assurance approach is the Hazard Analysis Critical Control Point (HACCP) system which can be applied to the production, handling and processing of food[1].

An important part of the HACCP system for ensuring that manufacturing processes are efficient is monitoring. This involves sampling at critical control points to determine if physical and chemical factors are under control. The results of such monitoring over time can be recorded graphically. The resulting control chart is useful in indicating trends even though the parameter is still within control limits. It provides a warning that, unless corrective action is taken, the process will pass out of control. The consultation recommended the use of this system[2] as an aid to the maintenance of GMP.

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(1) ICMSF: Microorganisms in Foods, Book 4: Application of the hazard analysis critical control point (HACCP) system to ensure microbiological safety and quality. Blackwell Scientific Publications, Oxford (1988).

(2) ISO/TC 69, Statistics and Quality, sections DP 7880, DP 8258, DP 7873, DP 7966, DP 7871. International Organization for Standardization. Secretariat, Delft.

In essence, good manufacturing practices require that raw materials should be as clean, wholesome and uncontaminated as possible when received. Products which are unacceptable should be rejected and those which are acceptable should be processed expeditiously and effectively so that any undesired quality defects or contamination are removed to the maximum extent that is practicable, and especially to the extent that finished products meet all the requirements of the food law.

A Task Force on the Use of Irradiation to Ensure Hygienic Quality of Food [(3)] pointed out that in some circumstances food irradiation processing can provide a more complete assurance of safety than that provided solely by the usual Good Manufacturing Practice (GMP). However, food which is intended for treatment by irradiation must still be handled in accordance with the best available hygienic practices prevailing under the conditions of production. The visual and commercial quality of the food should be fully acceptable, and the microbiological quality before irradiation should not be less than would be expected from the use of GMP.

Food accepted for such treatment should be prepared appropriately. Where necessary the product should be cooled, chilled or frozen and handled and transported under time and temperature conditions to minimize loss of quality. Where packaging is essential to prevent post-treatment recontamination (as will almost always be the case), the food should be so packaged before treatment. Package size, especially with bulk packs, should be such that they can be handled efficiently, thereby avoiding excessive delays and temperature abuse.

Some codes of GMP may have attached to them microbiological end-product specifications, which are criteria applied to ensure that those aspects of the code with hygienic significance have been followed. Unfortunately, for some foods, the present level of technology in practice does not always exclude from the product organisms that may be hazardous to the consumer, or detrimental to the acceptability of a subsequently processed food. These will commonly be raw foods. On this topic an FAO/WHO Working Group [(4)] concluded:

> "The example of raw meat and poultry has shown that the establishment of microbiological criteria for raw foods in general cannot serve the purpose of protecting the health of the consumer when the main source of pathogenic organisms is the raw food itself and when processing does not include steps which will eliminate or substantially reduce numbers of these organisms."

Therefore, the presence of particular pathogens in foods commonly contaminated with them must be assumed, microbiological criteria applied and the foods processed to inactivate the target organisms when those criteria have been met.

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(3) Report of a Task Force on the Use of Irradition to Ensure Hygienic Quality of Food. Unpublished Document WHO/EHE/FOS/87.2 (1987)

(4) Report of a FAO/WHO Working Group on Microbiological Criteria for Foods, WHO, Geneva, 20-26 February 1979, unpublished document.

3.3 Indicators

Unfortunately, it is not always simple, with raw foods, to establish criteria that will show clearly when hygienic practices have or have not been applied. This is true of such diverse products as raw meats and poultry [(6)] and herbs and spices [(7)]. For both groups of foods, low numbers of indicator organisms will generally indicate good hygiene. However, such is the nature of the environment and the slaughtering/harvesting procedures to which the products have been exposed that high counts are not necessarily evidence of unhygienic practices. This complication, and the need for adequate shelf-life of those raw foods that are perishable, must be taken into account when establishing criteria.

3.4 Microbiological Criteria

In many cases, little will be known of the past history of foods destined for further processing. It is therefore appropriate that 3-class attributed sampling plans for indicators be employed, as used in Codex codes of hygienic practice and discussed in detail in ICMSF [(8)].

The 3-class plans include four values:

n = the number of sample units to be examined;

c = the maximum number of sample units with values between m and M for the lot to be acceptable.

m = the population at or below which no concern is recognized; and

M = the population above which the lot is rejected.

In establishing criteria note is taken not only of the nature of the organism being enumerated but also of the conditions of use of the food and the likely effects of these conditions on the organism, i.e. increase, decrease or no change in numbers.

Values for m and M for indicators will vary between foods. They will relate, in the present context, to what is attainable under GMP and to what is acceptable in terms of the level of contamination they represent. They should be set only with reference to extensive data obtained from food subjected to GMP from representative suppliers/producers/production systems.

(6) Report of a FAO/WHO Working Group on Microbiological Criteria for Foods, WHO, Geneva, 20-26 February 1979, unpublished document.

(7) Microbial Ecology of Foods, Vol. 2: Food Commodities, Academic Press, New York (1980).

(8) ICMSF: Microorganisms in Foods, Book 2: Sampling for microbiological analysis - Principles and specific applications. 2nd edition 1986. University of Toronto Press, Toronto, Buffalo and London.

Microbiological Guidelines as proposed by this Consultation are as defined by the Codex Alimentarius Commission [9]. Thus they do not refer to the acceptability or non-acceptability of the food and are not intended as maximum limits for regulatory action. Instead, such guidelines refer to the manufacturing processes to which the food has been subjected. If in the course of microbiological testing, a food fails to meet a guideline, the suggested response would be inspection of the process for adherence to GMP and initiation of corrective action where necessary. In this context it should be noted that relatively little food in trade is accepted or rejected on the basis of microbiological criteria.

For most of the foods discussed by the consultation, there exist Codex Codes of Practice which should be followed by processors and which define GMP. Few of them contain end-product specifications and the Consultation was convened to consider recommending criteria where these are absent and to review existing criteria as they may apply to foods for further processing.

3.5 Foods considered for further processing

The types of foods that have been considered as suitable for the application of pre-processing criteria include several that were the subject of FAO/WHO Expert Consultations and Working Groups 1975-1981 [10]. These were red meats, poultry, frogs legs and cooked, peeled, frozen shrimps and prawns. Others are fish and shellfish, mechanically separated meat and herbs and spices.

Although some rapid tests exist which make it possible to detect large populations of microorganisms in foods in a relatively short time, these are not yet in common use in connection with microbiological criteria. Conventional testing, by aerobic plate count (APC) or most probable number determination (MPN), takes longer, usually more than 24 hours. These tests are thus often impracticable for perishable foods. If the quality (shelf-life) of foods to be further processed is not to be compromised by long delays for testing, the foods will need to be microbiologically stable, i.e. frozen or dried. Fortunately, many such foods respond much better to irradiation in the frozen than in the unfrozen state.

3.6 Conclusion

Foods to be further processed should be of such microbiological quality that, were it not for the assumed presence of the target organism, they would be considered wholesome and microbiologically acceptable. Microbiological criteria to ensure this should be based on tests which demonstrate that the hygienic aspects of good manufacturing practices have been observed. The microbiological criteria should be based on a statistically acceptable sampling plan and take into account the likely effects of subsequent treatments on the microorganisms .

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(9) CAC Procedural Manual, 6th edition, FAO, Rome (1986):
A microbiological guideline is applied at the establishment at a specified point during or after processing to monitor hygiene. It is intended to guide the manufacturer and is not intended for official control purposes.

(10) Christian, J.H.B., Microbiological Criteria for Foods. Summary of Recommendations of FAO/WHO Expert Consultations and Working Groups 1975-1981. Unpublished WHO Document VPH 83.54.

4. FOODS AND FOOD INGREDIENTS

4.1 Red meats (beef, pork, lamb)

In the production of meat animals, good husbandry practices should be followed. These include control of animal disease, provision of feed as free from pathogenic microorganisms as is reasonably possible, transportation to slaughter under hygienic conditions, sanitary holding and good stock handling practices before slaughter. At slaughter, particular attention is to be paid to preventing contamination of the carcass by the contents of the alimentary tract or by contact of the carcass surface with the fleece or hide.

Even when these practices are adhered to, raw meats may carry several microorganisms that are pathogenic to man and that cannot be detected by routine ante- and post-mortem inspection procedures(1). The bacteria of concern include *Salmonella*, *Yersinia*, *Campylobacter*, *Listeria*, *Staphylococcus*, pathogenic *Escherichia coli* and *Clostridium perfringens*. Multiplication of potential pathogens contaminating the carcass surface is minimized by prompt chilling, and storage under refrigeration, but their absence cannot be guaranteed even under conditions of GMP(2).

Although cooking before consumption will effectively eliminate viable vegetative pathogenic bacteria, it is common in some countries to consume beef, lamb, pork and mutton in the raw state. This practice is known to have resulted in foodborne disease. In addition, if these foodborne pathogens are introduced into the kitchen environment, they may become sources of cross-contamination of food ready for consumption. Consumer education and guidance on safe food preparations are, therefore, also an integral part of food safety.

Compliance with GMP could be assured by application of microbiological guidelines as suggested by ICMSF (3). These are as follows (per cm^2 or gram):

Carcass meat before chilling

APC* (35° or 37° C): $n = 5$, $c = 3$, $m = 10^5$, $M = 10^6$

Chilled carcasses

APC* (20° or 25° C): $n = 5$, $c = 3$, $m = 10^6$, $M = 10^7$

Carcass meat frozen

APC* (20° or 25° C): $n = 5$, $c = 3$, $m = 5 \times 10^5$, $M = 10^7$

*Aerobic Plate Count

It must be stressed again that the complete absence from raw meats of the pathogenic bacteria referred to above cannot be guaranteed by adherence to GMP, and hence irradiation may be a useful terminal process. In addition to eliminating these bacterial hazards, irradiation would inactivate or render non-infective parasites such as *Trichinella*, *Cysticercus* and *Toxoplasma*, which are common causes of illness in some countries.

Although red meat treated by irradiation would have increased shelf-life, it is not considered appropriate to irradiate with this as the sole objective because adequate shelf-life can be achieved by applying GMP at slaughter, chilling, cutting/boning and packaging, coupled with control of distribution and storage temperatures[2]. Nor is there any need to irradiate aged (conditioned) beef or beef primal cuts that have been held vacuum-packed under chill. Although such beef may carry high numbers of bacteria, these are usually harmless psychrotrophic bacteria and do not indicate failure to meet GMP at slaughter/dressing.

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(1) Recommended International Code for Ante-Mortem and Post-Mortem Inspection of Slaughter Animals (CAC/RCP 12-1976)

(2) Recommended International Code of Hygienic Practice for Fresh Meat (CAC/RCP 11-1976)

(3) ICMSF: Microorganisms in Food, Book 2 : Sampling for microbiological analysis - Principles and specific applications. 2nd edition 1986, University of Toronto Press, Toronto, Buffalo and London.

4.2 Poultry

Raw poultry meat is an important source of foodborne pathogens such as Salmonella, Campylobacter, Clostridium perfringens, Listeria monocytogenes and Staphylococcus aureus, all of which are commonly incriminated in outbreaks of foodborne diseases. They are generally present only in low numbers and normally constitute a hazard only after substantial multiplication on mishandled products, or when they contaminate foods that are ready for consumption.

Prevention of foodborne diseases from ingestion of poultry can in general be improved in three ways, namely rearing of poultry free from pathogens, decontamination of poultry meat and education of the consumer on how to handle potentially contaminated food items. As the first method will not be realized in the near future on a large scale and the third method is proving difficult to implement, it seems that the second method, the decontamination of poultry meat, will be necessary to safeguard public health. Application of GMP[(1)] to the processing of poultry is, of course, essential, but as there is no step in the process that can be relied upon to eliminate pathogens, their prevalence in raw poultry meat is more likely to reflect their incidence in live animals prior to slaughter than lack of adherance to a code of hygienic practice.

Microbiological guidelines for psychrotrophic aerobic bacteria and indicator bacteria immediately after processing may be useful to indicate if hygiene problems exist somewhere along the processing line. Counts in excess of those normally found should alert the processor to inspect the processing line more closely to locate and remedy problems, thus limiting contamination of the freshly processed carcasses.

An earlier consultation [(2)] gave first priority among food commodities to the irradiation of packaged poultry due to high levels of contamination by pathogens in nearly all countries, and the likelihood of cross-contamination and abuse in catering establishments and in households. Introducing decontaminated chicken meat could considerably reduce the risk of such cross-contamination. Packaging of poultry after slaughter and subsequent irradiation has been shown to be effective in eliminating pathogens, especially Salmonella and Campylobacter and could be applied now on a relatively wide scale. An alternative decontamination procedure in poultry meat production is in-plant chlorination, which may help to reduce contamination but which is not fully effective. Heating of poultry by steam or pre-cooking has been applied experimentally, but has limited consumer acceptability as it changes the character of the food completely.

A useful guideline to determine if poultry has been processed according to GMP, and is therefore acceptable for post slaughter treatment, is a criterion for APC (20^{o}) of $n = 5$, $c = 3$, $m = 5 \times 10^5$ and $M = 10^7$ [(3)]. This guideline is achievable for raw poultry in modern processing plants that follow good processing practices. It does not apply to edible offal.

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(1) Recommended International Code of Hygienic Practice for Poultry Processing (CAC/RCP 14-1976).

(2) Report of a Task Force Meeting on the Use of Irradiation to Ensure Hygienic Quality of Food. Unpublished Document WHO/EHE/FOS/87.2 (1987)

(3) ICMSF: Microorganisms in Food, Book 2: Sampling for microbiological analysis - principles and specific applications. 2nd edition 1986, University of Toronto Press, Toronto, Buffalo and London.

4.3 Mechanically Separated Meat (MSM)

A certain amount of meat remains on the bones of food animals after manual deboning. A technology common to several meats is used to remove such residual soft tissue, termed "Mechanically Separated Meat" (MSM). Concern has been expressed that the level of bacterial contamination of this product, whether from red meat or poultry, may constitute a health hazard. The consultation noted that from the microbiological point of view this product has several important characteristics:

1) The bacterial content depends largely on the raw material used. For example, the product harvested from chicken backs differs greatly from that harvested from chicken legs.

2) MSM has the highest surface to volume ratio of all meat products and, as bacteria tend to multiply on surfaces, MSM is a highly perishable product.

3) As MSM is a homogenate, contaminating bacteria are spread throughout the product.

4) MSM is frequently contaminated with various bacteria appearing on carcasses of meat animals, including Salmonella, Campylobacter, Listeria and Clostridium perfringens, and may have a relatively high count of coliform and other enteric bacteria.

5) In most countries, MSM is destined for further processed and heated products and is not offered directly to the public.

There have been no reports that MSM has been responsible for foodborne disease. It is usually incorporated into products to be heated and this would normally exclude the need for an additional process to ensure a safer product. However, MSM is commonly traded in frozen form and might serve as an important source of pathogenic microorganisms disseminated by cross-contamination within the processing plant. Irradiation appears to be the most useful treatment with which to control this hazard, but it is important that GMP be followed throughout the process and that an appropriate microbiological guideline be applied to demonstrate the suitability of MSM for such further processing.

The relevant International Code of Practice (1) does not include a microbiological end-product specification and insufficient data from international sources were available to enable the Consultation to suggest a guideline. However, it should be noted that in French regulations for poultry MSM, the relevant guideline is an APC (30^o) of 10^6/g before treatment by irradiation (and 10^4/g afterwards). Where MSM production is in-line with conventional poultry processing, opportunities for contamination and temperature abuse are much less and lower bacterial counts can be expected. Similar products are produced from red meats, but there are inadequate microbiological data on MSM from these sources to make recommendations on guidelines.

The Consultation recommended that appropriate microbiological data be collected on MSM produced under GMP so that an appropriate criterion could be established for MSM for further processing.

(1) Recommended International Code of Practice for the Production, Storage and Composition of Mechanically Separated Meat and Poultry Meat intended for further Processing (CAC/RCP 32-1983).

4.4 Frogs Legs

It is well established that Amphibia frequently harbour Salmonella because their natural environment is often heavily contaminated. Subsequently, cross-contamination can occur during transport, storage and preparation in a slaughterhouse. As a consequence the frequency of contamination of frogs legs with Salmonella is very high and sometimes several serotypes can be isolated from a single batch. They are, on the whole, exported and there is a need to ensure that the products in international trade are not excessively contaminated. Although frogs legs have not been implicated as a direct cause of foodborne illness, they may contribute to the dissemination of salmonellae in the food chain.

Frogs legs should be processed in accordance with GMP. However, the appropriate Codex Code contains[(1)] no specific microbiological criterion for the end-product.

Limited studies indicate that frogs legs processed under good hygienic conditions appear to reach a level for aerobic plate count (APC 30°C) in the order of 10^6/g. Microbiological standards are already in force in a few countries. In France, there are criteria for APC, faecal coliforms and Staphylococcus aureus which must be met before further processing by irradiation, after which Salmonella must be absent from 25g samples. It is clear that this process is effective in eliminating Salmonella. Other countries simply require absence of Salmonella.

At the international level, the data available, particularly from exporting countries, are not sufficient to determine which criteria should be recommended. A similar conclusion was reached by an earlier Expert Consultation [(2)]. The present consultation therefore recommended that, before proposing criteria for frogs legs to be further processed by irradiation, more microbiological data be gathered from exporting and importing countries. The initial microbial load on frogs legs varies greatly, so that, even when such criteria become available, enforcement of GMP in the producing countries must be assured.

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(1) Recommended International Code of Hygienic Practice for the Processing of Frogs Legs (CAC/RCP 30-1983).

(2) Report of the Second Joint FAO/WHO Expert Consultation on Microbiological Specifications for Foods, Geneva, 21.2. - 2.3.1977, unpublished document.

4.5 Fish and crustaceans

Over 800 species of fish and crustaceans are harvested, processed, traded, marketed, and consumed around the world and the microorganisms found on and in them come from the environment, from the fishing vessel hold, and from processing. An increasing volume of fish and crustaceans are coming from aquaculture sources, and although this technology provides greater opportunity and flexibility for quality control it may also present unique microbiological problems, e.g. *Clostridium botulinum* in trout ponds. So far little relevant microbiological data on the products of this industry are available.

Fish and crustaceans harvested from clean environments and processed under hygienic conditions should contain no pathogenic microorganisms originating from humans or warm-blooded animals. However, on certain occasions contamination of the environment or the product can occur from pathogens such as *Salmonella* or *Shigella*. At present there is no completely effective means to prevent contamination from pathogens of environmental origin such as *Vibrio parahaemolyticus*, *V. vulnificus*, *Listeria monocytogenes* and *Yersinia enterocolitica*. These pathogens are usually present only in low numbers, yet a treatment that would inactivate them could provide significant public health protection which may be especially beneficial when fish is eaten raw, a practice once confined to the Orient but now gaining popularity in the West. Irradiation is currently the only treatment that will leave raw fish, free from these pathogens.

Parasitic infection may occur from eating raw or mildly cured fish. Well-known examples are anisakis from green herring, tape worm from salmon and liver fluke from various fresh water fish. Further processing such as freezing or irradiation is recommended for these commodities if they are to be eaten raw or only mildly cured.

The presence of pathogens in fish and crustaceans cannot be predicted by the microbial load and contamination often occurs in an unpredictable manner. Thus the best assurance of GMP[1] is knowledge of the source of the fish or crustaceans and their production history. An important contribution to this assurance can be the certification of processing plants based on their historical performance and adherence to agreed process controls.

Any product intended for further processing should be produced under the conditions of GMP[1] and should meet the following guideline: APC (20°C): $n = 5$ $c = 3$ $m = 5 \times 10^5$ $M = 10^7$ [2].

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(1) Volume B of the Codex Alimentarius contains several Codes of Practices for commodities relevant to this discussion.

(2) ICMSF: Microorganisms in Food, Book 2: Sampling for microbiological analysis - principles and specific applications. 2nd edition 1986, University of Toronto Press, Toronto, Buffalo and London.

4.6 Oysters and clams

Oysters and clams eaten raw are well known causes of foodborne disease, as they are frequently contaminated with pathogenic bacteria and viruses. Harvesting them from waters that meet strict microbiological standards for faecal pollution will reduce, but cannot eliminate with certainty, contamination with human enteric bacteria and viruses. A higher level of safety is provided, especially if the microbiological status of growing waters is suspect, by depuration, in which molluscs cleanse themselves in a flow of sea water that has been disinfected by chlorination, ozonization or ultra-violet light. A similar effect may be obtained by re-laying the live molluscs in clean water areas.

These processes can be very effective in removing human enteric pathogens such as Salmonella spp. from molluscs. However, the pathogenic Vibrio spp., e.g. V. parahaemolyticus and V. vulnificans, are part of the normal environmental flora of molluscan shellfish and may not be excreted during such treatments. Nor are viruses removed, because they may penetrate from the gut of the mollusc into the meat, where they are protected from depuration. Major outbreaks of viral diseases such as hepatitis A have been traced to shellfish. Epidemiological evidence has implicated shellfish mediated transmission in many outbreaks of gastroenteritis in which viruses were suspected but no pathogens were recovered either from shellfish samples or resident waters.

Microbiological criteria exist in some countries for raw molluscan shellfish and could, in principle, be expanded to include limits for Vibrio spp. However, such criteria would give little assurance of safety in respect of these bacteria and none with respect to viruses. No recovery, isolation, or enumeration techniques are available for several important pathogens harboured by molluscan shellfish. Even with those viral pathogens for which identification procedures have been developed, the viruses may be present in such small numbers as to defy detection. A single virion may, however, constitute an infectious dose. The concept of acceptable microbiological criteria based on indicator bacteria is untenable as viral contamination is not always predictable from bacterial data derived from shellfish meats.

Preliminary (unpublished) data indicate that oysters and clams tolerate irradiation doses of 2 kGy without adverse effects upon longevity or organoleptic properties. Such doses will reduce or eliminate populations of contaminating vegetative bacterial pathogens. Unpublished data also indicate that this treatment will reduce the number of infective units of human viral pathogens by one or more orders of magnitude, but further studies are needed to confirm this observation.

The consultation concluded that microbiological criteria for live and fresh-shucked oysters and clams cannot provide assurance of safety to consumers of the raw or lightly cooked shellfish. It is essential that the shellfish be harvested from waters that meet the guidelines of good manufacturing practice (GMP) as exemplified by U.S. National Shellfish Sanitation Programme[1] or the EEC proposal on bivalve molluscan shellfish.

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(1) National Shellfish Sanitation Program (NSSP). US Dept. of Health, Education and Welfare (1965). Manual of operations. Part 1 - Sanitation of Shellfish Growing Areas: PHS Pub. 33 Revised 1986. Washington, D.C., US Government Printing Office.

There are acceptable and widely used methods of depuration for improving the microbiological quality of live shellfish, and irradiation is not a substitute for that process. However, since some organisms of public health significance, e.g. Vibrio spp., may not be removed by depuration, irradiation is an effective method for improving the microbiological safety of such products.

The consultation also concluded that more data are required on the contamination of cockles by viruses and their possible elimination by application of irradiation.

4.7 Cooked, peeled, frozen shrimps and prawns

Freshly caught shrimps and prawns from tropical waters may carry high loads of commensal bacteria, and when fished in in-shore waters subject to pollution may be contaminated with human pathogens. As there can be little control over the microbiological condition of these raw products, microbiological guidelines for the raw crustaceans would not be practical. However, the product is cooked prior to distribution. This process should destroy most contaminants and the resulting product should meet a criterion based on adherence to the appropriate code of hygienic practice. For this reason an end product specification is recommended.

The Recommended International Code of Practice for Shrimps and Prawns (CAC/RCP 17-1978) describes in detail the processing of these products, which should comply thereafter with the following microbiological end product specification.

APC (30^oC): $n = 5$, $c = 2$, $m = 10^5$, $M = 10^6$

Staphylococcus aureus: $n = 5$, $c = 2$, $m = 5 \times 10^2$, $M = 5 \times 10^3$

Salmonella: $n = 5$, $c = 0$, $m = 0$

However, even if complying with such specifications, products which are consumed without any further bactericidal process have at times been implicated in foodborne epidemics, for example the shrimpborne *Shigella* epidemic in the Netherlands in 1983 [(1)]. Some governments consider it therefore reasonable and prudent to apply a further terminal bactericidal treatment for optimal consumer protection. Such treatments have included reheating or irradiation.

When originally drafted in 1975[(2)] for submission to the Codex Alimentarius Commission, the above quoted microbiological end product specification was in close agreement with the existing national standards for these products. However, a more detailed and recent consideration[(3)] of microbiological aspects of precooked peeled frozen shrimps and prawns has suggested that a less stringent limit for Aerobic Plate Count (APC) is appropriate ($n = 5$, $c = 2$, $m = 5 \times 10^5$, $M = 10^7$). It is also apparent that microbiological loads on crustaceans both before and after cooking may vary considerably due to differing climatic and hygienic conditions. For these reasons the consultation recommends that a reassessment of the microbiology of precooked shrimps and prawns and of criteria that may accurately reflect adherence to GMP be undertaken.

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(1) Bijkerk, H. en M. van Os: Bacillaire dysenterie (*Shigella flexneri* type 2) door garnalen. Ned. T.v. Geneesk. 128, 431 (1984)

(2) Report of a Joint FAO/WHO Expert Consultation on Microbiological Specifications for Foods, Geneva, 7-15 April 1975, unpublished document.

(3) ICMSF: Microorganisms in Food, Book 2: Sampling for microbiological analysis - principles and specific applications. 2nd edition 1986, University of Toronto press, Toronto, Buffalo and London.

4.8 Spices, herbs and vegetable seasonings

Spices, herbs and vegetable seasonings are very heterogeneous groups of commodities in regard to their botanical origin, production environment and microbiological contamination.

While a wide range of bacteria and fungi forms the normal microflora of spices and herbs, aerobic spore-forming bacteria frequently predominate. Microbiological contamination of spices and herbs can be a source of spoilage microorganisms when they are used as seasoning for foods. Because of the fact that under prevailing conditions of production and harvesting, bacteria of public health significance (e.g. Salmonella, Escherichia coli, Clostridium perfringens, and Bacillus cereus) and toxigenic moulds may be present, untreated spices and herbs may constitute a potential health hazard, particularly in household use, or if used as ingredients of processed foods that are insufficiently heat-treated. Heat resistant bacterial spores originating from these dry ingredients are also of serious concern for some branches of the food industry manufacturing heat processed food products. Therefore, the purpose of decontamination treatments of spices, herbs and vegetable seasonings is the partial or complete destruction of viable microorganisms that would impair the safety and suitability for use of spices and herbs.

In principle, estimation of coliform bacteria and mould contamination may serve as general indicators of good production and harvesting procedures. However, although a vast literature exists and has been surveyed regarding the microbiology of spices and herbs, the available information is not sufficiently detailed in respect of the history and representativeness of samples investigated by various laboratories. Therefore, not enough information is presently available to establish any rigid criterion.

In addition, the total biomass of indicator microorganisms (both dead and living cells) would be a more relevant estimate. Some methods (e.g. Limulus lysate assay for gram negative endotoxins or gene probes for Enterobacteriaceae, and microscopic, chemical and immunological tests for moulds) show some promise in this direction. However, at present only methods of counting viable cells are applied extensively.

In spite of the above difficulties, on the basis of a preliminary statistical evaluation of relevant literature for distribution and variance of viable counts of the above indicator groups, the Consultation concluded that some provisional guidelines may be useful to orientate both processors and food control authorities concerning the probability of problems in manufacturing and handling practices worthy of further investigation. It was agreed that, when tested by appropriate methods of sampling and examination, most untreated spices, herbs and vegetable seasonings, harvested under acceptable hygienic conditions, should contain

- not more than 10^4 coliform bacteria per gram;
- not more than 10^5 mould propagules per gram.

The same provisional guidelines should be considered for spices, herbs and vegetable seasonings intended for decontamination by any physical or chemical process, including by irradiation. This latter process is gaining favour over established decontamination treatments involving chemicals, e.g. ethylene oxide. It should be noted that the Codex Committee on Processed Meat and Poultry Products has recommended as an end-product specification for such ingredients, after decontamination, n = 5, M = 10 000 for spores of aerobic bacteria (Alinorm 89/6 Appendix III).

It is recommended that:

1) systematic studies be performed to establish more relevant microbiological data on representative samples of lots of spices and herbs produced under good manufacturing, handling and storage practices;

2) further research be directed towards developing simple, reliable and sensitive methods for detection of biomass of specific groups of microorganisms foreseen as indicators of deviation from such good manufacturing practices;

3) the Hazard Analysis Critical Control Point system[1] should be applied for the production, handling and processing of spices and herbs, as a means of improving the microbiological quality of these commodities. It would increase the significance of data obtained from any microbiological testing.

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[1] ICMSF: Microorganisms in Food, Book 4: Application of the hazard analysis critical control point (HACCP) system to ensure microbiological safety and quality. Blackwell Scientific Publications, Oxford (1988).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Many foods after harvesting or slaughter carry microorganisms that may have serious consequences for the health of the consumer. In most cases, these contaminating microorganisms are derived from the environment. To the greatest extent possible they should be excluded from the product by exercising good agricultural and manufacturing practices. However, with some current technologies, contamination with such microorganisms cannot always be avoided.

There may thus be a need for further processing to eliminate the hazards resulting from this contamination. Physical (e.g. heating, irradiation) and chemical (e.g. fumigation, chlorination) treatments are available and are applicable in particular cases. However, concern has been expressed that such treatments, in particular irradiation, might be applied to clean up "dirty food", food which had not been hygienically processed and which, without such a treatment, would be considered unfit for human consumption.

The best way to ensure that treatments are not misused in this way is to insist that every care is taken to minimize contamination with and growth of the relevant microorganisms during production. Food producers and processors must initiate and maintain adequate quality control procedures over raw materials and food processing systems. Governments must carry out regular inspections of food producers and processors to ensure that the requirements of applicable legislation are met. Strict adherence to the good manufacturing practices (GMP) as described in codes of hygienic practice such as those adopted by the Codex Alimentarius Commission can greatly assist food processors to ensure food quality and safety.

Adherence to such codes of GMP is greatly facilitated by applying the Hazard Analysis Critical Control Point (HACCP) system to processing and the consultation agreed that this approach should be adopted wherever practicable.

When adequate data are available, hygienic codes of practice may contain microbiological end-product specifications which should be met if those aspects of the code with hygienic significance have been adhered to. As the foods of concern to this Consultation are in general raw, adherence to GMP cannot ensure absence of some pathogenic microorganisms, and so the Codes do not contain such specifications.

The consultation concluded that, to overcome this deficiency, microbiological guidelines should be introduced - wherever possible - to give some assurance of GMP. They would generally refer only to non-pathogenic microorganisms, and a food, meeting these guidelines, would not necessarily be safe for consumption without appropriate further processing.

Microbiological guidelines were suggested for red meats and poultry for further processing. It was concluded that the most appropriate technology to give added assurance of safety to these products after processing by GMP and to retain the organoleptic qualities of raw food was irradition. Inadequate data were available on which to base guidelines for mechanically separated meat, or frogs legs.

Provisional guidelines were suggested for spices, herbs and vegetable seasonings to be decontaminated by chemical or physical means. It was recognized that chemical decontamination was no longer considered desirable or even acceptable in some countries and that irradiation treatment was frequently the method of choice.

Because some sea foods are eaten raw or lightly cooked, special consideration was given to the inactivation of pathogenic bacteria, parasites and viruses without unacceptable changes in the characteristics of the raw food. Freezing is a proven treatment for inactivating some parasites in fish, but for control of bacterial pathogens in fish and crustaceans irradiation can be considered when permitted by national legislation. A microbiological guideline for products that will receive further treatment was suggested.

Molluscs such as oysters and clams are frequently implicated in outbreaks of bacterial and viral diseases. There is no substitute for harvesting from unpolluted water and for depuration where necessary. However, molluscs may contain pathogenic bacteria that are part of the normal marine microbial flora of the environment and that are not eliminated from the molluscs by depuration. Irradiation can be used to inactivate these bacteria without affecting adversely the longevity or organoleptic properties of the molluscs. Preliminary and so far unconfirmed data suggest that such treatments may also reduce significantly the activity of contaminating viruses. The consultation did not recommend guidelines but emphasized that irradiation treatments be applied only to molluscs meeting accepted standards of production conditions and depuration.

The Recommended International Code of Practice for Shrimps and Prawns includes a microbiological end-product specification for cooked, pealed, and frozen shrimps and prawns. The consultation was informed that some shipments of these products in international trade did not meet this specification. It concluded that greater efforts needed to be made to improve the standard of hygienic processing in many countries. In addition, it was considered that the existing specification may be too strict, and that its revision, based on new data related to GMP, be urgently considered.

In many of the treatments discussed, particularly irradiation, there is a clear need to provide genuine assurance to the consumer as to the safety and propriety of the process. The consultation agreed that consumers require a comprehensive framework of regulations, proper enforcement and control, and an open dialogue on the effectiveness of such a system.

5.2 RECOMMENDATIONS

5.2.1 General

1. Only foods produced under conditions of good agricultural and manufacturing practices (GMP) should be accepted for further processing, including irradiation. Further processing should not be used to disguise the consequences of poor hygiene.

2. The Hazard Analysis Critical Control Point (HACCP) concept should be applied to food production and processing systems to give added assurance of adherence to GMP.

3. Where appropriate, foods to be further processed should meet appropriate microbiological guidelines.

4. Microbiological guidelines should not be used as limits for regulatory action. Failure to meet such guidelines should direct attention to the manufacturing process and the re-establishing, if necessary, of GMP.

5. Irradiation should be considered by governments as a useful treatment to increase assurance of the safety of foods to be consumed raw or lightly cooked and to prevent cross-contamination/dissemination.

6. Studies should continue on ways to improve the hygienic processing and handling of foods.

7. Governments should encourage the training of managers, technical personnel and operators, as well as food inspectors, in the application of GMP and HACCP to food processing in general and food irradiation in particular.

8. The importance of food safety, not only for its direct impact on public health but also for its influence on the economic well-being of society should be acknowledged by governments.

9. The consultation recommended that the Secretariat of the Codex Alimentarius Commission make this report available to the Codex Committee on Food Hygiene for further elaboration.

5.2.2. Specific

1. Poultry has been identified as a major cause of foodborne disease and a prime candidate for treatment by irradiation. Only poultry produced under conditions of GMP and meeting the appropriate microbiological guidelines should be subjected to this treatment.

2. Red meats intended for irradiation should have been produced under GMP and meet the microbiological guideline proposed by this Consultation.

3. Microbiological data on frogs legs produced under GMP should be gathered from exporting and importing countries and appropriate microbiological guidelines for further processing be derived from them.

4. Appropriate data should be collected for mechanically separated meat (MSM) (red meats and poultry prepared under GMP), so that microbiological guidelines for MSM intended for further processing can be established.

5. Fish and crustaceans, especially those to be eaten raw, should meet the microbiological guideline achieveable under GMP and proposed by this consultation, whether or not further processing is intended.

6. Oysters and clams should be harvested only from certified clean waters and depurated as necessary. Irradiation can markedly improve the bacteriological safety of such products but it must not be used as a substitute for GMP. Reports that infective units of viruses are reduced by such treatment require independent confirmation.

7. More data should be gathered on the contamination of cockles by viruses and its possible elimination by irradiation.

8. Current data on the microbiology of cooked, peeled, frozen shrimps and prawns, processed under GMP, should be obtained for a review of the microbiological end-product specification in the Recommended International Code of Practice for Shrimps and Prawns (CAC/RCP 17-1978).

9. The Hazard Analysis Critical Control Point (HACCP) system should be adopted for production, handling and processing of spices and herbs. This may be a means of improving the microbiological quality of this group of dry commodities and would increase the significance of any microbiological testing.

10. Systematic studies should be performed to establish more relevant microbiological data on representative samples of lots of spices and herbs produced under good manufacturing, handling and storage practices.

11. Further research should be directed towards developing simple, reliable and sensitive methods for detection of biomass of specific groups of microorganisms foreseen as indicators of deviation from GMP.

ANNEX I

LIST OF PARTICIPANTS

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Dr K. Bögel, Chief, Veterinary and Public Health Unit, Division of Communicable Diseases, WHO, Geneva

ANNEX II

LIST OF WORKING PAPERS

prepared for the Consultation

Rationale for microbiological criteria for foods to be irradiated and guiding principles for their development (J.H.B. Christian and F.K. Käferstein)

The policy of the US Department of Agriculture concerning microbiological criteria (R.E. Engel)

The bacteriology of red meats (T.A. Roberts, W.R. Hudson & R.H. Dainty)

The microbiological quality of chicken meat to be irradiated (I. Klinger)

The microbiology of raw fish and shellfish (J.S. Lee)

Potential use of gamma irradiation to improve shellfish sanitation (J.C. Mallett & L.E. Beghian)

The bacteriology of precooked, frozen shrimps and prawns, (Ms Z. Merican)

The bacteriology of processed frogs legs (J. Gledel)

The microbiology of herbs and spices (J. Farkas & E. Zukal)

Bateriological criteria for animal feed, with special reference to fish meal (T. Rubio)

Copies of working papers may be obtained by requesting them directly from the authors (addresses see Annex I)

ANNEX III

MICROBIOLOGICAL GUIDELINES PROPOSED BY THE CONSULTATION

Red meats (beef, pork, lamb)

Carcass meat before chilling

APC (35° or 37°C): $n = 5$, $c = 3$, $m = 10^5$, $M = 10^6$

Chilled carcasses

APC (20° or 25°C): $n = 5$, $c = 3$, $m = 10^6$, $M = 10^7$

Carcass meat frozen

APC (20° or 25°C): $n = 5$, $c = 3$, $m = 5 \times 10^5$, $M = 10^7$

Poultry

APC (20°C): $n = 5$, $c = 3$, $m = 5 \times 10^5$, $M = 10^7$

Fish and crustaceans

APC (20°C): $n = 5$, $c = 3$, $m = 5 \times 10^5$, $M = 10^7$

Cooked, peeled, frozen shrimps and prawns*

APC (30°C): $n = 5$, $c = 2$, $m = 10^5$, $M = 10^6$

Staphylococcus aureus: $n = 5$, $c = 2$, $m = 5 \times 10^2$, $M = 5 \times 10^3$

Salmonella: $n = 5$, $c = 0$, $m = 0$

* end-product specification contained in the Recommended International Code of Practice for Shrimps and Prawns (CAC/RCP 17-1978). The consultation recommends a review of this specification which might be too strict.

Spices, herbs and vegetable seasonings

provisional guideline only

coliforms	not more than 10^4/g
mould propagules	not more than 10^5/g