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Determinants of aflatoxin levels in Ghanaians: Sociodemographic factors, knowledge of aflatoxin and food handling and consumption practices

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Abstract

Aflatoxins are among the most potent of carcinogens found in staple foods such as groundnuts, maize and other oil seeds. This study was conducted to measure the levels of aflatoxin B_1 (AFB_1) albumin adducts in blood and aflatoxin M_1 (AFM_1) metabolite in urine of people in a heavy peanut and maize consuming region of Ghana and to examine the association between aflatoxin levels and several socio-demographic factors and food handling and consumption practices. A cross-sectional study was conducted in four villages in the Ejura Sekyedumase district of Ghana. A socio-demographic survey was administered to 162 participants. Blood samples were collected from 140 and urine samples from 91 of the participants and AFB_1 albumin-adduct levels in blood and AFM_1 levels in urine were measured. High AFB_1 albumin-adduct levels were found in the plasma (mean $\pm$ SD $= 0.89 \pm 0.46$ pmol/mg albumin; range $=$ 0.12–3.00 pmol/mg; median $= 0.80$ pmol/mg) and high AFM_1 levels in the urine (mean $\pm$ SD $= 1{,}800.14 \pm$ 2602.01 pg/mg creatinine; range $=$ non-detectable to 11,562.36 pg/mg; median $= 472.67$ pg/mg) of most of the participants. There was a statistically significant correlation ($r = 0.35$; $p = 0.007$) between AFB_1–albumin adduct levels in plasma and AFM_1 levels in urine. Several socio-demographic factors, namely, educational level, ethnic group, the village in which participants lived, number of individuals in the household, and number of children in the household attending secondary school, were found to be significantly associated with AFB_1 albumin-adduct levels by bivariate analysis. By multivariate analyses, ethnic group ($p = 0.04$), the village in which participants live ($p = 0.02$), and the number of individuals in the household ($p = 0.01$), were significant predictors of high AFB_1 albumin-adducts.

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These findings indicate strongly that there is need for specifically targeted post-harvest and food handling and preparation interventions designed to reduce aflatoxin exposure among the different ethnic groups in this region of Ghana.

Keywords: Aflatoxin B_1; Aflatoxin M_1; Sociodemographic factors; Food consumption; Ghana

Introduction

Aflatoxins are a group of highly toxic metabolites produced by the common fungi *Aspergillus flavus* and *A. parasiticus* (Gourama and Bullerman, 1995) and are among the most potent of carcinogens found in foods. Although the most common aflatoxins (B_1, B_2, G_1 and G_2) occur naturally together in various foods in different proportions (Park et al., 2002), aflatoxin B1 (AFB_1) is usually the predominant and most toxic form. AFM_1 is a major metabolite of AFB_1 and is frequently excreted in milk and urine of humans, dairy cattle and other mammals that have consumed food or feed contaminated with aflatoxins (Gourama and Bullerman, 1995). AFB_1 has been shown to cause liver tumors in a number of animal species (IARC, 1993) and is associated with hepatocellular carcinoma in humans (Omer et al., 1998; Peers et al., 1976, 1987; Wild et al., 1992a), especially in people with hepatitis B virus infection (Peers et al., 1976, 1987; Wild et al., 1992a; Henry et al., 1999). Consumption of moderate to high levels of aflatoxin has also been linked with acute illness resulting in death in humans (Ngindu et al., 1982; Bourgeois et al., 1971; Krishnamachari et al., 1975; Lye et al., 1995; CDC, 2004). In the outbreak in Kenya from January to July 2004, 125 of 317 patients (39.4%) died from acute aflatoxicosis (CDC, 2004). However, chronic aflatoxicosis results from continued consumption of low to moderate levels of aflatoxins, and the effects are usually subtle.

The highest aflatoxin contamination is found in groundnuts, maize, and other grains. In Ghana and other West African countries, most rural people depend on these foods for survival. Unfortunately, the basic staples that are produced and consumed (and the excess traded in urban and rural markets) are poorly handled and stored prior to marketing and are frequently contaminated by toxigenic fungi. Awuah and Kpodo (1996) reported high levels of aflatoxins (5.7–22,168 ppb) in market groundnut samples in Ghana. The samples were contaminated by a variety of fungi including *A. flavus*. Mintah and Hunter (1978) reported that 50–80% of groundnut samples from the Accra area of Ghana, especially those emanating from the Northern and Volta regions, had aflatoxin levels that exceeded the 30 μg/kg hazard level recommended by the FAO/WHO/UNICEF Protein Advisory Board (Frazier and Westhoff, 1988).

One study on aflatoxin levels in maize conducted in Ghana examined only 15 samples collected from major processing sites in Accra and reported the presence of aflatoxin in 8 (53%) samples (Kpodo et al., 2000). The level of aflatoxin ranged from 2 to 662 $\mu g/kg^{-1}$. A study conducted in the neighboring country of Benin showed that aflatoxin levels in maize varied by agro-ecological zones and length of storage time (Hell et al., 2000). Maize samples with higher aflatoxin levels came from the southern Guinea and Sudan savannas of Benin. Storage for 3–5 months, insect damage and use of local plants for protection during storage were associated with higher aflatoxin levels (Hell et al., 2000). The Ashanti Region of Ghana falls in the transitional zone between the forest and savanna and has a bimodal rainfall pattern (US Library Congress, 2005) and two maize growing seasons similar to the forest/savanna mosaic region of Benin (Hell et al., 2000). Dried yam chips that had a moisture content above 15% were also found to be contaminated with high levels of aflatoxin in Benin (Mestres et al., 2004).

In some East and West African countries 75–100% of individuals tested have been found to be positive for the AFB_1–albumin adduct in their blood with levels ranging from >5 to 720 pg AFB_1–lysine eq./mg albumin/ml blood (Wild et al., 1992a). Furthermore, unborn children are exposed to aflatoxins in utero and the AFB_1–albumin adduct has been found in umbilical cord blood (Wild et al., 1991). Gong et al. (2003) showed that there is an increase in aflatoxin albumin levels with age; in children 1–3 years it is related to weaning status. A higher consumption of maize was correlated with higher aflatoxin albumin adduct level. Ankrah et al. (1994) examined AFB_1 and AFG_1 in serum, urine and fecal specimens from 40 volunteers from the Greater Accra region of Ghana and detected aflatoxins in one or more of the specimens from 35% of the study participants. However, no studies have been conducted on aflatoxin levels in people in the Ashanti region of Ghana (a predominantly agricultural and heavy maize producing area) or on the sociodemographic factors that determine high aflatoxin levels. In this study, we examined the levels of AFB_1–albumin adducts in blood and AFM_1 metabolite in urine of people living in this region and identified factors associated with high AFB_1 levels.