Risk assessment and emerging chemicals hazards in foods

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Abstract

The main beliefs relating to the risk assessment of chemicals in foods, new chemicals in raw material as well as in food processing are briefly presented. Evaluation reviews of representative chemicals found in traditional and novel foods are given. Old and new processes or newly recognized compounds, that require careful assessment in terms of their potential human health impact, are discussed. As example of processing-related contaminants, a risk assessment for acrylamide, is described, providing two different approaches in food safety assessment and the management of carcinogenic contaminants.

Key words: risk assessment, chemicals in foods, traditional and novel foods, acrylamide.

Introduction

Risk assessment of foods encompasses both the evaluation of their microbiological and chemical safety. This paper focuses on latter of these two aspects, specifically, chemical hazards in relation to the food production cycle. It is estimated that annually in the United States there are 76 million cases of foodborne illness, 5,000 foodborne illness related deaths and 325,000 food-related hospitalisations.[1] Of the 1,417 foodborne disease outbreaks reported in the year 2000 to the Centres for Disease Controls and Prevention (CDC) in the U.S.A., 1198 outbreaks were recorded as bacterial diseases, 176 as viral, 37 outbreaks were classified as having a chemical aetiology and 6 were considered to be parasitic.

The increasing world-wide consumer demand for a large variety of readily available foods, that are also convenient, nutritious and healthy, has lead to an increase in new food ingredients, new food processing or new food packaging, as well as new chemicals compounds and contaminants in foods. This is because unprocessed materials for cooking, such as cereals, vegetables, meat or fruits, are now produced using chemical production supports, for instance, pesticide for crops or veterinary drugs for farm animals. Therefore, industrialisation has resulted in the necessity to use a number of chemicals for food production in order to prepare ready-to-eat traditional foods and to protect the food or maintain colours and flavours for the duration of transport and storage.[2]

In the early '50s, awareness of the potential effect, of a single or groups of narrowly related chemical compounds in food, on human health was principally focused on compounds intentionally used in food manufacturing, for example, food additives and pesticides. But, with improving technology and the new ability of analytical chemists to reveal more compounds at their lowest level, it has become evident that an ever-increasing number of unwanted contaminants could also be present in food. These impurities are naturally occurring toxic substances or may originate from environmental pollution or are formed during food production or preparation. In order to assure the highest level of human health protection, new food processes or food ingredients, rather than the novel foods themselves, must now undergo a complete safety evaluation before being placed on the market.

Furthermore, if most current Hazard Analysis Critical Control Point procedures (HACCP for the identification, assessment and control of hazards in food during their preparation, storage, transport and commercial processes) focus on microbiological and physical hazards, then to-date, the use of HACCP to control chemical hazards has been limited, particularly in auxiliary practices (as well as non-production or non-manufacturing practices), due to the high costs of chemical monitoring that largely restrict chemical HACCP to other, less direct, control measures. So, it's evident that the importance of a well carried out risk assessment, aimed at improving safety in relation to chemical contaminants in food, is not only to protect public health safety but also to simplify HACCP procedures in order to identify chemical hazards.

Sources and contaminants

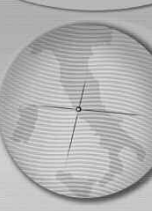Industrial areas, small-scale enterprises, production and use of pesticides, mining activities,

Table 1. Examples of classic food contaminants, sources and health effects.

Contaminants	Example of Sources	Main Contaminated Food	Main Effects on Health

Mercury, cadmium, lead	➢ Industries wastes
	➢ Soils
	➢ Mining activities
	➢ Engines exhaust
		➢ Contaminated waters
		➢ Fruits and vegetables
		➢ Fish:
		  o Swordfish
		  o King mackerel
		  o Tilefish
			➢ Foetal nervous system damages
			➢ Kidney pathologies
			➢ Gastrointestinal symptoms
			➢ Neurological problems

Polychlorinated biphenyls (PCBs)	➢ Insulation Materials ➢ Pesticides	➢ Breeding animals ➢ Fish ➢ Milk	➢ Cancer ➢ Dermatological pathologies

Ciguatoxin	Bioaccumulation from Dinoflagellates	➢ Fish:
		  o Grouper
		  o Mackerel
		  o Snapper
			➢ Gastrointestinal symptoms
			➢ Neurological problems
			➢ Cardiovascular symptoms

Scombroid poisoning	Histidine or other aminoacids conversion to histamine	➢ Fish:
		  o Tuna
		  o Mackerel
		  o Anchovies
		  o Sardines
			➢ Low blood pressure
			➢ Headache
			➢ Itching
			➢ Gastrointestinal symptoms

Paralytic shellfish poisoning (PSP or Saxitoxin)	PSP formed in tropical seas by algae, on which shellfish or fish feed	➢ Shellfish ➢ Fish	➢ Difficulty with speech ➢ Neurological problems ➢ Respiratory paralysis

Mycotoxins:
  ➢ Ochratoxins
  ➢ Trichothecenes
  ➢ Aflatoxins
    (B1, B2, G1, G2)
  ➢ Fumonisins
	Fungi that grow on foods during unfortunate weather conditions or during storage of crops under humid conditions.	➢ Corn
		➢ Peanuts
		➢ Milk
		➢ Meats
			➢ Haemorrhage
			➢ Liver damages
			➢ Abnormalities in digestion and absorption
			➢ Lethal oedema
			➢ Dismetabolic states

Pesticides	➢ Agriculture ➢ Food storage ➢ Corns ➢ Hobbies	➢ Fruits ➢ Vegetals ➢ Crops	➢ Neurological problems ➢ Asthma ➢ Birth defects ➢ Cancer ➢ Muscle weakness and paralysis ➢ Gastrointestinal symptoms (diarrhoea, nausea, vomiting, abdominal pain) ➢ Hypertension ➢ Miosis

hazardous wastes and even atmospheric pollution are important sources of toxic food contamination (see Table 1). [3] Examples of well-known environmental pollutants that contaminate foods are *polycyclic aromatic hydrocarbons* (PAH), *polychlorinated dibenzo-p-dioxins and dibenzofurans* (PCDD, PCDF: "dioxins"), *polychlorinated biphenyls* (PCBs), other persistent halogenated organic substances and toxic trace metals such as *mercury*, *lead* and *cadmium*.

Foodborne exposure to agricultural chemicals is a public health concern in most countries and the scientific and epidemiological literature indicates that the general population in developing countries is mainly exposed to a mixture of pesticide residues in food whereas, in industrial countries, they are exposed to a combination of veterinary drugs, potentially carcinogenic substances and metal residues.[4]

The exposure to a combination of contaminants, as experienced by populations worldwide, is clear and indisputable, resulting in risk assessments for chemicals in traditional foods focusing primarily on the potential adverse health effects arising not from the presence of a single component but from groups of strictly related chemicals in the foods. For example, some agricultural areas, in developing and industrial countries, are naturally contaminated with *arsenic*; therefore an interaction between
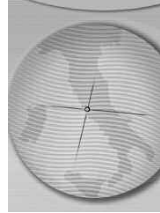
pesticides or other toxic compounds with arsenic might be expected in these areas.

In industrial as well as European Countries, chemical agents can consist of those naturally occurring in the food or those added to the food either intentionally or accidentally.[5] Environmental contaminants that unintentionally may contaminate food or supplies include mercury that can be consumed as a constituent of contaminated water or fish and *polychlorinated biphenyls* (PCBs). Examples of naturally occurring chemical agents identified in foods and associated with fish consumption and foodborne outbreaks in the year 2000 are *ciguatoxin*, *scombroid* toxins and paralytic shellfish poisoning.[6,7] Other naturally occurring chemical substances in foods are *mycotoxins*, *tetrodotoxin* (in puffer fish), *phytohaemagglutinin* in undercooked red kidney beans, and certain types of mushrooms (Table 1).[8]

Chemicals are also intentionally used in agriculture, for example pesticides, antibiotics and hormones. All of these chemical classes are used to bring about positive effects on food supply, for example, pesticides are used to reduce crop damage caused by pests and insects; antibiotics are given for disease treatment, disease prevention and growth promotion; and hormones (steroids in particular) such as recombinant *bovine somatotropin* (BST) has been used to accelerate milk production in cattle.[9-11]

In 1997, the WHO published a report indicating that antibiotic use in animals reared for food might lead to problems with antibiotic resistance and treatment failures, for example *fluoroquinolone* resistance.[12] The use of antibiotics to promote growth is widespread in food animal production; but antibiotics used for growth promotion increase the pressure for bacteria to become resistant. To address this public health problem, the World Health Organization (WHO) has recommended that antibiotics should not be used for this purpose,

because this practice is unsafe for the public's health.[13] On the other hand, many of the bacteria in food that cause disease are found in the intestinal tracts of animals or people. Healthy food-producing animals commonly carry bacteria that can cause illness in humans, including *Salmonella* and *Campylobacter*.[10] Furthermore, the use of antibiotics in animals (reared as food) and people can result in resistant strains of antibiotics ending up in the food supply.
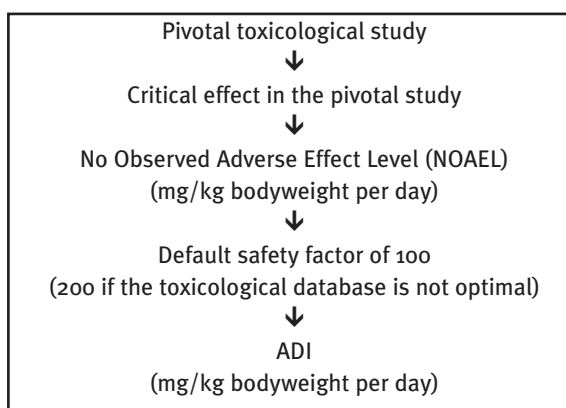
The health effects of pesticides as well as other chemical compounds are dependent on toxicity and dose. Pesticide residues can be found on fruits and vegetables as well as crops but there are also cases of human exposure related to their use in buildings and gardens. Among pesticides, organophosphates are among those primarily reviewed because their efficacy; they act as cholinesterase inhibitors and a lack of acetylcholinesterase can in humans cause a variety of symptoms and pathologies. According to WHO, CDC, FAO and EU Toxicological Unit, children and infants eat and drink more in relation to their body weight than do adults and, on the other hand, children also have immature and growing body organs. Because of this increased susceptibility, older persons and pregnant women may also be particularly vulnerable to the health risks associated with pesticides (Table 1).[14]
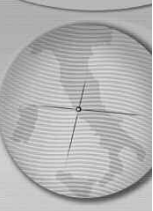
Concern has been expressed about the safety and the health effects of *bovine somatotropin* (BST) in terms of its relationship with the insulin-like growth factor.[15] Milk from cows that receive BST has higher levels of IGF1, and these levels actually pose an important human health risk.

Some foods may cause health effects related to allergenicity, and it is not unusual to find the statement that all food additives and other chemicals found in food have an increased risk of allergy. Allergenicity involves an abnormal response to a food protein, glycoprotein or polypeptide in a food.[16] Theoretically, chemicals in the diet may influence allergic sensitisation in different ways: 1) directly, because they are allergens or haptens (IgE mediated food allergy); 2) indirectly, because they may act as adjuvants; or they may modulate the immune system by direct immunotoxicity, which may change the balance from tolerance to IgE production; or they may trigger non-allergic intolerance reactions (non-IgE mediated immune responses associated with food) like that to *tartrazine* or *sorbic acid*, *monosodium glutamate*, *benzoic acid* and *sulphite*.[17,18]

Common food allergies IgE- mediated include allergies to milk, wheat, egg and peanuts. The primary route for food allergies or sensitisation is

Figure 1. The acceptable daily intake (ADI).

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            Pivotal toxicological study
                      ↓
         Critical effect in the pivotal study
                      ↓
      No Observed Adverse Effect Level (NOAEL)
            (mg/kg bodyweight per day)
                      ↓
           Default safety factor of 100
    (200 if the toxicological database is not optimal)
                      ↓
                     ADI
            (mg/kg bodyweight per day)
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probably via the oral route or inhalation, while some chemicals that cause contact allergies are also normal constituents in food. Ingestion of the contact allergen may cause skin flare reactions or other symptoms: patients with unexplained eruptions of *nickel* eczema of the hands may benefit from a diet with a low nickel content.[19] Allergic oral and perioral symptoms have also been described and linked with antioxidants and flavours.

Carrageenan is used in the food industry, as a thickening, gelling or protein suspending agent and it is probably an adjuvant with immunomodulatory effects depending on the route of exposure and on the dose, as well as the nature of the antigen and the time of the antigen administration. Emulsifiers or other food additives (thickeners, flavour enhancers in ready-to-make cake and bread mixes, or candy and soft drinks) may enhance the absorption of other chemicals.

Direct immunotoxicants include colour additives such as the imidazole derivative *2-acetyl-4(5)-(1,2,3,4-tetrahydroxybutyl)-imidazole* (THI) found in caramel colour III, for which the health effects have been linked to a diet low in vitamin B6 and to a reduced lymphocyte count. Several mycotoxins that occur as food contaminants are direct immunotoxins, for example, *ochratoxin A* and *T2* toxin (*Fusarium*); while lead or persistent organochlorine pesticides in food (such as *dieldrin*, *hexachlorobenzene*, *polychlorinated dibenzodioxins* and *furans*, PCDD/F, or *polychlorinated biphenyls* (PCB's)) are immunotoxic in experimental animals. In the end, intolerance to a food may also occur due to enzyme abnormalities, an abnormal pharmacologic reaction, or an unknown mechanism.

Chemicals can also be introduced into foods unintentionally, for example, during food processing, storage or preparation. *Diethyl carbamate* is formed during fermentation processes and the heterocyclic aromatic amines are formed during frying, baking and grilling of fish and meats ("cooked food mutagens"). Cooking procedures, for example, comprise of a number of compounds that have been associated with genotoxic and carcinogenic effects *in vivo* in animals, such as *acrylamide* or PAH, which are formed in considerable quantities during the smoking and barbecuing of food; furthermore, N-nitroso compounds are formed by the reaction of nitrite with secondary amines and amides during the pickling, smoking and frying of nitrite/nitrate treated meats or fish foods.

During the preparation or serving processes, cleaning materials (tensioactive or detergents) or metals from food containers or kitchen and/or dining surfaces, or preservation or antioxidants gas, vapours and other substances from packaging (that saturate packaging materials and from these are transferred to food) may contaminate foods or supplies.

Risk assessment of chemicals contaminants in food

In the EU, until 2003, the European Commission's Scientific Committee for Food (SCF) performed safety evaluations for food additives and contaminants, while now this task has been taken over by the European Food Safety Authority (EFSA). On a global level, it is the World Trade Organization (WTO) that recognises the FAO/WHO Codex Alimentarius Commission (CAC or "Codex") standards as a reference point for the safety of foodstuffs traded internationally and, for instance, establishes new standards in the Codex Committee on Food Additives and Contaminants (CCFAC), which uses the Joint FAO/WHO as an advisory committee with regards to the safety evaluation of food additives and contaminants.

The risk assessment is an important part of the risk analysis (a global concept subdivided into three separate tasks although through an interactive process, which includes risk assessment, risk evaluation or risk management and risk communication).

The risk assessment of chemicals in food contains the following steps:[20,21]

1) *Hazard evaluation/identification* – this step basically tries to answer the question of what the chemical is capable of doing. The adverse effects of the chemicals are described throughout studies on absorption, distribution, metabolism and excretion of potential chemical contaminants of food; acute, short-term and long-term or chronic toxicity; in vitro tests for mutagenicity, clastogenicity and genotoxicity; studies on carcinogenicity, often combined with the long-term studies as well as studies on reproductive and developmental toxicity.

2) *Hazard characterisation* – mainly describes and evaluates the dose-response and dose-effects relationships for the most sensitive adverse health effects reported in the available studies, as well as issues regarding the mechanism/mode of action and extrapolation between species.

3) *Exposure assessment* – considers different elements, the occurrence of chemicals in food and the amount of food consumed, in order to estimate the daily intake levels of the compound from food at the time of consumption, and concerns the whole population, segments of the population and individuals.
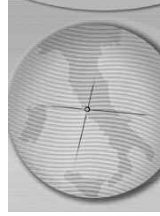
4) *Risk characterisation* – integrates information from the interactive process which considers the characteristics of the hazard and the exposure assessment, as well as evaluating the quail-quantitative probability for the health risk in a given population as well as the significance of any health risk.

Risk assessment of chemicals in traditional and in novel foods

Traditionally, in the area of food, two different approaches to risk assessment for chemicals are recognized: if the compound is not directly genotoxic and if the compound presumably acts via a genotoxic mechanism. On the other hand, new developments in some areas of the risk assessment are improved in traditional foods as well as in "*novel foods*": the subdivision of the safety factors; new approaches to susceptibility of infants and children or pregnant women; the concept of threshold of toxicological concern (TTC for the assessment of flavouring substances); risk assessment of chemical substances that are both genotoxic and carcinogenic.

Novel foods in United Europe (EU), compared to traditional, are foods or food components that have never been used for human intake, within the EU market, before May 1997 (EC regulation n° 258/97 of 27 January 1997). This comprises foods or ingredients to which a production process at this time has not yet been applied.

Under this regulation, a novel food is examined and evaluated in comparison with the corresponding traditional food, according to a comparative principle of "substantial toxicological equivalence". This principle is not a substitute for a risk assessment, but it should form an integral part of the overall safety evaluation, by addressing toxicological experiments in a targeted, case-by-case method.

If the substance is not directly genotoxic, it is presumed that it acts through a mode, which has a threshold and a valuable no-effect level (NOEL/NOAEL). So, a safety level for its intake should be extrapolated for humans through the application of safety/uncertainty factors, such as: acceptable daily intake (ADI) or, for contaminants, tolerable daily intake (TDI); margin of safety (MOS: ratio between the NOAEL used for the derivation of the ADI/TDI and the estimated human intake of the compound) and/or reference dose (RfD). In particular, ADI is derived from experimental studies, (in *vivo* and in *vitro*) as well as from humans (Figure 1), furthermore, ADI ensures that the amounts of a given compound allowed in various foods (additives, pesticides, veterinary drugs, flavours) would not result in using higher quantities than the safety level permits and "that can be ingested daily over a lifetime without appreciable health risk".

The default 100-fold safety factor (when the toxicological database is not optimal, but there are no indications of any short-term health problems, a temporary ADI may be established using a larger safety factor of 200) is considered to comprise a factor of 10, to allow for differences between test animals and humans (variation in inter-species sensitivity), and a factor of 10, to take into consideration human variability (variation in inter-individual sensitivity).

On the other hand, if the compound presumably is active through a genotoxic or carcinogenic metabolic pathways, historically a non-threshold mode is supposed and no-safe level of intake can be determined. In the end, for those substances that are judged to be undesirable but unavoidable in foods, different principles are applied including risk assessments using a "weight of evidence" approach such as "ALARA" (the level should be as low as reasonably it is possible to achieve) or "ALARP" (the level as low as reasonable practicable). The mechanistic understanding of the compound's action, which does not take into consideration the presence or the absence of a threshold, is in fact the way in which policy decisions are made, i.e. quantitative risk assessment; the determination of the likelihood of an adverse effect occurring at a certain level of exposure, is actually rarely used in the food area (with some exceptions such as, for example, the evaluation of aflatoxins).

Risk assessment and innovative developments

Further subdivision of each component of the ADI safety factor was carried out by Renwick (1993)[22] and WHO (1994), [23,24] in order to examine the two areas of uncertainty (inter-species and inter-individual differences in *toxicokinetics* and *toxicodinamics* of chemicals), and so the default values of the four individual factors were modified. But these new default values may be further modified when appropriate data becomes available.

In fact, the susceptibility of infants, children and pregnant women to food additives and contaminants is of growing concern for chemical food safety. These groups at risk, in general, are more susceptible than others due to the particular state of their biochemical and physiological processes (premature development in infants and children or foetus), and they also have a higher food intake and different dietary habits and food needs. But at this moment, no valid models can be
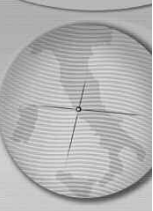
established that reflect age or pregnancy-related differences in susceptibility to chemicals with respect to adults or other groups. So, if at present the risk assessment for these groups is addressed only on a case-by-case basis, then new toxicological databases should adequately protect for the most sensitive effects and the most sensitive age groups and, therefore, new ADIs should be derived from this evidence. In fact, the older ADI safety factors derived from test methods were, at the doses of additives and contaminants normally used, and no major systematic differences in toxicokinetic parameters between animals and humans were found. In effect, xenobiotic-metabolising enzymes are more enhanced in the humans foetus and neonate than in their animal counterparts. But to protect infants, children as well as the foetus during pregnancy and the neonatal period or young infants during the nursing period, concern should be expressed about "*delayed functional toxicity*", which the currently used methods and ADI do not adequately reveal. Sub-toxic doses present in foods and given to the developing foetus, infants or children during the developmental period might produce, in fact, functional deficits of the central, reproductive, immune and endocrine systems, for which related symptoms or pathologies manifest themselves in adult life.

On the other hand, the toxicologists, in general, have no serious health concerns about occasional excursions of intake above the ADI/TDI, however, they consider that excursions are generally undesirable, in particular for a long period. Although ADI for food additives relates to the lifetime exposure for adults and provides a large margin of safety, to take into consideration the occasional excursions of intake above ADI limits. The safety factor level formulas have been produced in order to tolerate a large number of contaminants that exceed ADI levels and short-term excursions above the ADI/TDI, for contaminants that have a very long half-life in humans, should not impact greatly on the body's overall burden. Despite this, estimates of human exposures to chemicals are not precise and the precision of the estimates should not exceed the precision of the methodology. So, interpretation of intake data in relation to the ADI should recognise the limitations of the estimates.[25]

Until 1995, only about 70 of the approximately 3000 flavouring agents used in foods had been evaluated by the Joint FAO/WHO Expert Committee on Food Additives (JEFCA). From 1995 to 1998 JEFCA developed and adopted a new PSE (Procedure for the Safety Evaluation) for flavouring agents, and over 1500 flavouring substances were at this time evaluated. The PSE divides the flavouring substances into three structural classes based on increasing structural complexity and structural alerts. It also includes the acceptance of a threshold of toxicological concern (TTC) of 1.5 µg/person per day, based on a large number of long-term toxicity/carcinogenicity studies. However, the AFC Panel (EFSA scientific panel) has not accepted this TTC, and additional intake estimates are being made using a modified theoretically anticipated maximum daily intake approach (M-TAMDI).

Compounds with genotoxic and carcinogenic properties have no threshold (or no dose without a potential effect) but, on the contrary, threshold-based mechanisms are plausible for genotoxic agents, which do no react directly with DNA, but indirectly cause DNA damage, for example, through oxidative stress. In general, the animals are exposed to the probable genotoxic compound during their lifetime at high dose levels, so statistically significant tumour incidence can be produced. These data must then be extrapolated to the usually much lower human exposure levels, with any calculations and estimation errors. Furthermore, the models that are most often used are a linear extrapolation from the recognizable range (DNA binding normally shows a linear dose-response relationship in the low dose range), and the perceptible precision of the calculations does not reveal the uncertainty in the risk estimate and, so, the related results are misread as quantification of the actual risk (under or overestimation). In fact, there is now an emerging scientific rationale on cell "household" mechanisms, such as DNA repair, that indicate non-linear dose-response relationships. The European Food Safety Authority (EFSA) and JEFCA recommend the use of a Margin Of Exposure (MOE) approach in the assessment of compounds that are both genotoxic and carcinogenic.[26] MOE is the ratio between a defined point on the dose-response curve (reference point) for the adverse effect of the substance in the animal carcinogenicity study and the estimated human intake of the substance. However, JEFCA and EFSA recommend using the benchmark dose approach (BMD: based on mathematical modelling that estimates the dose that causes a low but measurable response) to estimate the reference point. In the end, the reference point is not equivalent to a NOAEL and effects can occur at lower doses; but the dose effect relationship, between the reference point and the dose level below, for which cancer incidence is not increased are unknown, representing additional doubts.
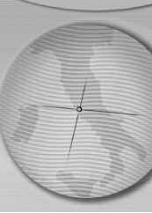
The acrylamide example: risk assessment or balancing risks?

Swedish National Food Administration announced, in April 2002, that Swedish scientists have reported the detection of partially high levels of acrylamide in certain grilled, baked or fried foods.[27] Acrylamide was detected in starchy foods that were fried or baked at a high temperatures at home or industrially; with the highest levels of acrylamide being found in carbohydrate rich foods such as potato chips, french fries and crisp breads. In raw, unheated or boiled foods no acrylamide was detected. The source for low levels of acrylamide in foods is also due to its migration from food packaging materials.

Acrylamide is readily absorbed from all exposure routes and due to its high water solubility; it is widely distributed throughout the body, including via maternal milk and the placenta. Acrylamide is known to be neurotoxic in humans, causing peripheral neuropathy and interferes with the proteins involved in axonal transport, including microtubule-associated proteins. However, no dose-response data are available at this point in time. The NOAEL for reproductive toxicity was derived from a study of rats using 2 mg/kg body weight per day. Acrylamide is not mutagenic in bacterial tests and results of mutagenicity tests in mammalian cells are equivocal. However, acrylamide is positive in a number of *in vitro* and *in vivo* tests for genotoxicity (micronuclei, sister chromatid exchange, mitotic disturbances, etc.). The carcinogenicity of Acrylamide has been tested for and has demonstrated an increase in the following tumour incidences:[28]

• thyroid tumours in male and female rats;
• testicular tumours in males and breast tumours in females;
• pheochromocytomas in the adrenal gland;
• glial tumours in the central nervous system;
• squamous papilloma in the oral cavity;
• adenocarcinomas in uterus and in the clitoral gland;
• pituitary adenomas.

In vivo studies, acrylamide was metabolized to glycidamide, which is a chemically-reactive epoxide that forms DNA adducts. There are two models to approach to carcinogenic risk assessment and the impact of acrylamide on public health.

In one of these, JEFCA used different statistical models in order to determine the lowest range for BMDL10 for total mammary tumours (0.30-0.46 mg/kg bw per day), then the more conservative lower end of this range was used for the evaluation. A value of 0.001mg acrylamide/kg bw per day was taken to represent the average intake by the general population, and a value of 0.004 mg/kg bw per day by high consumers. So, MOE was fixed at 300 for the general population and at 75 for those considered to be high consumers, but JEFCA considered these MOEs to be low for a compound that is genotoxic and carcinogenic and concluded that appropriate efforts to reduce acrylamide concentrations in foods should continue.

On the other hand, any authors consider that for chemicals in foods, that are ingested daily in substantial quantities, a sufficient edge between the threshold determined in animal experiments and actual human exposure levels can almost never been guaranteed. So, it is reasonable to assume that humans are more sensitive than experimental animals to components of foods, which have had a long history in the human diet. Balancing risks, the health risk of acrylamide produced in starchy foods seems relatively low among other inherent food-related factors when one considers the risk from the perspective of its impact on Loss of Life Expectancy (LLE), although this does not imply that this risk should be ignored. People have already been exposed to a certain degree of chemical risk without being overly affected in their daily life.[29] The cooking process reduces the likelihood of becoming ill from microorganisms present in the raw materials, and people have extended their LLE by reducing major food-related health risks (such as food poisoning), rather than focusing on minor risks such as the probable development of toxic substances. Therefore, based on the assertion that some scientists accept some degree of chemical risk in balance with others, regulatory agencies would provide better support for public health if they took a more flexible and effective approach in controlling the health risk of chemicals and, finally, the public would also be encouraged to make the changes in lifestyle needed in order to effectively reduce risk. So, a quantitative and integrated approach (determination of LLE) to assessing the impact of chemicals would be more effective than merely pursuing the reduction of all chemical risks, as well as acrylamide, to zero or negligible levels.

In conclusion, the existence of the above-mentioned different hypotheses, illustrates that there are still significant knowledge gaps that at present exclude a more reliable estimate of the cancer risk due to acrylamide and to other carcinogenic chemical compounds in food.

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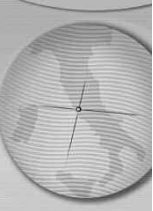
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