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Risk Analysis of Seafood for Food Safety

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Seafood is a common ingredient in the diet of many people. In countries like Japan, Iceland, etc., fish is almost like a staple food. Today, more and more people are turning to seafood for scientific reasons like better protein quality, digestibility and the beneficial effects on cardio-vascular system of man. However, unlike other food sources, the species diversity and location-specific properties of fish are numerous. Species and location related hazards and their associated risks for consumers are a major problem of fish and fishery products. Organized aquaculture is gradually picking up in many parts of the world. Countries like China, Thailand and Japan have gone far ahead in this line. But still majority of the fish and shellfish harvested belong to the wild stock. In the absence of necessary legal measures and approved aquaculture practices, the inputs to the farm are only aimed for more yield at less cost in unit time. All natural water bodies are subjected to contamination from human industrial and agricultural wastes. Fish and shellfish tend to accumulate different kinds of microorganisms and chemicals from the water body as these organisms filter huge quantities of water for collecting oxygen and food. Consequently, the hazards associated with these organisms are both species and location specific. A thorough analysis of the risks involved and stream lining the processing procedure to suitably address the risks are essential steps in ensuring seafood safety. The paper briefly describes a key for risk analysis and procedures for risk free seafood processing.

Key words: Risk analysis, seafood, aquaculture

Risk and hazard are widely used terms in food quality assuranc programmes. Depending on context and location, these terms are used t describe qualitatively and quantitatively harmful properties of any food item However, the context of use are too many that the beginners in the field of quality assurance as well as the general public are often confused about the concept of hazard and risk. Realising the situation, various national and international agencies have defined and described in detail the scope of these terms for ensuring safety and quality of food. According to US FDA and the Codex (FAO/WHO), hazard can be defined as a component or property

of a food material that can cause injury/illness to the consumer. Theoretically, four major groups of hazards are identified *viz.*, physical hazard, biological hazard, chemical hazard and economic hazard. As far as food safety and food quality are concerned, the economic hazard is not of much consequence and hence this hazard is not a matter of concern for hazard control in food quality assurance programmes. On the other hand, the other three groups of hazards are critically evaluated and controlled at all food processing steps so that elimination/control of all significant hazards within critical limits are achieved for ensuring food safety and quality.

In contrast, risk is defined as the probability or likely occurrence of an illness/injury due to a hazard in a food material. In other words, risk is the manifestation of a hazard in a food material resulting in some illness/injury and as a corollary, if any food is having a risk factor, it is definite to contain a hazard. This leads to the conclusion that risk evaluation and risk assessment are essential for identification of any hazard in any food material and that risk assessment is a precondition for HACCP implementation.

In the past several years, health risks were recorded as a result of eating various kinds of food materials. While such records are many in developed countries, the same is scanty in developing and underdeveloped countries mainly due to lack of a system for documentation and reporting. Study of some such data from certain developed countries is very interesting. Table 1 gives a compilation of the percentage of risk leading to food borne diseases from selected food groups consumed in USA, Canada and Netherlands. (Huss, 1988).

Table 1. Percentage of risk associated with major food groups in certain developed countries

Food group	USA	Canada	Netherlands
Seafood	24.8	7.6	8.7
Meat	23.2	20.7	13.2
Poultry	9.8	9.9	2.7
Vegetables	4.9	7.1	2.2
Eggs	2.2	0.2	0.1
Bakery products	3.3	7.7	3.9
Dairy products	4.2	8.1	5.2

It is evident that the occurrence of a food related health risk will depend upon the quantity and frequency of consumption of this food. In all these three countries, among the food groups considered, the item consumed in highest quantity is meat and meat products. Consequently, all these countries recorded significant level of risk associated with meat and meat products. In other words, incidence of food borne disease in these countries is maximum from meat and meat products. In the case of USA, where fish and fishery products are consumed comparatively more than that in Canada and Netherlands, the risk of food borne disease from fish and fishery products is 24.8% of the total disease outbreaks reported. A classical case of incidence of food borne risk from fish and fishery products is in Japan, where more than 50% of the risk of food borne diseases are attributed to eating of fish especially *sashimi*, the dish of raw fish and *techire*, the dish from puffer fish.

A survey by UK Public Health Laboratory Service (PHLS) reveals a similar picture of risk associated with fish and shellfish. Some of the data revealed by UK PHLS is shown in Table 2. (Dillon & Griffiths, 1997).

Table 2. Cases of health risks reported from major food groups consumed in UK

Food group	No. of health risks reported
Shellfish	22
Fish	10
Fish and shellfish	32
Meat and meat products	25
Poultry	15
Egg and egg products	11
Rice and rice products	8

It is interesting to note that the risk factor is more with fish and shellfish products than any other food groups. Even though risk is more, the nutritional quality and the health supplementing factors of fish and shellfish products are unparalleled. Besides, fish and fishery products are tasty and appealing to man. In this situation, the role of Public Health Authorities to minimize the risk and risk factors in food items in general is very important. As a consequence, all national and international agencies interested in safety of food have come up with methods for risk analysis. The schemes of risk

analysis evolved by USFDA, the Codex Alimentarius Committee of UN and EU, more or less work on the same principles.

The increasing international trade in food was the immediate concern for the developed countries as well as the UN for developing a system for risk analysis so that risks and risk related hazards can be effectively managed to promote the movement of safefood materials from one country to another, without jeopardizing public health. Originally, the risk assessment procedure was perfected for controlling risks arising from chemicals. Later, it was extended to microbial and other risk factors. The major difference between the risk from pathogens and other types of risk factors, is the possibility of multiplication of pathogens, as the food move from farm to the table making the assessment all the more difficult. Nevertheless, methods were developed based on mathematical models by introducing pathogens into food, their multiplication in food, thermal destruction of the pathogens, consumption of the treated food and evaluating the risk of subsequent illness. Based on the results obtained, control strategies can be formulated. Such planned study of food risks is called risk analysis. Risk analysis is mostly performed by national and international agencies and they form the basic guideline and data bank for hazard control programmes of food industries and enforcement agencies.

The process of risk analysis

As per the FAO/WHO guidelines (FAO/WHO, 1995; 1997), risk analysis consists of three steps *viz*., (i) risk assessment, (ii) risk management and (iii) risk communication.

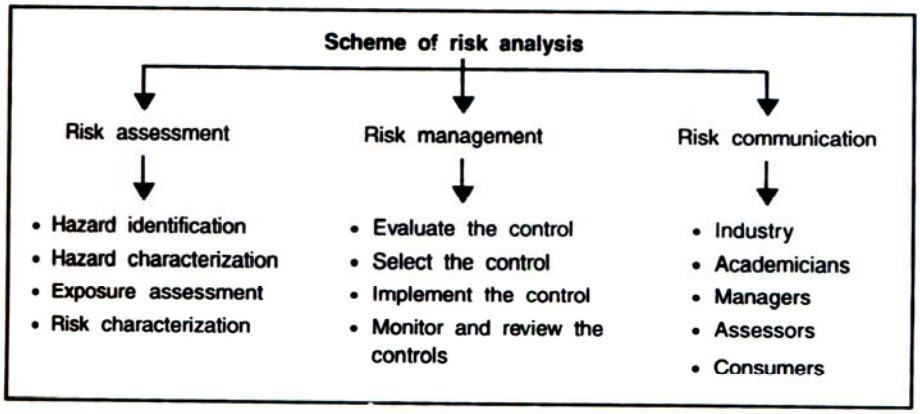

Fig 1. Scheme of risk analysis (after Dillion & Griffiths, 2001)

Risk assessment

Risk assessment involve an evaluation of the risk as to what ingredient of the food is causing the risk, what are the chemical, biological and physical attributes of the responsible ingredient, what is the consequence of its exposure to consumer. In other words, risk assessment consists of four steps *viz.*, (i) identification of the hazard in the food, (ii) exposure assessment by actual case studies or by mathematical modeling, (iii) characterization of the hazard as to the nature of adverse effects of the identified hazard on consumers, including a dose related evaluation and (iv) risk characterization, depicting the qualitative and quantitative aspects of the probability of occurrence along with severity of the illness/injury caused by the hazard in a given population (Fig. 1).

Table 3. Some typical risk related hazards

Type of hazard	Associated food
Biological hazards	
Clostridium botulinum	Low acid canned foods
C. perfringens	Improperly cooked protein rich foods
Salmonella spp.	Meat and fish items, chocolate, baked and dried foods
Listeria monocytogenes	Milk and milk products, raw meat, vegetables, raw and cooked poultry and fish items, smoked fish
Vibrio cholerae 01	Raw fish and shellfish
Chemical hazards	
Pesticide residues	Agricultural products of plant origin
Antibiotic and hormone residues	Farmed animals (poultry, shrimp, fish)
Histamine	Scombroid fishes
Biotoxins	Certain species of fish and shellfish.
Heavy metals (Pb, Cd, Hg)	Certain species of fish and shellfish

Thus, risk assessment will give a clear idea about the hazard responsible, the impact of the hazard on consumers, the nature of the impact as well as the probability and severity of the impact on consumers.

Risk management

Once the information about any food related risk are available, the next step in risk analysis is to devise methods of managing the risk so that the food is free or within tolerance limit of the hazard and the consumers are safe. This procedure is known as risk management which consists of four

steps *viz.*, (i) risk evaluation (ii) selection of control measures, (iii) implementation of control measures and finally (iv) monitoring and review for ascertaining effectiveness or for further modification (Fig. 1).

Risk evaluation will reveal the hazard as well as the degree of its severity in causing the illness/injury/toxicity such as high/medium/low degree of severity of the impact. Knowledge of hazard and risk evaluation will be useful in devising procedures for controlling the hazard, which in turn will form risk management options. In case of biological hazards, the management option can be cooking which will eliminate the risk or methods like GMP and SSOP to prevent contamination. Finalization of risk management options is followed by actual testing of the risk management options through experiments or trials. Successful risk management options can be practiced in production line. All such procedures can be periodically monitored and reviewed to ascertain that the risk management procedures practiced are effective.

Table 4. Risk related biological hazards grouped according to risk severity

High severity	Medium severity	Low severity
Clostridium botulinum A, B, E & F	*Listeria monogytogenes*	*Bacillus cereus*
Salmonella typhi, paratyphi A&B	Other *Salmonella* spp.	*C. perfringens*
Vibrio cholerae 01	*V. parahaemolyticus*	*Staphylococcus aureus*
Escherichia coli 0157	Hepatitis A&E	
	Shigella spp.	

Risk communication

The final data obtained in risk assessment and risk management gives useful information, which is to be communicated to all interested parties and this is known as risk communication (Fig. 1). Codex has defined risk communication as the interactive exchange of information and opinion throughout the risk analysis process concerning risk related factors, risk perceptions, among interested parties like assessors, risk managers, consumers, academicians and other interested parties.

Within FAO/WHO, the risk assessments are carried out only by joint committees on Food Additives, Pesticide Residues and Microbiological Criteria, while the Codex manages the risk management part. All participants in the process of risk assessment and risk management are responsible for

risk communication. The guidelines developed by FAO/WHO can be adopted by member nations or they can harmonize their own versions with the FAO/WHO versions. Ultimately, the risk analysis will provide all details on significant hazards and their control measures to tackle the problems of food borne infections and intoxication, which can be effectively used for implementation of HACCP in any food industry, so that the food produced will be safe for human consumption and the general public will be free from food related health risks.

References

Dillon M. and Griffith, C. (1997) *How to Audit*, MD Associates Ltd, Grimsby, U.K.

Dillon, M. and Griffiths, C. (2001) *How to HACCP*, MD Associates Ltd, Grimsby, U.K.

FAO/WHO (1995) *Application of Risk Analysis to Food Standards*, Report of Joint FAO/WHO Consultation, 13-17 March 1995, Geneva

FAO/WHO (1997) *Risk Management and Food Safety*, Report of Joint FAO/WHO Consultation, 27-31 Jan 1997, Rome

Huss, H.H. (1988) *Safety of seafood*, Personal communication