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Decomposition and detoxification of aflatoxin B_1 by lactic acid

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Abstract

BACKGROUND: A degradation study of aflatoxin B_1 (AFB_1) was carried out using a combination of physical and chemical methods. AFB_1 was heated at 80 °C in the presence of acetic, citric and lactic acids for various time periods. The cytotoxicity of the degraded AFB_1 and its products were determined by MTT assay.

RESULTS: The results showed that among the three organic acids lactic acid was most efficient in degrading AFB_1. Although complete degradation was not observed, up to 85% degradation of AFB_1 was obtained when heated for 120 min. Degradation of AFB_1 was confirmed by the reduced toxicity on HeLa cells using MTT assay. Treatment with lactic acid resulted in the conversion of AFB_1 into two degradation products. These products were observed at lower retention factors of 0.63 and 0.38, which were identified as AFB_2 and AFB_{2a}, respectively. The cytotoxicity of AFB_{2a} exhibited much reduced toxicity on HeLa cells compared to that of AFB_1.

CONCLUSION: The results have shown the efficiency of lactic acid in degrading AFB_1. This study suggest that lactic acid may be considered for use in the food and feed industry since it is present naturally in food and is considered safe.

Keywords: aflatoxin B_1; aflatoxin B_{2a}; degradation; lactic acid; cytotoxicity assay

INTRODUCTION

Aflatoxins (AFs) are a group of structurally related metabolites produced by *Aspergillus flavus, A. parasiticus* and *A. nominus*.[1,2] These fungi can grow and produce aflatoxins under favourable temperature and moisture conditions in various food materials such as groundnut, tree nuts, dried fruits, spices, herbs and a number of food grains.[3,4] In order of their toxicity, the four major AFs are AFB_1, AFG_1, AFB_2 and AFG_2. They are known to be genotoxic, hepatotoxic, mutagenic, carcinogenic and immunosuppressive in animals and humans.[5] Among them, AFB_1 is the most toxic and has been classified as Group I human carcinogen by the International Agency for Research on Cancer.[6] AFB_1-8,9-epoxide, the carcinogenic metabolite which is activated by cytochrome P450, is responsible for the mutagenic activity of AFB_1.[7] It has been reported that the double bond in the terminal furan ring and the lactone ring in the coumarin moiety of AFB_1 are the main sites responsible for its toxicity.[8,9]

Removal or degradation of AFB_1 from food materials and the environment has become a necessity. AFB_1 is highly oxidized and hence stable to dry heat up to its melting point, i.e. 260 °C. Several degradation techniques involve a combination of heat treatment and moisture content. Factors such as temperature, moisture (acidic or alkaline) and time period determine the level of degradation.[10,11] Use of chemicals for degrading AFB_1 has been practised in the food industries. Ammonia is one of the most effective methods for AFB_1 degradation and has been accepted for use by the corn production industry. Ammoniation of AFB_1 leads to the formation of a degraded product, AFD_1, which has reduced toxicity and mutagenic potential.[12] Chlorine gas has been successfully used for inactivating 75% of AFB_1 in corn meal, copra meal and groundnuts without the formation of new compounds.[13] Although aqueous chlorine is used as a sanitizer in the food industries, the safety of chlorinated foods remains a concern. In the presence of acids, AFB_1 is converted to less toxic derivatives such as AFB_{2a}, AFD_1 and AFB_2.[14–17] It was reported that a higher level of degradation and loss of mutagenicity of AFB_1 in maize and sorghum was achieved with heat treatment in the presence of citric and lactic acid.[18] Safara *et al.*[19] demonstrated the efficacy of citric acid in reducing the level of AFB_1 in rice grains. The natural occurrence of organic acids in food makes them suitable in aiding the degradation of AFB_1 in food. Lactic acid bacteria and lactic acid in fermented foods have also been exploited for the detoxification of AFB_1.[20,21]

The present study evaluated the efficacy of organic acids in degrading AFB_1, and detoxification of AFB_1 was studied in animal cell lines.

MATERIALS AND METHODS

Aflatoxin B_1 purification and photometric quantification

An AFB_1-producing strain of *Aspergillus* was isolated in the laboratory and identified as *Aspergillus flavus* Link 1809 at the

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