Patulin: a Mycotoxin in Apples

Ellen C. Hopmans, Department of Food Science &Technology

The word mycotoxin stems from the Greek word "mykes", meaning mold, and "toxicum" meaning poison. Mycotoxins are toxic secondary metabolites produced by molds and can contaminate a wide variety of foods and feeds. Human cases of ergotism or St. Anthony's Fire have been described in Europe since the Middle Ages and are now known to be caused by alkaloids produced in rye by the mold *Claviceps purpurea*. In 1960, an outbreak of Turkey X disease in England and the subsequent discovery of the aflatoxins stimulated great interest in the field of mycotoxin research (Bullerman, 1979). Since then many more mycotoxins, such as thricothecenes, zearelenone, ochtratoxins and fumonisins have been discovered.

Typically, mycotoxins are considered a problem of grains. Grains are stored for long periods of time before use or processing and small elevations in moisture content can lead to postharvest growth of mold and mycotoxins production. However, one fruit mycotoxin, patulin, has received a fair amount of attention. Patulin was first isolated in the 1940's but is now know to occur world-wide in apple and apple products. This mycotoxin is produced by several species of mold including *Penicillium expansum* and other *Penicillium* spp. These molds are common postharvest pathogens of apples and pears. Fruits decayed by these molds are also likely to be contaminated with patulin. Patulin is heat stable and will survive processing. It has been found in apple products in concentration up to 16 milligrams per kilogram [16 parts per million (ppm)], although that should be considered an exception. The contamination incidence is fairly high but the level of contamination is generally low with usual levels of less than 10 µg/L[10 parts per billion (10 ppb)] in commercial apple juices (Fremy et al., 1995).

Patulin is not considered a particularly potent mycotoxin. It was initially studied as an antibiotic but it is also toxic towards plants and animals. In 1954 patulin was implicated in the deaths of 100 cows in Japan that ate contaminated feed. Several studies have found that patulin is genotoxic, i.e. that it causes damage to DNA or chromosomes, in short term studies. However, these studies were performed in bacterial or mammalian cell cultures and with doses of the toxin that are not relevant to human exposure levels.

Patulin was studied for carcinogenicity in rats and mice. In only one study in rats was a significant increase in tumor incidence observed between control and patulin treated animals (Dickens and

Jones, 1961). Subcutaneous injections caused cancer at the injection site, but cancer experts agree that this alone is not sufficient evidence that patulin is a carcinogenic mycotoxin. In the same study both male and female rats receiving the highest dose (1.5 mg/kg bodyweight) did not survive for the duration of the study, demonstrating patulin's toxic potential. The International Agency for Research on Cancer has evaluated the toxicity data and in 1986 classified patulin a Group 3 carcinogen or "a compound for which there is not enough data to allow its classification" (IARC, 1986). Several European countries have established regulatory limits for patulin in apples and apple products. Switzerland, Sweden, Belgium, Russia, and Norway, have set maximum permitted concentrations of 50ppb. In addition, the World Health Organization has established a maximum recommended concentration of 50 µg/L (50 ppb) in apple juice (van Egmond, 1989).

Patulin has also become important to apple processors as a method for monitoring the quality of apple juices and concentrates. The presence of high amounts of patulin indicates that moldy apples were used in the production of the juices. For that reason the problem of detecting low levels of patulin in apple juices continues to receive attention. Most recently the Association of Official Analytical Chemists International adopted a liquid chromatographic method as first action after an international collaborative study performed by among others the U.S. Food and Drug Administration (Brause et al., 1997). Because apple juice is such a popular beverage and the potential for life-long exposure exists, patulin will likely remain important to apple processors and governments interested in monitoring the quality of apple juices and products.

References

Brause, R., Trucksess, M.W., Thomas, F.S and S.W. Page. 1997. Determination of patulin in apple juice by liquid chromatography: collaborative study. JAOAC Intl. 79: 451-455.

Bullerman, L.B. 1979. Significance of mycotoxins to food safety and human health. J. Food Protection 42: 65-86.

Dickens, F. and H.E.H. Jones. 1961. Carcinogenic activity of a series of reactive lactones and related substances. Br. J. Cancer 15: 85-100.

van Egmond, H.P. 1989. Current situation on regulations for mycotoxins. Overview of tolerances and status of standard methods of sampling and analysis. Food Addit. Contam. 6: 139-188.

Fremy, J.M., Castegnaro, M.J.J., Gleizes, E., De Meo, M. and M. Laget. 1995. Procedures for destruction of patulin in laboratory wastes. Food Addit. Contam. 12: 331-336.

IARC. 1986. Some naturally occurring and synthetic food components, furocoumarins and ultraviolet radiation. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans; IARC: Lyon, France, Vol. 40, pp. 83-98.