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Preventive Practices from Field and Shelf to Fork to Minimize Chemical Hazards Dietary Intake

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Abstract

Chronic diseases such as cancer, neurodegenerative disorders, cardiovascular and autoimmune diseases have been related with food chemical hazards intake. Therefore, great concern of food manufacturers and authorities is to ensure food safety and quality and minimize exposure to relevant risks. Nevertheless, the latter cannot be totally eliminated, when by employing erroneous treatments extra risks are added. Public awareness and relevant knowledge among food professionals and food handlers is lacking, even on countries that possess advanced food safety systems and strict food legislation. Besides, financial difficulty reinforces people to utilize low quality food and houseware increasing the health related hazards. Regarding the severity for global health and damage costs, the need for information on precautionary practices that will reduce chemical hazards dietary intake is imperative. In the present review certain practices such as thermal processing, washing or appropriate handling of the raw material are listed to educate anyone related with the food sector how to minimize heavy metals, acrylamide, pesticides residues, heterocyclic aromatic amines and polycyclic aromatic hydrocarbons intake and promote health. The introduced simple practices can be applied except for home kitchens, also in quality systems of professional kitchens, warehouses and food industries.

Introduction

It is widely known that there is an unquestionable link between nutrition and health. Additionally, the higher living standards along with frequent food safety incidents have increased consumers concern for safer and healthier foodstuffs. Although efforts are being made to improve food safety and quality the number of related risks remains very high, resulting in considerable costs to individuals, industries, communities and economies [1-3]. The latter applies even to countries that possess advanced food safety systems and strict food legislation [2,4]. On the other hand, people in developing countries are exposed to higher food safety risks due to uncontrolled environmental pollution and circulation of "suspect" foodstuffs, in addition to lack of knowledge on food safety issues [5]. Besides, in 2016 there still exist risks for severe water born diseases due to poor sanitation and poor access to safe drinking water (e.g. in some West African countries) [6]. The magnitude of human suffering and economic losses cannot be accurately determined as many cases are unreported and many outcomes of new food hazards have not emerged yet [2].

Data reveal that there are worldwide important knowledge gaps even for simple food related issues concerning handling, hygiene and safety [1,2,4,5]. On the other hand, matters related to food associated hazards are quickly changing, with new "chemical poisons" to place serious health risks. In addition, financial difficulties reinforce people to utilize low quality food and houseware introducing safety issues. Relative knowledge is absent not only for the public, but also among food handlers and professionals. Most hazards are more dangerous for vulnerable individuals such as pregnant and breastfeeding women, prenatal, natal and early childhood [7,8]. The latter are very susceptible to chemical threats, as being in early development and having a dietary pattern (higher food intake per kg body weight) that differs notably from that of adults [9].

Although hazards accumulation is associated among others to toxicity, carcinogenicity, neurodegenerative, cardiovascular and autoimmune disorders it is difficult to directly link certain foods or certain harmful chemicals intake with the cause of a disease. In general, the severity of the harm is related to the properties of the contaminant, its concentration in the foodstuff and the frequency of human exposure to it. The co-intake of other substances and other parameters such as heredity, physical activity, lifestyle significantly affect the overall human health [10]. However, the intake of harmful chemicals is widely accepted to negatively contribute to human status and therefore it is vital to be minimized [11]. Therefore, circulation of relevant information is imperative.

Numerous scientific papers and reviews on analytical issues, chemical, biological, health and medicinal aspects of chemical hazards exist. However, no preventive actions for hazards minimization, applicable in every sector where food is handled, are summarized. The aim of this review is to present precautionary practices for everyone implicated in the food chain that consumes, produces and/or handles food, so as selected chemical hazards intake to be decreased for a healthier wellbeing. The introduced simple practices can be also incorporated in quality systems of professional kitchens, warehouses and food industries. From the plethora of food related hazards, this review addresses to the harmful heavy metals, acrylamide, pesticide residues, heterocyclic aromatic amines and polycyclic aromatic hydrocarbons.

Harmful metals dietary intake prevention

Heavy metals have been related with toxicity, carcinogenicity, abnormalities in early childhood, neurodegenerative disorders,

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undesirable metabolic actions, kidney, bone and gastrointestinal damages, cardiovascular diseases and other acute and chronic illnesses [12-16]. They mainly accumulate in blood, kidney and liver causing deleterious effects on human health [12]. Individuals may be exposed to metals through the environment, as well as cookware, food, water, medicines, and products of personal care. The major concern regarding toxic metals intake is related to food contact materials, though strict regulations exist and firm limits are established by official bodies for the leaching of harmful metals from food contact materials. Ordinarily, food originated metal toxicities are not frequent under regular conditions [12,17]. Still, Joint FAO/WHO and EC Committees established maximum limits for the presence of some toxic metals (Cd, Pb, Hg and Sn) in certain foodstuffs (Commission Regulation EC No 1881/2006).

Exposure related to food contact materials

Regarding Europe, materials that are intended to come in contact with food should comply with the regulation EC No 1935/2004 and the maximum limits set by the council directives (e.g. Directive 84/500/EEC for ceramics). Still, the number and frequency of notifications recorded in the Rapid Alert System for Food and Feed (RASFF) concerning heavy metals (mainly Mg, Ni, Pb, Cr, Cd) migration from food contact materials indicate the magnitude of declination from the norms. Low quality houseware have overwhelmed international markets, as financial difficulties reinforce people to seek for inexpensive alternatives. Notified materials, mainly originated from China, include among others oven trays, coffee percolators, tea and other strainers, toasters, knives, spoons and forks, scissors, electric oven and barbecue grids and sets, baking dishes, ceramic plates and mugs, porcelain and other tableware, kitchen utensils, colored and decorated glasses, enamel fondue sets, microwave ovens, woks and frying pans.

Frequently, risk from food contact materials is related to public ignorance and traditional habits. Consumers are unaware that the use of crystal glasses and decanters, as well as glazed ceramic and earthenware equipment is a severe risk for lead toxicity. In certain communities (e.g. African and Asian countries) significant amounts of toxic metals are frequently ingested by consumption of beverages from traditional pots [18]. The risk is serious if such dishware are frequently used for the consumption of hot or acidic beverages or addressed to pregnant woman and small children [7,18-20].

Metals (mainly Al, Fe, Cr, Ni, Cd, Sn, Pb, Cu) may migrate from cookware, utensils, containers and packaging materials (such as cans and wrapping foils) [21,22] One of the most frequent and severe risks is related to aluminum, as it is related to serious neurogenerative disorders (e.g. Alzheimer). Levels of metals (usually Al, Cd, Sn, Pb and Cu) in canned foods are reported to be higher than that of uncanned relevant products [23]. Concentrations are usually reported to be acceptable for human consumption [24-26]. Still, canned foods in some cases exceed tolerable limits. Last but not least, various inorganic elements (Al, As, Ba, Br, Ca, Cd, Co, Cr, Cu, Fe, Hg, Ni, Pb, Sb, Sn, Se, Ti, Zn etc.) contained in plastic containers to enhance quality may contaminate food through containers' degradation [27]. Metals migration is favored under low or high pH conditions [22]. Among the factors that may enhance migration are high temperatures, the available oxygen, the presence of nitrites, un-lacquered or poorly lacquered cans, the quality, age and previous use of the material, duration of contact (long storage or prolonged cooking), and presence of salt, sugar and some ions (e.g. F, Cl, CO_3) [27-30]. In Table 1 precautionary practices for minimizing harmful metal intake from migration from food contact materials are summarized.

Exposure related to food

Metals occur in all foodstuffs, and their content is influenced by many factors including environmental conditions (contaminated soils and/or atmospheres, aquatic conditions), the nature and part of the foodstuff, post-harvest treatments, processing, and kitchen practices [31]. In addition drinking and cooking water can be contaminated with heavy metals due to the poor quality of the water source, the use of chemicals for the water treatment or the leaching of metals from pipeline materials [32]. As shown by literature and RASFF portal notifications the most metal burdened foodstuffs are fish, cephalopods and related products, followed by canned products, leafy and root vegetables, fruits, cocoa and coffee. The origin of the foods with harmful metals (mainly Hg, Cd and Pb) in levels above the

Table 1: Overview of precautionary practices for minimizing harmful metal intake from migration from food contact materials.

Precautionary practice	Reference
Prolonged preparation and long term storage of acidic, alkaline, salty foods and drinks in cans, aluminum, steel, metallic containers, and relevant vessels, cookware and packages should be avoided; low temperature (e.g. 5 °C) storing conditions should be preferred.	[22,26,28-30,106-108]
Aluminum foil to wrap acidic, salty or fluoride containing food products upon cooking should not be used; high temperatures, prolonged cooking and prolonged storage should be avoided.	[29,109]
Boiled water of first use from new cookware should be thrown away.	[106]
Wrapping foils, containers, cookware, utensils and packaging papers, only of materials appropriate for contact with foods, that bear the respective signs should be used; use should be according to manufactures suggestions and directions.	[27,110,111] Regulation EC No 1935/2004
Good grade plastic containers should be used, and their often replacement is strongly suggested.	[27]
Frequent consumption of alcoholic and acidic beverages from crystal glasses and decanters should be avoided; consumption of long term stored beverages in crystal decanters should be avoided.	[112,113]
Care should be given with glazed earthware, porcelain and ceramics that should not be used for regular food consumption, preparation, serving, and storage, especially for acidic and/or hot foodstuffs and beverages; use of porcelain, ceramic dinnerware and metallic teapots of questionable origin and quality should be avoided.	[7,16,19,20,114] Directive 84/500/EEC [18]

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Table 2: Overview of precautionary practices for minimizing harmful metal intake.

Precautionary practice	References
Fruits, vegetables, cereals, spices, herbs, medicinal plants, marine products and other foodstuffs from unquestionable sources and contaminated environments (e.g. near to highways, industries, mines, contaminated aquatic environments) should be avoided.	[17,34,37,52,115,116]
Rice should be washed until clear and cooked in excess of water that will be discarded after cooking.	[26,107,117,118]
Regular consumption of canned food and drinks should be avoided; long term storage of canned products should be avoided; canned products should be stored at low temperatures either at home or at storehouses of producers, distributers and selling points.	[24,26,28,107]
Regular consumption of large size marine species, swordfish, shark, tuna, marlin, lobster, mussels, cuttlefish, squid, crabs, shellfish, mollusks, shrimps and relative products should be avoided.	[8,16,31,47,119]
When consuming edible crab, muscle than brown meat should be preferred.	[42,43]
Fish fillets should be dipped in a salt solution (e.g. 0.5% NaCl for ~15 min) prior cooking.	[120]
Co-ingestion of green tea, black tea or coffee with fish meals is strongly suggested.	[46]
Frequent consumption of visceral parts should be avoided; visceral parts should be removed prior food processing.	[49,121]
A broad variety of foodstuffs should be consumed; various modes of cooking should be employed.	[48]
Uncontaminated water should be used for drinking and cooking; Before water for cooking and drinking is collected the tap should be flushed and an appropriate filtration unit should be employed; Consumption of products cultivated by contaminated or questionable quality water should be avoided.	[16,38,39,116-118,122,123]
Recipes including the use of acidic means (such as vinegar, lemon juice) during cooking of meat coming from hunt, should be avoided.	[124]
Fruits and vegetables should be thoroughly washed before consumption.	[122,125]
The skin of fruits and vegetables should be peeled off.	[116]

allowable is mainly Asian countries. In many cases data from market basket surveys for heavy metals burden are reassuring [33]. Still, in several parts of the world (e.g. Asia, Pakistan, Nigeria, China, New Zealand, Saudi Arabia), heavy metals levels of products designated for human consumption are worryingly high [17,34].

Environmental pollution significantly burdens food chain [17,35]. Leafy and root vegetables, as well as rice, seem to be more susceptible to metal accumulation [36,37]. Groundwater contamination with heavy metals is an important issue in several regions of Asia. The latter leading to contaminated rice is viewed as a disaster for habitants of these areas due to the quantity and frequency of its consumption in their diet [36,37]. Besides, other factors, such as urban agriculture, irrigation of cultivated hectares with untreated wastewaters, industrial and municipal pollution, traffic emission and mining, may seriously contaminate vicinal food products [17,35,38,39].

Several published studies on how cooking practices affect metal levels in fish and seafood are available [40-47]. Still, findings are conflicting. The effect of cooking seems to depend upon the metal tested, cooking conditions employed (time, temperature, practice), the part, size and nature of the food, and the presence of other ingredients. Alteration of metal concentration has been related among others to the different bioaccumulation and chemical feature of each metal, water and fat loss, protein degradation, oil uptake and possible interactions with other constituents present [40,42,48,49]. In many cases cooking is shown to increase metal concentrations in cooked and processed fish and seafood [40,45,47,49]. Even though based on current knowledge general suggestions on cooking practices to minimize harmful metals intake cannot be given [41,44], cooking seems to positively affect metals bioaccessibility [50]. Recent data concerning experiments conducted on cooked tuna, shark and mackerel showed that the cooking procedure significantly reduced Hg bioaccessibility (40 and 60% for frying and boiling, respectively). Moreover, the co-ingestion of tea or coffee may lead to low levels of metals bioaccessibility [46,51].

On the other hand, traditional and therapeutic herbs with recent entry to the food sector (e.g. herbal beverages, functional products enriched with herbal extracts or essentials oils) have reports for toxic metals and other chemical poisons (e.g. pesticide residues) in alarming levels revealing the intense need for strict controls towards this direction [34,52,53]. An overview of precautionary practices and suggestions for minimizing dietary harmful metal intake can be found in Table 2.

Acrylamide dietary intake prevention

Acrylamide (AA) is a colorless, odorless and crystalline solid with a melting point of 84.5 °C. It is formed by hydration of acrylonitrile and it is soluble in water, acetone and ethanol. It is a biodegradable compound and exhibits high mobility in soil and groundwater [54]. It can be found in carbohydrate-rich foods that have been heated to temperatures above 120 °C, and it is one of the products of the Maillard reaction between free asparagines and reducing sugars (primarily glucose and fructose). Thermal treatment such as baking, frying and roasting favor its formation. Potatoes and cereals are

Table 3: Acrylamide (AA) content (g/kg) of various foodstuffs.

Foodstuff	(AA) g/kg
Fried potato	272-570
Bakery products	75-1044
Breakfast cereals	149
Coffeea	229-890

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Table 4: Overview of precautionary practices for minimizing acrylamide intake.

Precautionary practice	Reference
Temperatures above 175 °C should be avoided as formation of acrylamide proceeds with lower rate at temperatures below 175 °C. In general the formation of acrylamide increases with temperature, whereby at temperatures between 150 and 170 °C the rate is relatively low, while at temperatures 180 and 220 °C the rate is higher. A temperature of 175 °C can be considered as an upper limit for frying. This value of temperature is the temperature that has been agreed between food industry and food authorities in Germany.	[126-128]
Cooking time has a linear effect on acrylamide formation at a given temperature thereby frying time should be as short as possible to prepare organoleptic accepted food. Overcooking should be avoided.	[127,129]
Potatoes are suggested to be stored between 8-10 °C in order to prevent excessive enrichment of reducing sugars. Storage of potatoes at 2 °C results in increased free sugar content that is converted to higher acrylamide levels during cooking as compared with potatoes stored at higher temperatures.	[130,131]
Blanching and soaking can remove asparagine and reducing sugars, diminishing thus acrylamide content in the final foodstuff. An effective way to diminish AA in food is the reduction of asparagine and reducing sugars, precursors of AA, in the raw materials. Lower level of asparagine in potatoes can be achieved by blanching and soaking. The disadvantage of this method is that other valuable water-soluble compounds like vitamins can be lost. The effect of blanching and soaking strongly depends on the period of application, temperature, pH-value, and added compounds. Asparagin can be also diminished by using asparaginase, which transforms asparagine to aspartic acid from. Asparaginase has been effective tested to baked products.	[132,133]
Use of acidic solutions can diminish acrylamide. Maillard reaction is pH dependent and reduction of acrylamide formation can be achieved by soaking in acidic solution. Potatoes can be soaked with citric acid solution of 10 g/L for an hour. Soaking (60 min at 20 °C) of potato crisps in acetic acid solution prior to frying results in a 90% decrease in AA level.	[132,134]
Treatment with solutions of salts can diminish acrylamide. A technique that can be applied both in industries and in kitchen is the dipping of potatoes in salt solutions of 1-5% NaCl or 20% $CaCl_2$ for 20 min prior to cooking. A reduction of ~60% on AA has been observed after immersion (25 °C for 5 min) of potatoes in1% NaCl solution.	[135-137]
Acrylamide formation can be avoided with addition of antioxidant rich natural products (herbs, spices, fruits and vegetables) during cooking. Several natural antioxidants such as gallic acid, protocatechuic acid or herbs and foods rich in antioxidants like cumin, star anise, rosemary, thyme, oregano or virgin olive oil are found to reduce AA formation during frying. Also fruit extracts rich in polyphenols such as apple and red fruits have been found to inhibit AA formation. Based on these results fruits, herbs and spices with known antioxidant activity can be added during cooking in order to reduce AA formation.	[138-142]
Acrylamide formation can be decreased when carbohydrate rich food is covered (e.g. with egg) during frying.	[129]
Manufactures have recently applied alternative methods of frying such as flash frying (high temperature, short time), frying under increased air pressure or frying followed by forced cooling that can result in acrylamide free products. Vacuum frying (118-140 °C) almost eliminates acrylamide formation in potato chips giving a desirable color comparable to that resulting by the application of the traditional method.	[143,144]

the most common examples of AA contained products. AA can be also found in meat products such as burgers and coffee [55]. Table 3 presents the g/kg of AA found in different foods according to the European Food Safety Authority (EFSA). The presence of AA in foods was first reported in 2002 from the Swedish National Food Administration [56].

AA is known as a neurotoxic, potential carcinogen, and mutagenic agent. The International Agency for Research on Cancer (IARC) has classified acrylamide in Class 2A as probable human carcinogen [57]. It has a tendency to bind with hemoglobin forming adducts, reducing the surface for oxygen transportation to fetal organs and leading to damage of tissue cells [58]. The Joint Expert Committee on Food Additives (JECFA) of the World Health Organization (WHO) evaluated the most sensitive adverse non-carcinogenic effect to be the morphological changes in nerves of rats with a no-observed-adverse-effect level (NOAEL) of 0.2 mg/kg per day [59]. Fortunately AA levels in foods follow a clear, significant downward trend from 2002 to 2011 [60]. Thermal processing applied from individual households to food industries is an important treatment for the development of organoleptic properties such as color, taste and texture. Therefore, formation of acrylamide is frequently unavoidable as in baked and fried products maillard reaction, necessary for the development of a pleasant aroma, acquires thermal treatment. Factors that affect acrylamide formation are presented in Table 4. In general, thermal treatment conditions, pretreatment of the raw material and use of antioxidants, among others, have a strong influence on acrylamide formation.

Pesticide residues dietary intake prevention

Agricultural products are prone to weeds, insect and disease attacks, so pesticides are widely used in modern conventional farming to improve yields and products' quality [61,62]. However, despite their many advantages, pesticides are considered of the most dangerous environmental pollutants as they present stability, ability to bioaccumulate and toxicity, while they also increase resistance to pathogens and pests [63,64]. They are a diverse group of chemical compounds, structurally divided into inorganic and organic compounds; with the latter being more widely employed. Organochlorines, organophosphorates, carbamates, and pyrethroids are extensively used among others [63,64]. Pesticides are linked to neuro- and hypato- toxicity, reproductive disorders, disruption of hormonal and enzymatic regulation, several types of cancer and other chronic diseases [65,66]. They may burden consumers mainly through the consumption of fresh, raw and unprocessed conventionally cultivated vegetables and fruits.

Numerous studies deal with the estimation of pesticides exposure

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Table 5: Overview of precautionary practices for minimizing pesticide residues intake.

Precautionary practice	Reference
Consumption of organic products leads to lower intake of pesticides.	[61,62,69]
For drinking and cooking pesticides free water should be employed; questionable quality water should be avoided and before water for cooking and drinking is collected an appropriate filtration unit should be employed (e.g. activated carbon); Consumption of products cultivated by questionable quality water should be avoided.	[145,146]
Washing removes water soluble pesticides; % removal depends on the type of food, the type of pesticide, the type and concentration of washing medium and soaking time. Washing with tap water decreases pesticide residues in most cases in a small to medium extend. Washing cabbage with tap water for 20 min showed a 18%, 17%, 19%, and 15% loss in chlorpyrifos, p,p-DDT, cypermethrin and chlorothalonil, respectively. Washing cucumber with tap water for 20 min showed 54%, 33%, 52%, 27% and 63% reduction in the trichlorfon, dimethoate, dichlorvos, fenitrothion and chlorpyrifos, respectively. Washing of olives in mills prevented the presence of herbicide residues in the produced oil. Washing with neutral, acidic or alkaline solutions (e.g. sodium chloride, radish, acetic acid, citric acid, ascorbic acid, sodium carbonate, sodium bicarbonate) results in a higher removal of pesticides in relation to washing with tap water; reduction may be even complete. Washing potato tubers with a 10% acetic acid solution and a 10% sodium chloride solution was shown to result in a 60-98% and 40-90% pesticide residue (HCB, lindane, ppDDT, dimethoate, primiphos-methyl, malathion) reduction, correspondingly. The % reduction gets higher with increase of detergents solution's concentration. Washing tomatoes with 2% or 10% acetic acid solution resulted in a 12 or 51% reduction of the HCB pesticide. A gradual pesticides reduction takes place when soaking time is increased at the same washing solution's concentration. Trichlorfon decreased from cucumber in a percent of 24% or 63% after 5 or 20 min washing with 2% NaCl.	[147-154]
Peeling may result in a significant percent reduction that can reach even 100% in many cases (avocado, bananas, citrus, kiwifruit, mango, pineapple, potatoes) as several pesticides are accumulated to the outer part of several products. Peeling mango completely removed the examined pesticides (dimethoate, fenthion, cypermethrin, fenvalerate); peeling tomatoes led to 81-89% reduction of the organochlorine (HCB, lindane, p.p-DDT) and the organophosphorous (dimethoate, profenofos, pirimiphos-methyl) pesticides examined. Juicing that excludes pulp, core and skin results in a substantial decrease of lipophilic residues in the final formulation. Juicing of tomatoes led to 73-78% reduction of the organochlorine (HCB, lindane, p.p-DDT) and the organophosphorous (dimethoate, profenofos pirimiphos-methyl) pesticides examined.	[69, 70, 73, 147, 150, 153, 155-161]
Upon beverage preparation a partial transfer of residues takes place to the final formulation due to the low solubility of some pesticides in water and their intense binding to organic matter.	[162,163]
Thermal treatment, cooking, boiling, blanching, home canning, significantly contribute to pesticide residues removal due to volatilization, evaporation, hydrolysis and thermal breakdown of pesticides. Removal dissipation can reach 100% in certain cases. 5 min stir frying of cabbage at 100 °C removed the 68-87% of pesticides (chlorpyrifos, p,p-DDT, cypermethrin, chlorothalonil); home canning of tomatoes (30 min, 100 °C) led to a 31-82% residue (HCB, lindane, p.p-DDT, dimethoate, profenofos, pirimiphos-methyl) reduction.	[69,147,150-152,154,156-158,164]
Storing and preserving (at room temperature, in refrigerator, in fridge) leads in pesticides reduction in a smaller or higher extend depending on the type of food, the type of pesticide and conditions employed (time, temperature). Reduction of pesticides residues (trichlorfon, dimethoate, dichlorvos, fenitrothion and chlorpyrifos) in cucumber stored at 25 °C for 48 h was 83-98%; 11-33% reduction of the examined pesticides (HCB, lindane, p.p-DDT, dimethoate, profenofos, pirimiphos-methyl) was observed in tomatoes after freezing for 12 days and 3-4% residue (chlorpyrifos, p,p-DDT, cypermethrin, chlorothalonil) reduction after 48 h refrigeration of cabbage. The longer the storing period the higher the reduction of pesticides. Trichlorfon was reduced 20%, and 61% from cucumber after 12, and 48 h storing at 4 °C respectively.	[147,149,157,165]
Ozone application in fruits and vegetables enhance pesticide residue removal; treatment conditions should be individually determined for ensuring efficiency.	[166,167]

through food consumption with frequent results to indicate minor exposure [9,67]. Additionally, other data imply that chronic intake of pesticides via food consumption, total dietary, residential and occupational exposure throughout lifespan may have detrimental impact on human health [9,66,67]. There is a great concern for chronic toxicity to consumers of developing countries and low-income population [63,64,68-72]. Therefore, considering the possible threat to human health, their use is subject to regular monitoring and continuing reassessment. Maximum residue levels (MRLs) in food products and drinking waters have been set by official bodies to secure food safety and to control international trade, with baby foods to bear even lower MRLs. At least in developed countries, pesticides MRLs are harmonized to official legislations [9]. Still, some pesticides largely exceed the MRLs given by official regulation systems, banned compounds are still being used and several cases are constantly notified at the RASFF system [9,67]. Notification of border rejection due to pesticide residues to overcome the set MRLs are constantly applied mainly to fruit and vegetables that usually come from Asian and African countries.

Organic products have met wide acceptance and demand, since they are considered safer and healthier compared to conventional counterparts. Still, they are not necessarily free of synthetic chemicals [61,62,73] and contaminants (e.g. heavy metals, dioxins, polychlorinated biphenyls, mycotoxins) [61,74] and their qualitative, nutritional and sensory superiority has not been yet clearly proved [75-78]. Nonetheless, organic products consumption is one way to minimize synthetic pesticides residue intake. However, the latter stands only if the foodstuffs are not only by "name" organic, since related products are the target for many frauds. Minimizing synthetic chemicals intake is considered of major importance especially if

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Table 6: Overview of precautionary practices for minimizing PAHs and HAAs intake.

Precautionary practice	Reference
By thorough washing of vegetables and fruits a part of the light PAHs may be removed as these compounds present some water solubility.	[168]
Peeling of fruits and vegetables removes a significant percent of PAHs. The peel in contrast to the core of 3 carrot varieties had 15-32 and 4-8 μg/kg total PAHs respectively.	[73]
Removal of the rind of smoked products excludes a high amount of PAHs. Total concentration of PAHs in the rind of a smoked cheese was 7273 μg/kg, opposing to 1037, 154 and 89 in the exterior, middle and interior part respectively.	[169]
Temperatures higher than 200 °C are greatly responsible for high levels of PAHs and HAAs. Frying around 150 °C, grilling or pan frying at temperatures lower than 180 °C and roasting at no more than 200 °C is recommended.	[95,170-173]
Frequent use of open flames, charcoal or two plate grilling, barbecuing, pan-frying, high temperature oven broiling or gas oven-toasting should be avoided. Stewing, steaming, poaching, boiling, electric oven toasting and roasting in the presence of low air velocity, deep frying, microwave short time cooking, infrared or electric grill are preferable alternative cooking methods. Pretreatment with a moderate practice (e.g. steam, oven) before final cooking at a more intense method (e.g. grilling, barbecuing) is also suggested for reducing the formation of PAHs and HAAs.	[82,95,98-100,102,103,105,170-184]
Medium level of doneness is recommended in respect to well done and very well done proteinaceous food products; Lean cuts and frequent turning during cooking is strongly suggested.	[178,182,185-188]
Direct smoking and contact of the food with the heating medium (charcoal, open flame, heated pan) should be avoided; dripping of fat to the heat source should be avoided. Cooking proteinaceous foodstuffs in aluminum foil (the co-presence of acidic substances is discouraged to avoid Al migration) or banana wrapping can protect products from HAAs and PAHs formation. Browning of the food should be avoided; Skin, crust, and charred parts of fried or grilled foodstuffs should not be consumed. Inhalation of the emitted fumes (especially during cooking with wood, Chinese cooking, deep-frying and charbroiling) should be avoided. Out-of the ordinary grilling fuels and continuous barbecuing with the same charcoal should not be used.	[100,103-105,170-174,184,189-195] [170,196] [187,188,197]
Marinating and cooking with fruits and vegetables, honey and spices is recommended; For long stand marinates wine and beer are also recommended.	[180,198-201]
The presence of an antioxidant rich fatty mean (such as the rich in antioxidant polyphenols virgin olive oil), antioxidant rich products (fruits, vegetables, herbs and spices), and compounds such as salts, soy, carbohydrates (starch, fructose, lactose, glucose, powdered milk) can retard the formation of HAAs upon cooking.	[11,101,202]

vulnerable groups (pregnant, breast feeding women, infants and children) are the receptors. This meaning seems to have passed to consumers as only organic baby products have not followed the descending trend as a coherence of economic crisis outbreaks [79].

On the other hand there are alternative ways to reduce the levels of pesticide residues from contaminated crops and prevent relative negative health effects [69,70]. The extensive literature review on pesticide residue elimination due to food processing of Kaushik and co-workers [69], as well as the meta-analysis review of Keikotlhaile et al. that summarizes the effects of food processing on pesticide residue levels, present that processing leads to significant reductions in residue levels in the final foodstuff, particularly through washing, peeling, thermal treatments applied and preserving [70]. Other practices that are reported to reduce pesticide residues but are beyond the scope of this study are bread making, dairy product manufacture, drying, fermentation, malting, milling, parboiling and wine making [69]. Of course, the physicochemical characteristics of the food, the type of pesticides present, the pesticides' age on the product, treatment conditions employed, along with other parameters, affect residues removal patterns from burdened foodstuffs [69]. In Table 5 simple practices to reduce pesticides residues intake are summarized. At this point it should be mentioned that some practices recommended for the reduction of pesticides residues, for example peeling, juicing and thermal treating, may also decrease nutritionally important ingredients such as vitamins, antioxidants and fibers.

Polycyclic aromatic hazards dietary intake prevention

Polycyclic aromatic hydrocarbons (PAHs) are a group of compounds, products of combustion and pyrolysis. PAHs bear two or more fused aromatic rings without hetero-atoms or substituents. They are classified to "light" and "heavy" compounds containing up to four or more than four fused benzene rings, respectively. The latter are considered more stable and more harmful [80,81]. The toxicity of PAHs has been well documented and is mainly related to carcinogenicity, cardiovascular diseases, peripheral arterial disease and other severe disorders [82-84]. Sources of human exposure are environmental burdens (natural and anthropogenic), tobacco smoke, and diet. Diet is the main non-occupational source of PAHs to non-smoking population, estimated to contribute with a more than 90% of the total PAHs exposure. Food is burdened with PAHs through environmental pollution [80,85,86]. Incomplete burning of materials consisting of carbon, such as oil, wood, garbage, coal leads to their formation. Foodstuffs are mainly burdened with PAHs during industrial processing (mainly heating, drying and smoking) and cooking practices (mainly barbecuing, grilling, frying and roasting) and to a lesser extend via their contact with contaminated materials [80]. Practices that allow combustion products to come into direct contact with food are mainly responsible for PAHs formation. The most prone to PAHs contamination foodstuffs are meat and meat products, oils and fats, bread and relevant products, dairy products, nuts and crops, fish products, as well as smoked foodstuffs [87-90]. In order to protect public health from PAHs risk, maximum levels in certain foods have been set by the EC regulation [25]. Foods designated for consumption by infants and young children are set to the lower level of 1 μg/kg wet foodstuff weight.

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As PAHs are lipophylic compounds they can easily accumulate to high fat containing foods such as smoked cheese. It is important to point out that the higher percentages of cancer incidents reported for young people (mainly breast cancer incidents) in some African countries have been related to diets employing high PAHs intake due to smoked products frequent consumption [87]. Such findings reveal that in countries were smoked foodstuffs are an important part of the traditional diet there is an urgent need to educate for safe smoking processes that will ensure lower PAHs levels in relevant foodstuffs [87]. Another critical issue concerns the relation of PHAs exposure of fetuses and infants with reproductive and developmental problems [91]. Breast feeding of heavy smoking mothers especially when also residing in urban regions poses serious risks [92].

Heterocyclic aromatic amines (HAAs) is another group of polycyclic aromatic hazards formed during the high thermal treatment of food, and being related to similar serious health risks to PAHs [11,93]. In processed food products they are regularly found along with PAHs. HAAs are mutagenic and carcinogenic compounds mainly found in cooked proteinaceous food such as meat and fish. However, they may also appear in other food products for example pan residues, soup cubes, meat drippings, processed flavors, sauces, cheese products, coffee, alcoholic beverages, etc. [94]. They are usually formed via the Maillard reaction and are considered probable or reasonably anticipated to be human carcinogens, with some regarded mutagenically hundred and thousand-fold more active (Ames test) than the strongly mutagens aflatoxin B1 and benz(a)pyrene. Still some of the most frequent HAAs, such as harman and norharman, are not considered mutagenic, but their presence augments the mutagenicity of other harmful HAAs [11,93-96]. Up to now more than 25 harmful HAAs have been found to be formed during the heating processes of various food products. They are heterocyclic molecules with one or more nitrogen atoms in their aromatic rings (2-5) and they often contain one exocyclic amino group. HAAs are mainly classified in two categories according to the temperature at which they are formed; the "thermic" ones or amino-imidazo-azarenes formed around 100 - 300 °C, and the "pyrolytic" ones or aminocarbolines formed over 300 °C. Frequently HAAs are also distinguished to polar and non-polar ones [94]. No matter their well established harmful activity [97] maximum levels for HAAs have not been established, yet.

In brief, food origin, nature and composition, food fat content, cooking method, temperature, time, pretreatment practices, frequency of food turning during cooking, presence and content of other compounds, as well as level of doneness, among others, strongly affect PAHs and HAAs formation [82,98-105]. In Table 6 proven practices for minimizing PAHs and HAAs intake are presented.

Conclusion

Simply practices such as controlled thermal treatments, washing in certain conditions and proper handling of raw material, can remarkably reduce the levels of certain chemical hazards leading to safer foodstuffs. Moreover common salty, acidic or basic solutions or incorporation of natural antioxidants upon food pretreatment and cooking can significantly reduce the levels of the examined hazards. All treatments are precautionary practices addressed to consumers, professionals and anyone involved at any stage of food production and handling from farm to fork. Such practices can be incorporated in home and professional kitchens, as well as in quality systems of restaurants, canteens, food industries, storehouses of producers, distributers, selling points, etc. When the object of subject is safer foodstuffs and a healthier wellbeing relevant knowledge, positive attitude and good practice are mandatory.

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