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Review

The occurrence and effect of unit operations for dairy products processing on the fate of aflatoxin M_1: A review

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ABSTRACT

Mold contamination has challenged the safety of feed production and processing because of its undeniable role in the spoilage and the possible consequent toxicity impact on human health and the economy. Aflatoxin M_1 (AFM_1) is a hepatocarcinogenic derivative of aflatoxin B_1 excreted into the milk after ingestion of feed contaminated by certain molds. Because of the important role of dairy products, especially milk in the human diet, there is a huge concern about the presence of AFM_1 in milk and dairy products. In this article, the occurrence of AFM_1 and the fate of AFM_1 during processing of milk and dairy products, such as yoghurt and cheeses, since 1996 until today, was reviewed. The evaluation of mechanisms by which AFM_1 is affected by each processing step is of major importance to provide useful and accurate information to develop risk assessment studies and risk management strategies.

Contents

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1. Introduction

Milk and dairy products are commonly consumed by people of all age groups, especially children. Accordingly, milk is one of the major nutrient sources. Milk is very important in human nutrition because of it is biochemical complexity and for providing all essential amino acids. Confirmation of these nutritive benefits is the extensive and constant consumption of milk and dairy products in several countries (Galvano, Galofaro, & Galvano, 1996). According to Silva, Chalfoun, Silva, and Pereira (2007), the consumption of dairy products constitutes more than 80% of the habits and dietary intake of children worldwide.

Humans and animals are subjected to “biological hazard” from natural toxicants that occur in food and feed. Mycotoxins are secondary metabolites produced by a few fungal species belonging mainly to the *Aspergillus, Penicillium* and *Fusarium* genera. Such compounds may be formed by these mycotoxigenic molds when growing in contaminated foods at production, processing, transportation, and also during storage. Aflatoxins, trichothecenes, zearalenone, deoxynivalenol, fumonisin, patulin, ochratoxin, and ergotamine are the main mycotoxins that have challenged the safety of feed production and food processing because they are negatively affecting human health and the economy (Bhat, Rai, & Karim, 2010; Murphy, Hendrich, Landgren, & Bryant, 2006). According to the Food and Agriculture Organization of the United Nations (FAO), up to 25% of the world's food crops are significantly contaminated with mycotoxins.

Aflatoxin is one of the most important mycotoxins and it can be produced by different species of *Aspergillus* genus, mainly *Aspergillus flavus* and *Aspergillus parasiticus* (Elsanhoty, Salam, Ramadan, & Badr, 2014). The main economic source of this mycotoxin are cereal-based foods; however aflatoxin can also be found in foods of animal origin such as milk and dairy products. According to Bhat et al. (2010), at least 18 different types of aflatoxins have been identified, and aflatoxin B_1 (AFB_1), B_2 (AFB_2), G_1 (AFG_1), G_2 (AFG_2), and M_1 (AFM_1) are the most important from a food safety standpoint. “B” (blue) and “G” (green) refer to the fluorescence colour observed under exposure of mycotoxin to ultraviolet light, while “M” refers to an AFB_1 metabolite found in milk or dairy products (Murphy et al., 2006). The contamination of milk and dairy products with mycotoxin can occur by indirect contamination when lactating animals ingest AFB_1 contaminated feed which will pass to the milk as AFM_1, and also by direct contamination, when molds can grow in milk (very unlikely) or on dairy products as intentional additives or accidental contamination (Sengun, Yaman, & Gonul, 2008). Therefore, milk and dairy products are particularly susceptible to contamination by AFM_1 and are considered to pose certain risks for human health. Accordingly, milk has the greatest demonstrated potential for the introduction of aflatoxin residues in the human diet (Galvano et al., 1996).

As milk and dairy products are processed by different technologies involving various unit operations and present diverse chemical compositions, the effects of each processing step on the mycotoxin levels in the final product may be variable. Although some strategies have been proposed to prevent, control, and/or reduce the incidence of aflatoxins in animal feed and food, it is known that their effectiveness in reducing the levels of mycotoxins is limited, present high costs or lead to nutritional and sensory changes that are perceived as ‘unacceptable’ (El-Nezami, Kankaanpaa, Salminem, & Ahokas, 1998). Given the above, the knowledge on the occurrence of AFM_1 in dairy products, and how it is affected by each processing step, is of major importance to provide useful and accurate information for the development of risk assessment studies and risk management strategies. In this scenario that bounders food safety, technology, and public health, this study aims to review the incidence and the fate of AFM_1 in milk, yoghurt and cheeses during processing.

2. Aflatoxins: characteristics, producing fungi, regulations and incidence

Aflatoxins are compounds that have strong effect on human and animal health because they lead to serious damage to the liver, induction of tumors as well as immunosuppressive, mutagenic, teratogenic and carcinogenic effects (Hernandez-Mendoza, Guzman-de-Peña, & Garcia, 2009). Aflatoxins are fungal metabolites produced by at least 20 species of three different sections of the *Aspergillus* genus, such as *Flavi*, *Nidulantes* and *Ochraceorosei*. The members included in the *Flavi* section are *Aspergillus arachidicola, Aspergillus bombycis, A. flavus*, *Aspergillus minisclerotigenes, Aspergillus nomius, Aspergillus novoparasiticus, A. parasiticus*, *Aspergillus parvisclerotigenus, Aspergillus pseudocaelatus, Aspergillus pseudonomius A. pseudotamarii, Aspergillus togoensis, Aspergillus transmontanensis, Aspergillus mottae* and *Aspergillus sergii*; the members in the *Ochraceorosei* section are *Aspergillus ocharaceroseseus* and *Aspergillus rambelii*; and finally the members inserted