Trends in Food Science & Technology 48 (2016) 63–68

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: http://www.journals.elsevier.com/trends-in-food-science-and-technology

Review

Food contamination during food process

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ARTICLE INFO

Article history:
Received 15 October 2015
Received in revised form
21 December 2015
Accepted 21 December 2015
Available online 29 December 2015

Keywords:
Food contamination
Food processes
Packaging
Cooking
Analysis

ABSTRACT

Food contamination can come from different situations. A wide overview is presented in this paper, where the different steps applied to food, from the reception of raw materials to the final food intake by consumers, are shown.

Among the sources involved in the food contamination processes the following ones can be highlighted: a) External raw food contamination due to environmental contamination; b) Transport of raw materials to the factory where they will be processed; c) Food conditioning, which involves the storage of raw materials, preheating, disinfection, cleaning and sterilization steps; d) Heating steps either by boiling, cooking, baking, frying or combining with other ingredients at high temperature in an oven or in a reactor; e) Food packaging; f) Transport of packaged food and g) Storage and distribution of packaged food. The problems related to each step as well as the resulting contaminants for the food are shown and discussed.

1. Introduction

It has been demonstrated that food contamination, either from microbiological or chemical origin, is the highest concern for consumers. For this reason, there is a continuous research to deep into the contamination sources and the way to prevent them. A great deal of effort has been devoted to developing analytical strategies to be able to detect and identify these contaminants, since they are commonly at trace amounts. Sample treatment devices, such as microextraction techniques able to remove the matrix interferences and to concentrate the analytes from the sample, have been developed and proposed as powerful tools for food analysis. But the task of identifying the contaminants, either those coming from the food production, the food processing or the packaging is still a challenge. Different analytical tools have been developed to facilitate the task, but none of them provide a unique solution. When the likely contaminants are known, target analysis is more feasible, even though the low concentration of target compounds requires the use of sample treatment techniques as well as sophisticated analytical instruments for the task. However, untarget analysis in which the contaminants are unknown is a very difficult task, where the screening procedures play an essential role. In this frame the application of sample treatment techniques together with the high resolution mass spectrometry provide the powerful tools required for identifying the unknowns. Thus, the information about the likely contaminants coming from each step of the food processing is essential.

The food processing steps are shown in Fig. 1. In the following paragraphs the description of the main contaminants in each step, how to control them and how to prevent or diminish them from the food are discussed. This information is essential to identify the origin of the contaminants in the final food.

2. Food processing steps

2.1. External raw food contamination

Some chemicals may be already present in **raw food** at the beginning of food processing due to environmental contamination. Industrial growth, advances in the use of agrochemicals, or the urban activities can contribute to the presence of food contaminants. An important focus of food contaminants is the use of fertilizers and pesticides, since they can cause health problems if they are consumed by humans. Some studies detected pesticide residues in fruits and vegetables (Kobayashi, Otsuka, & Tamura, 2011) and also some derivatives with also adverse effects, such as metabolites from organochlorine pesticides have been found in fatty food (Chung & Chen, 2011). The use of fertilizers and pesticides is also

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http://dx.doi.org/10.1016/j.tifs.2015.12.004
0924-2244/

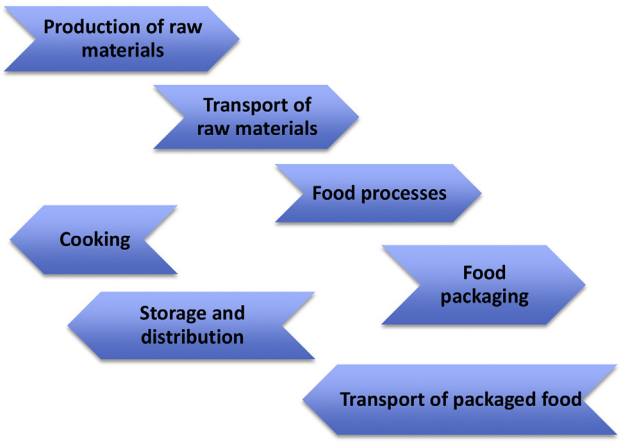

Fig. 1. The food processing steps.

supposed to be the main responsible for the release of toxic heavy metals. Heavy metals such as cadmium, lead, mercury, and arsenic, recognized as toxic (ATSRD, 2011), can be present in air, soil, and water (Zukowska & Biziuk, 2008) and therefore they can be transferred to foodstuff. The analysis of heavy metals has been performed in several foodstuffs such as honey, spinach, potatoes, fish and tea. The major techniques employed for heavy metal analysis are flame atomic absorption spectrometry (FAAS), graphite furnace atomic absorption spectrometry (GFAAS), cold vapor atomic absorption spectrometry (CVAAS), inductively coupled plasma atomic emission spectrometry (ICP-AES), and inductively coupled plasma mass spectrometry (ICP-MS) (Zukowska & Biziuk, 2008).

Another widely studied residues are antibiotic residues. They are used in animal farming, but without an appropriate quality control they can also be present as residues in food products. These residues can be harmful to humans if taken in large amounts. Several methods have been developed for determining antibiotic residues in foodstuff such as meat, eggs (Donkor, Newman, & Tay, 2011) or milk, such as using the microbial inhibition plate test described by Koenen-Dierick et al. (1995) (Koenen-Dierick et al., 1995) or by liquid chromatography methods (Freitas, Paim, & Silva, 2014).

2.2. Contamination during food transport

Food contamination can also take place during **transportation**. It can be cause by from vehicle exhausts of petrol and diesel or because a cross contamination in the vehicle used for food transportation. This cross-contamination can create a serious risk for food safety. In 1999, a major illness in the European Economic Community was attributed to fungicide-contaminated pallets used for transportation and storage of food packaging materials. Long distance transport ship has been also several times affected by cross contamination from chemicals used for disinfection or from other sources (Nerín, Canellas, Romero, & Rodríguez, 2007). The main problem is that usually the high barrier materials used for wrapping and protecting the food during long term transportation, for example by ship, are not always tested for the barrier properties against organic compounds, as only permanent gases such as O2, CO2 and water vapor permeation are commonly checked. These barrier properties cannot be extended to any organic compound. The study carried out by Nerín et al. (2007) is a good example of the contamination of food by permeation of naphthalene, methylbromide, toluene, ethylbenzene, and ortho- and para-xylenes through a theoretical high barrier material.

2.3. Contamination caused by cleaning processes

Cleaning and disinfecting during food processing eliminate the presence of possible microorganisms and therefore, they are crucial to reduce food contamination. Chemicals used as cleaners or disinfectants must be appropriate for food contact surfaces and need to be accepted by the legislation. Products such as glass cleaners or some metal cleaners can't be used because they might leave unsafe residues. The addition of sanitizers in quantities far above permitted levels could leave some residual concentration on treated materials or food even in minimum processed fruits and vegetables, and therefore, to quantify the residual chemicals present in the food is important in order to certify that they have been completely removed.

Some common surfactants are quaternary ammonium compounds such as dodecyl-trimethyl-ammoniumchloride and nonionic surfactants such as stearyl alcohol ethoxylate. Factors affecting its elimination from different materials surfaces, such as rinsing time or water temperature, were studied by Helmschrottet al. (Helmschrott & Wildbrett, 1985). These compounds are commonly analyzed by liquid chromatography–mass spectrometry (Vidal, Vega, Lopez, & Frenich, 2004) (Li & Brownawell, 2009).

Problems related to residues coming from cleaning agents and disinfectants used in surfaces of food handling equipment and its transference to food that has been in contact with such surfaces have been discussed by several authors (Naegeli & Kuepper, 2006). The development of safe, efficient and environmentally compatible detergent formulas is an important issue for the food industry. The use of food grade and edible surfactants allowed by FDA (US Food and Drug Administration) is an interesting option. Other alternative is the use of ozone, due to its strong oxidant properties. It has been studied in order to ensure adequate levels of quality and safety. More recently, a mixture of inorganic peroxides has been also proposed for this task. However, the additional risk involved in this step is the degradation of some compounds by fast oxidation and the emerging neoformed compounds resulting from the interaction of the food components with the disinfection reagents. Emerging technologies such as electrical pulses, high pressures or beta and gamma irradiation on food, open a new area. In these technologies, the transformation of nutrients and food components and the neoformed compounds should be investigated in depth.

2.4. Contamination due to heating steps

Heating treatment is by far the most widely method for food process in the industry or at home, as around 80–90% of the consumed food is processed in one or another way. The use of high cooking temperatures in combination with external factors, can lead to the formation of toxic compounds, which can have a deleterious effect on the food quality and safety. Certain toxics compounds (e.g., acrylamide, nitrosamines chloropropanols, furanes or PAHs) can be formed in foods during their processing, such as during heating, baking, roasting, grilling, canning, hydrolysis or fermentation. Frying is by far the cooking process that can act as a generator of a wide variety of toxic compounds into the food.

Frying is a dehydration process in which oil acts as the medium for heat transfer. Oxidation processes in frying oil are inhibited by the food, especially by proteins, starch or phenolic compounds. Mutagenic polycyclic aromatic heterocycles (i.e., heterocyclic aromatic amines (HAA) and polycyclic aromatic hydrocarbons (PAH)) are produced during the interaction of frying fat and protein.