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Food consumption in a population of the Amazon region *versus* mycotoxins

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Abstract

In addition to providing nutrients, the feeding is a process that must follow safety principles to prevent contamination or the presence of toxic agents. Among these agents are mycotoxins, which are carcinogenic substances and associated with some foods. In this context, this study aimed to survey the foods consumed by a population group in Amazonas State (Brazil) using a 24-hour recall food survey questionnaire and weekly eating habits. We observed that 100% of the volunteers reported consuming the foods listed in the literature at risk of mycotoxin contamination in the 24-hour recall. As for weekly habits, 12% consume bovine milk, 30% consume cereals, 73% did not consume raw Brazil nuts, 57% consumed them in culinary recipes, and 63% in by-products. Therefore, we conclude that despite being a regional food, Brazil nuts are not in the most frequent public habits, whether for financial reasons, allergy prevention, or consumer preference.

Keywords: aflatoxin, Brazil nuts, cereals, food survey, mycotoxins.

1. INTRODUCTION

Mycotoxins are toxic agents produced by fungi that affect food. Because they are carcinogenic substances, these secondary metabolites may affect consumer health acutely and chronically.

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Moreover, mycotoxins cause commercial losses due to associated conditions that affect the secondary metabolism of fungi, which in addition to the genetic factor, can be affected by the environment (e.g., temperature and relative humidity of food storage). Aflatoxins form one of the major groupings of mycotoxins and are mainly produced by *Aspergillus flavus*, *A. parasiticus*, and *A. nomius*. These highly toxic fungi metabolites stand out as the most thoroughly studied mycotoxins due to their occurrence and toxicity for humans and animals with nephrotoxic, teratogenic, and mutagenic action (IARC, 2015). Its compounds include Aflatoxin B1 (AFB1), Aflatoxin B2 (AFB2), Aflatoxin G1 (AFG1), and Aflatoxin G2 (AFG2), which are associated with food contamination, including Brazil nuts, peanuts, nuts, dried fruits, figs, spices, cereals, and milk (Caldas and Jardim, 2012; Santili et al., 2015; Vidal et al., 2018). Ochratoxin A (OTA) is a mycotoxin produced by fungi of the genus *Aspergillus* and *Penicillium* and has already been found in products such as coffee, wine, cocoa, cereals, dried fruits, nuts, milk, and grapes (Khaneghah et al., 2019). Furthermore, ingesting OTA through contaminated foods is linked to immunotoxicity, teratogenicity, nephrotoxicity, and carcinogenic effects (Agriopoulou et al., 2020). Deoxynivalenol (DON) is a toxin produced by *Fusarium* fungi and associated with barley, corn, wheat (Piacentini et al., 2018), and food products derived from cereals, including bread, pasta, and beer (Agriopoulou et al., 2020). DON is one of the most common mycotoxins in the food chain, and its chronic exposure may lead to immunosuppression, anorexia, and growth retardation. In addition, acute exposure to high doses may cause diarrhea and vomiting (Morimura et al., 2020; Piacentini et al., 2018). Fumonisin is a mycotoxin produced mainly by *Fusarium spp.* and present in maize, wheat, and similar cereals (Cendoya et al., 2018). Nonetheless, fumonisin effects on human health are not clearly established, and research has suggested there may be a relationship between the intake of contaminated maize and esophageal cancer incidence (Alizadeh et al., 2012). Among the foods potentially associated with mycotoxin contamination in Brazil in the last five years, maize, rice, wheat, and peanuts stand out (Andrade et al., 2020; Coppa et al., 2020). The consumption of these foods in Brazil varies according to the geographic region due to cultural habits and seasonal availability. Therefore, the present paper sought to study the eating habits of a population group in Manaus (Amazonas State,

Brazil) regarding the weekly consumption of mycotoxin-associated food.

2. MATERIAL AND METHODS

2.1 Study population

This study was a pilot study comprising 30 volunteers consisted of men and women (aged between 19-52 years) from the Faculty of Pharmaceutical Sciences of the Federal University of Amazonas, Manaus (Amazonas State, Brazil). The research ethics committee approved the project under the number: 909.195. The study group consisted of 11 male participants (37%) and 19 female volunteers (63%), being 23 (77%) students and 7 (23%) faculty members. The average age of the volunteers was 26±8 years (19-52 years), with the women being older than the men. This age difference was of about 26 years. All volunteers were informed about the study and a consent form was signed before participation. The participants appeared to be in good physical health and were asked to complete a questionnaire with information about their weight, height, age, medication use, and pathological conditions. They were also asked to complete a food frequency questionnaire to record their weekly eating habits and food ingested within 24 h. The frequency of consuming foods most susceptible to mycotoxin contamination in Brazil was classified from 0 to 8 times a week or more.

3. RESULTS AND DISCUSSION

3.1 Clinical conditions

The pathological information reported by the volunteers is shown in Figure 1. No volunteer presented the clinical condition of diabetes or renal pathology, 3% reported the presence of liver pathology, 17% had some intolerance or food allergy, and 40% were using medication.

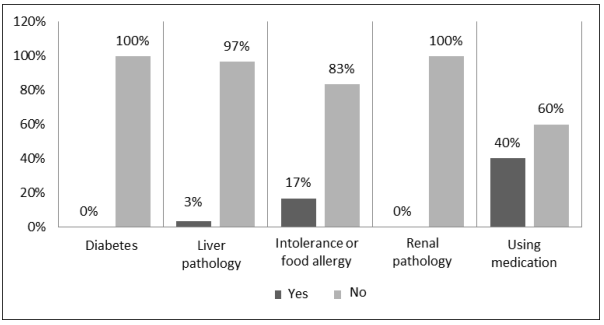


Figure 1. Pathologies reported by volunteers.

3.2 24-hour recall survey

Among the foods reported in the 24-hour recall questionnaire, foods from the Brazilian diet were reported according to the family budget survey (2009), such as coffee, bread, milk, meat, rice, beans, and fruits (Figure 2). The most consumed food reported by all volunteers were rice. Nonetheless, it is linked to aflatoxins presence due to the tropical region, where hot and humid climates favor fungal growth on foods (Ali, 2019).

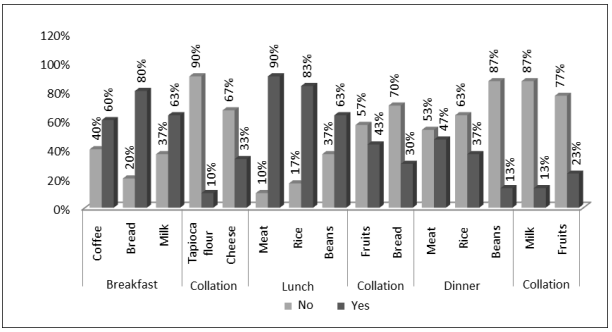


Figure 2. Food consumption of volunteers in a 24-hour recall.

3.3 Consumption of mycotoxin-associated food

3.3.1 Beverages

Among the beverages, the volunteers were surveyed on bovine milk and alcohol consumption, such as wine. For bovine milk, Santilli et al. (2015) analyzed milk samples in São Paulo State (Brazil) and reported that only three samples (0.5%) had contamination above the tolerated limit in Brazil (0.50 µg/kg), and 64 samples (10.1%) had more significant contamination than the maximum limit defined by the European Union (0.050 µg/kg). The estimated daily intake of aflatoxin

M_1 was 0.358 and 0.120 ng/kg body weight/day for children and adults, respectively. For wine, 77% did not consume it during the week and only 3% for two times a week.

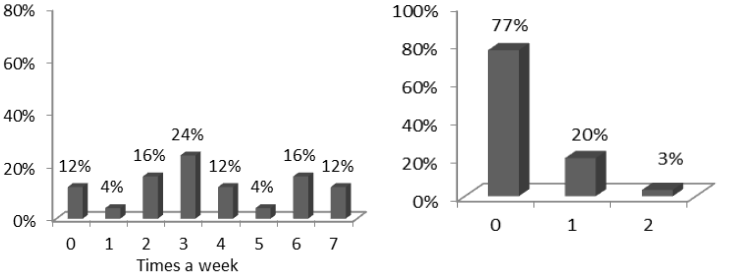


Figure 3. Drinking by volunteers.

3.3.2 Cereals

Among the volunteers, 37% reported consuming cereals seven times a week, with the highest percentage reported in the survey regarding frequent consumption during the week. Diaz et al. (2015) analyzed Colombian samples of maize, rice, and cassava for mycotoxins and concluded that indigenous Amazonian communities are exposed to mycotoxins (particularly aflatoxins) and other mycotoxins, especially through ingestion of locally grown maize. The authors also showed that citrine content in maize was significantly high and had not been reported elsewhere.

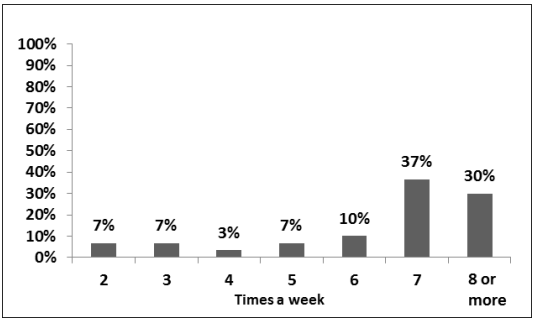
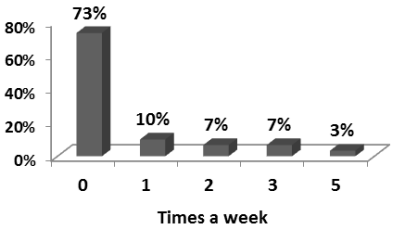


Figure 4. Cereal consumption by volunteers.

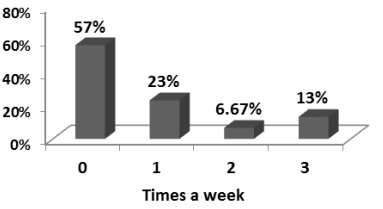
3.3.3 Brazil nuts and derivatives

Considering that several studies have reported aflatoxin contamination in Brazil nuts (Kluczkovski et al., 2020; Taniwaki et al., 2019; Cunha et al., 2018), the volunteers were surveyed on their

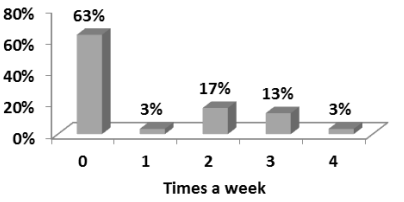
Brazil nut consumption frequency during the week. According to Figure 5, 73% of the volunteers did not consume raw Brazil nuts, 57% consumed them in culinary recipes, and 63% in by-products. Considering that the consumption of Brazil nuts in the interviewed group was not frequent, more studies must be conducted regarding chestnut contamination in the retail sector and understand the contamination of the chestnut and its derivatives present in the regional diet.



Brazil nuts (raw nuts)



Brazil nuts in culinary recipes



Brazil nuts in by-products

Figure 5. Brazil nut consumption in different forms.

4. CONCLUSION

The present study sought to identify the main foods consumed weekly by the volunteers and the presence of mycotoxin-associated foods, according to scientific literature. Among the foods reported in the 24-

hour recall questionnaire, foods from the Brazilian diet were reported and included: coffee, bread, milk, meat, rice, beans, and fruits. Regarding regional foods such as Brazil nuts, consumption frequency was not high. Considering that it is an aflatoxin-related food, we suggest further research to assess the level of contamination of food sold in the region and consumed by the population in order to compose a risk analysis.

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