CONTAMINATION OF FOOD WITH POLYCYCLIC AROMATIC HYDROCARBONS

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ABSTRACT: The paper presents issues regarding food safety and food contamination sources with polycyclic aromatic hydrocarbons. The main food processing methods that contribute to the contamination with polycyclic aromatic hydrocarbons are smoking, frying, baking, obtaining grills, using polymer packaging. Benzopyrene is the most carcinogenic polycyclic aromatic hydrocarbon, formed as a result of food preparation processes with starch, at temperatures of 370-650 degrees Celsius. Biological monitoring of PAH exposure is important due to the toxicity and reactivity of their metabolites (epoxides and dihydrodiols), which can react with cellular proteins and as a result, DNA is not synthesized and genetic mutations, malformations, tumors and cancer develop.

KEY WORDS: food, contamination, hydrocarbons, benzpyrene, carcinogens

1. ASPECTS REGARDING FOOD SECURITY AND POLYCYCLIC AROMATIC HYDROCARBONS

Food security is a relatively recent concept, which has been imposed since 1970 and has evolved from quantitative and economic considerations to a definition that takes into account food quality and the human dimension. Food security is important in assessing the quality of industrial and commercial management of the public catering system. Public alimentation is an area responsible for creating and promoting nutritionally balanced diets and absolute safety. Nutritional fitness of food it is canceled by the presence of biological or microbiological risk factors for the human body (Figure 1).

Figure 1. Food security

Polycyclic Aromatic Hydrocarbons (PAHs) are a large class of organic compounds that contain two or more linear or angular condensed benzene nuclei. PAHs are chemicals considered carcinogenic for more than 200 years, which are formed and released during the process of incomplete combustion or pyrolysis of organic material, following the process of incomplete combustion of fuels used in internal combustion engines or naturally, through carbonization processes .

Polycyclic aromatic hydrocarbons are lipophilic. As the mass of these compounds increases, their volatility and solubility in water decrease (Figure 2).

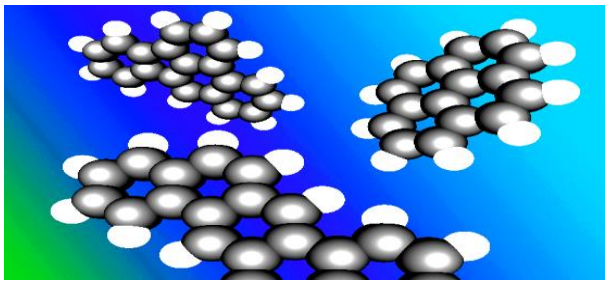

Figure 2. Polycyclic Aromatic Hydrocarbons

Depending on the number of benzene nuclei in the structure, polycyclic aromatic hydrocarbons are classified into:

- with low molecular weight - less than 4 aromatic nuclei
- with high molecular weight - 4 or more aromatic nuclei
- with 2 or 3 nuclei (naphthalene, acenaphthene, anthracene, fluorene, phenanthrene) - present in the air in the vapor phase
- with 4 nuclei (fluoranthene, pyrene, chrysene) - in a state of vapors and particles
- with 5 or more aromatic nuclei (benzoperylene) -present in the particle state

2. SOURCES OF POLYCYCLIC AROMATIC HYDROCARBONS IN THE DIET

The persistence and ability of PAHs to bioaccumulate in the food chain are determined by the following physicochemical properties:

- ✓ contamination of food with PAH is due to its solubility in water and organic solvents and determines the absorption, ability to be transported and distribution between different compartments in the environment and their accumulation in living organism
- ✓ the presence of PAHs in the atmosphere is influenced by their volatility
- ✓ the chemical reactivity of PAHs influences their adsorption on organic matter and degradation in the environment

The concentration of polycyclic aromatic hydrocarbons (HPA) in food is 40 times higher than in soil. Up to 300 degrees C, carbohydrates, amino acids and fatty acids are not cyclized in HPA. Between 300 -500 degrees C, carbohydrates are the main sources of polycyclic aromatic hydrocarbons, and over 500 degrees C sterols and fatty acids are cyclized.

The sources of polycyclic aromatic hydrocarbons in food are the following:

- food can be contaminated with environmental PAHs, which are present in the air (by deposition), soil (by transfer) or water (by deposition or transfer), in areas with urban or industrial activities or along motorways (vegetation contamination being tens of times higher than in rural areas) (Figure 3)

Figure 3. Sources of food pollution with HPAs (industry and vegetation fires)

- the level of PAHs in unprocessed food reflects the degree of contamination of the environment, which comes from airborne particles, which have traveled long distances or from natural emissions from vegetation fires or volcanic eruptions; emissions of polycyclic aromatic hydrocarbons into the atmosphere have a short or long transit and can accumulate in wet or dry deposits
- food processing by drying, preservation by smoking and preparation at high temperatures or using biomass-based fuel (grill, frying, baking, coal or wood-based), causes HPA contamination, which are formed on the basis of carbohydrates in food, at high temperatures (melting fat, undergoes the pyrolysis process when

it flows on the heat source; the pyrolysis process of food due to high temperatures, above 200° C) (Figure 4)

Figure 4. Food processing methods that cause HPA contamination (smoking and grilling)

For example: preparing meat on hot pottery and obtaining smoked sausages are two important processes, which produce polycyclic aromatic hydrocarbons; smoked meat and fish contain significant amounts of PAHs; smoked sprat and canned smoked sprat have been shown to have higher PAH levels than other smoked fish; PAHs are rapidly metabolized in fresh fish and do not accumulate in fillet muscle (Figure 5).

Figure 5. Foods that contain large amounts of PAHs (smoked sprat and canned smoked sprat)

A comparison of the level of PAHs in the duck breast steak, that was processed in different ways over 0.5-1.5 h showed that:
- samples prepared without skin, on a charcoal grill, had a level = 320 µg HPA / kg
- samples prepared with leather, in the same way = 300 µg HPA / kg
- samples prepared by smoking or frying = 210 µg HPA / kg
- samples prepared by boiling = 8.6 µg HPA / kg
- samples prepared with liquid smoke = 0.3 µg HPA / kg.

- vegetable oil is one of the most important sources of PAH contamination; the presence of HPA in margarines and mayonnaises is due to the contamination of the oils used to obtain them; coconut oil contains high levels of PAH due to the higher presence of benzo (a) anthracene and chrysanthemum, which cannot be removed during oil refining
- cocoa butter, as a lipid fraction, contains higher levels of PAH than other oils and fats, due to inadequate methods of drying cocoa beans and the fact that it cannot be refined like other vegetable oils and fats; being the main ingredient in raw cocoa-based products (cocoa paste, cocoa liquor, chocolate and other cocoa-based products frequently consumed by children), it contributes to human exposure, especially in children (Figure 6)

Figure 6. Sources of polycyclic aromatic hydrocarbons in food (margarine, mayonnaise, coconut oil, cocoa butter, milk, polymer packaging, cigarette smoke)

- milk fats (extract 95% benzopyrene from paraffin packs and glasses: HPA can form in milk, following the chemical reaction between eluents - elements formed in a solvent and the polymer packaging)
- cereals and vegetables contain low levels of PAH, so it is not justified to set maximum levels, but they can be important sources of human exposure due to their high consumption
- packaging made of polymeric materials
- cigarette smoke in the food area (contains 150 HPA-type substances, responsible for 30% of lung cancer cases)
- pharmaceutical products based on coal tar (used in animal diseases) and some food supplements
- contamination of water consumed or used in cooking (concentrations are below 1 ng / l in drinking water and may be higher if the tank in which the water is stored is insulated with asphalt)

3. BENZOPYRENE IN FOOD

The compounds in the PAH class considered the most potent carcinogens are: 7,12-dimethylbenzoanthracene (DMBA) and benzo (a) pyrene (BaP), which are found in water, soil, various powders and many foods. Of the several hundred persistent chemical compounds, depending on the spread and toxic effects, 33 PAHs pose a risk to human health (Figure 7).

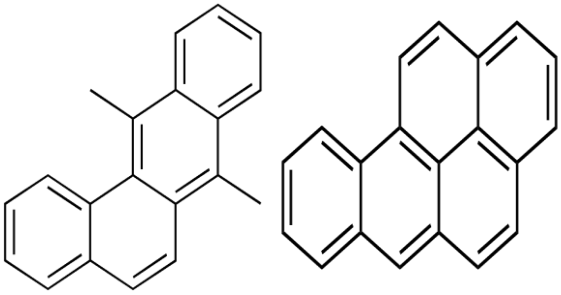

Figure 7. 7,12-dimethylbenzoanthracene (DMBA) and benzo (a) pyrene (BaP) - the most carcinogenic polycyclic aromatic hydrocarbons

The most studied PAH is **benzopyrene,** being very common in various foods. Benzo (a) pyrene belongs to the group of polycyclic aromatic hydrocarbons (PAHs) and is used as an indicator of the presence and effect of carcinogenic polycyclic aromatic hydrocarbons in food. It was discovered in 1933, and in 1935 it was shown to cause lung cancer.

It is formed as a result of food preparation processes, at temperatures of 370-650 degrees Celsius, in starchy foods (the temperature reached during the baking of the bread surface = 400 degrees C, of the biscuits = 320 -380 degrees C, the fats during frying and grilling = 400-600 degrees C, coffee roasting = 370-390 degrees C) (Figure 8)

Figure 8. Baking bread and frying fats - sources of benzopyrene formation

The substances that contribute to the formation of this compound are amino acids and fatty acids. The mechanism of action of benzopyrene can cause a reaction with some intracellular components (DNA), and mutations can occur.

The benzopyrene content in certain heat-processed foods is shown in Table 1:

Table 1: Benzopyrene content in heat processed foods

Heat processed food	The content of HPA (mg / kg)
smoked meat	>50
boiled sausages	0,26 - 0,5
fried game meat	0,18 – 0,63
fruits and vegetables	0,2 - 150
smoked fish	11,2
vegetable oil	0,9 - 30
potatoes	1-16
apples in the road area	10
apples from unpolluted areas	0,2-0,5

4. HPA TOXICITY

Based on scientific studies, a number of seven HPAs: benz (a) anthracene, benzo (a) pyrene, benzo (b) fluoranthene, benzo (k) fluoranthene, crisen, dibenz (ah) anthracene, have been classified as being carcinogenic to animals and humans and indeno (1,2,3-cd) as probably carcinogenic to animals and humans. In order to characterize the risk posed by HPAs, the carcinogenic potential is evaluated, the genotoxic and mutagenic effects being demonstrated by in vitro and in vivo research.
Benzo (a) pyrene was the first substance identified to induce cancer in the animal body. Administered orally, benzopyrene produced tumors in the gastrointestinal tract, liver, lungs and mammary glands, dibenzanthracene and benzanthracene produced tumors in the gastrointestinal tract, lungs and liver.
The acute effect of PAH on health depends on duration, route of exposure, concentration, relative toxicity, health status and age. Exposure to high concentrations of PAH causes eye irritation, nausea, vomiting, diarrhea and confusion. The chronic effects of PAH on human health lead to decreased immunity, affect the kidneys, liver, lungs, cause respiratory diseases and asthma.
Repeated skin contact may induce irritation and inflammation. Anthracene, benzopyrene and naphthalene cause skin irritations and allergic reactions. Naphthalene can cause red blood cells to drop if inhaled or ingested in large quantities. Long-term studies have shown that workers exposed to PAH have developed skin, lung and gastrointestinal cancer.
The content of HPA entering the human body in a year is 0.006 mg. Biological monitoring of PAH exposure is important due to their spread in the environment, toxicity and reactivity of their metabolites (epoxides and dihydrodiols). Once they have entered the human body, HPAs react with enzymes and form an epoxy compound. I'm also in contact with guanine. Metabolites can react with cellular proteins, DNA is not synthesized and genetic mutations, malformations, tumors and cancer develop (Figure 9).

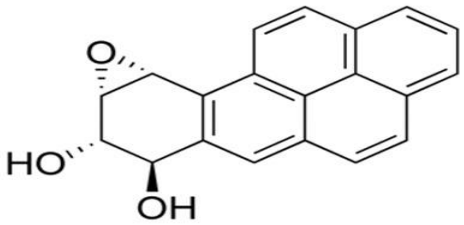

Figure 9. Benzo (a) pyrene -7,8-dihydrodiol-9,10-epoxide - the metabolite of HPA in the human body

5. CONCLUSIONS

1. Food security is important in assessing the quality of industrial and commercial management of the public catering system.
2. Public alimentation is an area responsible for creating and promoting nutritionally balanced diets and absolute safety.
3. PAHs are chemicals considered carcinogenic for more than 200 years, which are formed and released during the process of incomplete combustion or pyrolysis of organic material, following the process of incomplete combustion of fuels used in internal combustion engines or naturally, through carbonization processes.
4. The sources of polycyclic aromatic hydrocarbons in food are the following: smoking, frying, baking,

obtaining grills, using polymer packaging.

5. Sources of polycyclic aromatic hydrocarbons in food are margarine, mayonnaise, coconut oil, cocoa butter, milk, polymer packaging, cigarette smoke.
6. 7,12-dimethylbenzoanthracene (DMBA) and benzo (a) pyrene (BaP) are the most carcinogenic polycyclic aromatic hydrocarbons (benzopyrene is formed as a result of food preparation processes with starch, at temperatures of 370-650 degrees Celsius).
7. Biological monitoring of PAH exposure is important due to the toxicity and reactivity of their metabolites (epoxides and dihydrodiols), which can react with cellular proteins and as a result, DNA is not synthesized and genetic mutations, malformations, tumors and cancer develop.

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