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Preliminary study to assess mycotoxin concentrations in whole corn in the California feed supply

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ABSTRACT

Mycotoxins are naturally occurring environmental contaminants recognized worldwide in a variety of food and feed products. Produced as secondary metabolites by filamentous fungi, mycotoxins can have acute and chronic effects. Differing seasonal weather patterns and harvesting and storage conditions put corn grain at high risk for mycotoxin contamination. The objective of this study was to assess the risk of mycotoxin exposure posed to California livestock from whole corn. Random samples (n = 50) of whole corn were collected and analyzed for 6 different mycotoxins, including aflatoxins, fumonisins, ochratoxins, trichothecenes (deoxynivalenol and T-2 toxin), and zearalenone. The samples represented a cross section of the corn entering California from various corn-growing states (n = 43) as well as additional samples from California-grown corn (n = 7). The experiment was a randomized sampling design. Over the course of a 6-mo period, 16 trains in California (100–110 railcars) and 5 California grain elevators were randomly sampled. Aflatoxins were detected in 14 samples, with 1 sample containing a concentration of 41.3 μg/kg (as-is basis), which was above the action level of 20 μg/kg for corn fed to dairy cattle. The average concentration of aflatoxins for the 13 samples below the regulatory action level was 8.69 μg/kg (range 4.67 to 13.82 μg/kg). Deoxynivalenol was found in 15 samples and averaged 553 μg/kg (range 340 to 1,072 μg/kg), which was below the federal advisory level of 5,000 μg/kg for grain fed to dairy cattle. Fumonisins were found in 38 samples and averaged 1,687 μg/kg (range 435 to 4,843 μg/kg), which was below the federal guidance level of 30,000 μg/kg in corn for dairy cattle. Ochratoxins, T-2 toxins, and zearalenone were not detected in any samples of whole corn. Fumonisins were the most prevalent mycotoxins found.

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INTRODUCTION

Mycotoxins are secondary metabolites produced by fungi that pose a continual threat to producers and manufactures of livestock feeds as well as foods for humans (Yiannikouris and Jouany, 2002; Balázs and Schepers, 2007; Bryden, 2012). Their deleterious effects have a long history dating back centuries (Yiannikouris and Jouany, 2002; Richard, 2007). Approximately 25% of the world's food supply is contaminated by mycotoxins annually (Richard et al., 2003) with corn (maize) being one of the food supplies of greatest concern (Rodríguez-Amaya and Sabino, 2002; Wild and Gong, 2010; Rodrigues and Naehrer, 2012). Fumonisins were found in a variety of corn-based food products commercially sold in Brazil (Caldas and Silva, 2007). In addition to corn, other cereals, peanuts, and tree nuts often contain mycotoxins in low-income countries, with aflatoxins and fumonisins the prevalent mycotoxins (Wild and Gong, 2010). Indeed, the importance of mycotoxins in foods is illustrated by the fact that the *World Mycotoxin Journal* devoted a special issue to *Fusarium* mycotoxins [e.g., deoxynivalenol (**DON**), T-2/HT-2 toxins, and zearalenone (**ZEN**)] and their effects on human health (Shephard et al., 2010) and that an international workshop entitled "Mycotoxins from the Field to the Table" was held in 2006 (Balázs and Schepers, 2007).

Mycotoxins are also of concern in the feed supply of livestock industries because of their ability to cause acute and chronic toxic effects, leading to illnesses and subsequent vast economic losses. A survey of feedstuffs on 24 dairy farms in the Netherlands found that DON, ZEN, roquefortine C, and mycophenolic acid had the highest prevalence (Driehuis et al., 2008). A 2-yr survey of feedstuffs sampled at the farm and feed manufacturer levels in the European/Mediterranean markets (1,507 samples) and the Asian-Pacific region (1,291 samples)

revealed that DON, ZEN, and T-2 toxin were the major mycotoxins in the European feed samples and DON, ZEN, fumonisins, and aflatoxins in the Asian-Pacific region (Binder et al., 2007). Mycotoxins are clearly a specific concern in corn (Binder et al., 2007; Wild and Gong, 2010). Seventy percent of the corn samples from the Asian-Pacific region were contaminated with DON, 69% were contaminated with fumonisins, and 41% were contaminated with ZEN (Binder et al., 2007). For European samples of corn, 81, 63, and 56% were found to be contaminated with DON, ZEN, and fumonisins, respectively. Mycotoxin levels are seasonally variable in corn crops due to environmental conditions, particularly during the growing season. Seasonal differences in mycotoxin contamination of corn were recently reported in a German study (Goertz et al., 2010). Corn grown with high temperature and low rainfall conditions resulted in 75% of the corn samples contaminated with DON, 34% with fumonisins, and 27% with ZEN. In the following year with moderate temperatures and frequent rainfall events, 90% of the corn samples had DON and 93% had ZEN, but no fumonisin-positive samples were detected. However, improper harvesting and storage can also cause rapid formation of mycotoxins after harvest. Storing moist corn for 7 d following harvest before drying significantly increased the concentrations of fumonisins and ZEN (Magan and Aldred, 2007). Corn is often harvested at moisture contents greater than 14 to 15%, but this requires subsequent drying of the grain to reduce the available water to less than 0.70 water activity (a_w) to allow safe storage of the corn (Magan and Aldred, 2007).

The amount of corn used in California has steadily increased. Corn is used by the dairy and livestock industries and, more recently, large amounts of corn are used by the ethanol industry to produce alcohol for fuel purposes. California has a grain production-use deficit of almost 4.82 million tonnes (Cothern, 2000). Thus, to meet the corn demand, California imports corn from other states. One of the largest imported feed commodities into California is corn. In 2003, corn shipped into California from Iowa and Nebraska accounted for 72% of California's corn supply needs. Recent information obtained through way bill sample data shows that the amount of corn being railed into the San Joaquin Valley of California is over 4 times larger than local corn production (California Grain Foundation, 2005).

Corn is grown for grain in the Northern San Joaquin Valley in Central California, with little corn grain production in the Southern San Joaquin and Imperial Valleys. Most of the corn imported into California is produced in the Midwest. Quality components to monitor for imported corn are mycotoxins because they can elicit toxic responses (mycotoxicosis) in animals and humans. Mycotoxins or their metabolites, or both, can be found in milk (González-Osnaya et al., 2008) and meat, which, if consumed, can have detrimental effects on human health (Yiannikouris and Jouany, 2002; Wild and Gong, 2010). However, no information exists on the mycotoxin contamination of corn imported into California.

It is evident that it is impossible to fully eliminate the presence of mycotoxins in feeds and food. Thus, it is important to assess mycotoxin concentrations and compare them to scientifically sound maximum concentrations. The objective of this preliminary study was to assess the concentrations of mycotoxins in whole corn destined to be fed to California livestock.

MATERIALS AND METHODS

Sample Collection

Fifty random samples (n = 50) of whole corn were collected and analyzed for 6 different mycotoxins. The corn samples (n = 43) represented a cross section of the corn entering California from various corn-growing states, including Nebraska, Iowa, Michigan, and South Dakota via the Union Pacific and the Burlington Northern Santa Fe rail lines, as well as additional samples (n = 7) from corn grown in California. The grain elevators sampled for California grown corn were in the California cities of Petaluma, Stockton, and Williams. Information on agronomic growing and harvesting conditions was not collected.

During a 6-mo time period (March 2006 through September 2006), 16 unit trains (100 to 110 railcars per unit train) delivering products into California and 5 grain elevators in California were randomly sampled for corn by special investigators of the California Department of Food and Agriculture (**CDFA**) Feed, Fertilizer, and Livestock Drugs Regulatory Services Branch (Sacramento). All investigators used official CDFA methods of sampling. Three railcars were chosen at random from each unit train and sampled using the CDFA commercial feed sampling methods (CDFA, 1997). Briefly, the CDFA bulk corn sampling method involved using either a Seedburo model 815, 8-foot (2.4-m) partitioned with 16 openings, grain probe (Seedburo Equipment Co., Des Plaines, IL) or a 500-mL stream cutter, 6-foot (1.8-m) handle, polyethylene sample dipper (Fisher Scientific, Pittsburg, PA). In the event that samples were obtained using the compartmented grain probe, a minimum of 3 cores per railcar or truck were gathered. Similarly, a composite sample of 20 stream cuts was obtained while the railcar or truck was unloading. Three railcars were chosen at random from each unit train and sampled as described. Samples were collected