Detoxification of Corn

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ABSTRACT

Corn samples contaminated with aflatoxins were ground by a Wiley Mill, using a 40-mesh sieve to make meal. The toxin level was reduced to less than 20 ppb, as detected by minicolumn tests. Detoxification was done by the separate treatments of 3% hydrogen peroxide, 75% methanol, 5% dimethlyamino hydrochloride or 3% perchloric acid. Loss in fresh weight by these treatments was 28, 14, 7, and 7% respectively. Loss in proteins and lipids due to the detoxification processes did not exceed 0.5 and 0.6%, respectively, when compared with the fresh weight of corn.

In recent years, scientists have been trying to save corn from being destroyed by aflatoxin contamination. These investigations have progressed in two directions and are as follows: (a) to inhibit growth of the causative organism, Aspergillus flavus or Aspergillus parasiticus on corn either on the cob or in storage bins, and (b) to remove the aflatoxins (B1, B2, G1, and G2) from corn after the toxin has been produced by the Aspergillus infection.

Most researchers have concentrated on the former objective, that is, to stop the causative organism from infecting the corn. Some chemicals have already been found effective in inhibiting mold growth in storage conditions (6). This, however, does not solve the problem of field damage of corn by mold infection since the airborne spores of the causative organisms are very readily available in the environment. The spores can germinate on the cob and infect the inner tissues under optimum temperature and moisture conditions. Therefore some researchers became interested in pursuing the second objective in recent years, that is, detoxifying corn. To bring the toxin level down to the FDA regulation guidelines of 20 ppb (parts per billion) or less has been termed as detoxification in this research.

The only method that is being tried for reducing the aflatoxin level in feed grains is ammoniation (treating the grains with ammonia gas). Peanuts and cottonseed meals were totally detoxified by this method (5). The ammoniation process is not only expensive from the standpoint of equipment and operation, but it may also cause health hazards during the operation. Ammoniated corn turns brown and never is freed from the smell of ammonia (2,3). Unfortunately, this is the only method being tried on a limited scale to detoxify corn. It is imperative, therefore, to use other chemicals that cause less damage to corn.

MATERIALS AND METHODS

The solvent extraction method, using one of these chemicals: 3% hydrogen peroxide (H2O2), 75% methanol (CH3OH), 3% perchloric acid (HClO4), and 5% dimethylamino hydrochloride [(CH3)2NH-HCl] was used to detoxify corn contaminated with 397 ppb of aflatoxin B1 and 31 ppb of aflatoxin B2. The corn did not have any detectable amount of aflatoxins G1 and G2. Hydrogen peroxide and perchloric acid, however, being oxidizing agents will directly react with aflatoxins rather than extracting them from corn. Since there is a problem of penetration of the chemicals through the hard coat of the corn kernel, the treatments were applied to ground meal.

Corn samples contaminated with aflatoxins were collected from the Laboratory Division of the South Carolina Department of Agriculture in Columbia, South Carolina. The blended samples that were received in sealed plastic bags were tagged with the exact amounts of aflatoxins B1, B2, G1, and G2 in ppb. The Department chemists confirmed that the samples were correctly pretested by the minicolumn method (7), and that standard TLC methods were used to quantitate amounts of aflatoxins present in corn (7). Samples were screened again by applying the minicolumn method before and after the detoxification procedure. The general detoxification procedure that was followed, using one of the above chemicals, is described as follows:

The blended corn was ground through a 40-mesh screen of a Wiley Mill, weighed to 50 g, incubated 1 h with 100 ml of one of the above mentioned chemicals, using a shaker waterbath (American Optical) preset at 65 C. The speed of the shaker was set at a low setting of 3 (83 gyrations/minute). After cooling to room temperature, the extract and the corn residue were separated by filtering through an eight-layered cheese cloth and Whatman No. 1 filter paper. Drying of detoxified corn was done in two phases: (a) air-drying, and (b) by mild heating at 37 C in a preheated incubator when detoxified corn was spread about one-half inch thick on aluminum foil. The detoxified corn was also tested for the presence of chemical odor or any visual change in appearance that could occur during detoxification. Complete drying of detoxified corn further ensured total removal of the detoxifying chemicals from the meal. The detoxified corn residue was screened again for presence of aflatoxins by the minicolumn test. This test was able to detect if the aflatoxin level of the detoxified corn could be brought down to 20 ppb or less.

The loss in the amounts of sugar and protein was measured by the anthrone assay (8) and the spectrophotometric assay (9), respectively. The loss in the amount of the total lipids was measured by the gravimetric method, using petroleum ether (8).
RESULTS AND DISCUSSION

The above detoxification methods, using any one of the above mentioned chemicals, were able to detoxify corn to the level of 20 ppb or less, as revealed by minicolumn test. Loss in fresh weight as occurred during treatments with hydrogen peroxide, methanol, dimethylaniline hydrochloride or perchloric acid was 28, 14, 7 and 7%, respectively. Loss in proteins and lipids did not exceed 0.5 and 0.6%, respectively, due to the detoxification processes. The second sample, when compared with the fresh weight of corn. Loss in sugar was negligible regardless of treatment.

Detoxification of aflatoxins by treatment with sodium hypochlorite and commercial bleaches was accomplished on a culture of A. flavus. It was found that aflatoxin production was inversely proportional to the logarithm of the hypochlorite concentration and the time of the treatment (1/2). Thus use of an oxidizing agent such as perchloric acid as a detoxifying agent for aflatoxins is not a new concept. Aflatoxin was also removed from cottonseed meal by methylamine treatment (1/2), and from peanut meal by 80% aqueous isopropanol treatment (1/1). Therefore the treatments with dimethylaniline hydrochloride or methanol as detoxifying agents may not be considered as new discoveries. On the other hand, removal of aflatoxins from corn meal by the solvent extraction or oxidation methods is not found in the literature and this attempt may be considered as the first of its kind. The greatest drawback of this discovery is the high cost of the chemicals, although the instrumentation or the operational methods are rather simple. Costs of the chemicals alone for detoxifying a pound of corn by the treatments with hydrogen peroxide, methanol, perchloric acid and dimethylaniline hydrochloride are $2.63, $3.02, $2.72 and $6.35, respectively.

It is difficult to estimate the actual cost of instrumentation, such as costs of a commercial-type mill for grinding and a shaker water bath that can hold a large volume of toxic corn. It can be safely suggested, however, that it will cost at least $2 for instrumentation alone per pound of corn. For practical purposes sun-drying may be chosen over use of an incubator.

The advantages of discovering these methods are as follows: ammoniation of feed corn to remove aflatoxins or using the toxic corn for gasohol production should not be the only alternatives for corn contaminated with high levels of aflatoxins. Lastly, it gives a new direction for future research on chemical detoxification of aflatoxins in corn meal.

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