Ultraviolet Light Effects on Patulin Mycotoxin in Foods

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Patulin is a mycotoxin produced by a wide range of molds involved mainly in apple spoilage and is a health concern primarily in fresh apple juice and cider. Patulin can lead to acute, but more commonly, chronic condition when consumed at levels greater than 50 ppb that is a current regulatory standard. The toxicity and high occurrence of patulin in apple cider/juice promoted to establish tolerance limits in these products. Failed or insufficient application of good agricultural practices (GAP) and good manufacturing practices (GMP) during pre- and post-harvest, however, may result in the processing of damaged apples with high concentration of patulin. The limited ability of traditional downstream processing such as juice clarification and thermal pasteurization to reduce patulin levels encouraged the search and development of novel processing techniques to control the contamination in the final products without affecting product quality.

The research conducted in GFRC of AAFC studied the feasibility of ultraviolet (UV) irradiation as alternative treatment to reduce patulin levels in apple products. The hypothesis was based on the high patulin absorbance in the UV-C range (200 - 280 nm) with the maximum absorbance at 276 nm as shown in Figure 1. The UV light from traditional low-pressure mercury (LPM) lamps which release 90 percent of photons at 254 nm can be absorbed by the patulin molecule and reduce the mycotoxin through photochemical reactions. Moreover, the approval of UV light at 254 nm as an alternative treatment to thermal pasteurization of fresh juices by U.S. FDA and Health Canada makes it feasible to adopt the UV light based technique in the commercial application.

In the study of UV radiation at 254 nm it was found more than 85 percent reduction of patulin in the apple cider and apple juice in the experimental pilot conditions after exposure to UV sources for 40 min at UV fluence rate of 3.00 mW·cm^{-2}. The degradation rates of patulin varied and depended on the UV fluence rate, exposure time, sample thickness and constitute of juice/cider. Generally, the higher fluence rate and/or longer exposure time, the higher degradation rate of patulin was observed. With the same UV irradiation levels, the thinner sample resulted in the higher reaction rate. Among different apple juices, the addition of ascorbic acid (vitamin C) accelerated the degradation of patulin. The degradation followed the first-order reaction model. The reaction rate constants were determined to predict patulin photo-degradation in the same apple based beverages (Zhou et al 2013).

The gap between the emitted spectrum of LPM UV lamp at 254 nm and the peak absorption of patulin at 276 nm suggested that alternative UVC wavelengths could enhance the degradation process. The excimer lamps were considered as the alternated UV lamps as their specific feature of narrow emission band depend n the choice of rare gas and/or halogen (e.g. KrCl* ,λ = 222 nm; XeBr*, λ = 282 nm). These UV sources was used to modify and further enhance the reduction of patulin based on the potential mechanism of either providing photons with higher energy or matching to the peak absorption peak of patulin at 276 nm. When comparing the three monochromatic UV light at 222 nm, 254 nm and 282 nm, the average UV fluences of 19.6, 84.3 and 55.0 mJ·cm^{-2}, respectively, resulted in the 90% reduction of patulin in apple juice through the exposure of UV lights. Therefore, the efficiency order

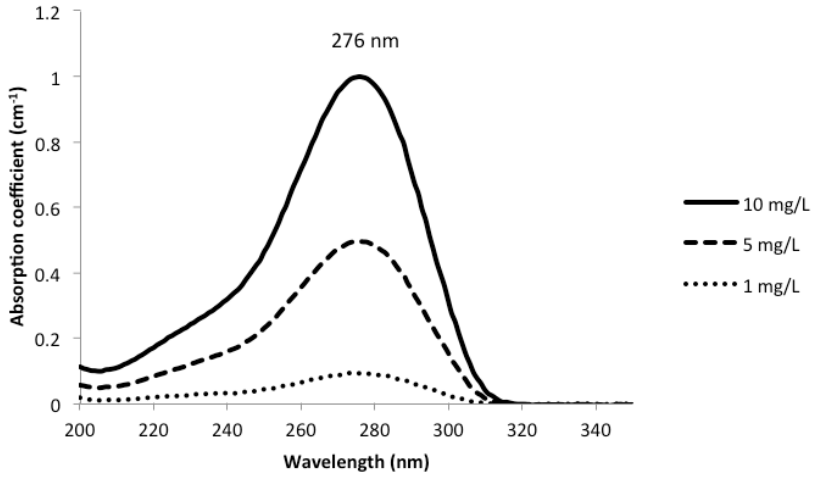

Figure 1. The absorbance spectra of patulin between 200 and 350 nm (10 mg·L^{-1}, 5 mg·L^{-1} and 1 mg·L^{-1})

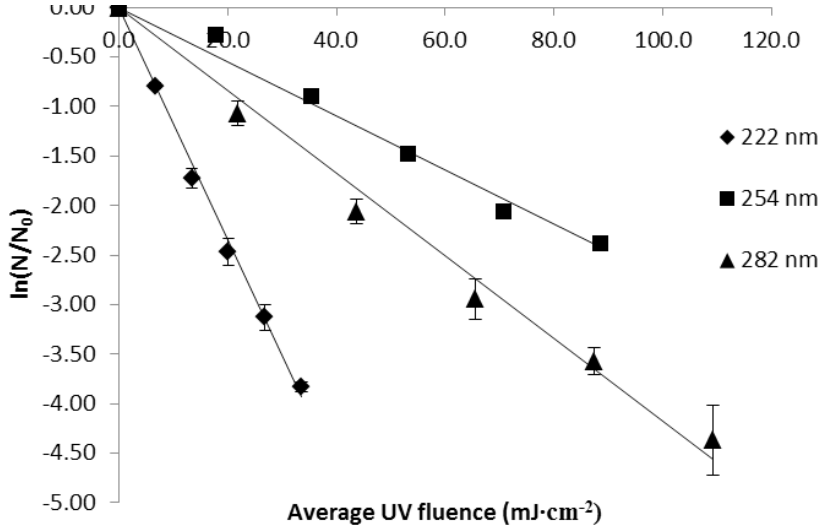

Figure 2. Reduction of patulin in apple juice by UV exposure with 222, 254, 282 nm wavelength UV lamps

of three wavelength lamps was: 222 nm > 282 nm > 254 nm (Figure 2). In the apple juice quality attributes study, UV irradiation supporting a 90 percent reduction of patulin did not significantly affect pH values and total soluble solid (Brix°) of juice. The absorption coefficients at 254 nm were compared and all the four treatments showed significant decreases after UV exposure. Also, there was a significant decrease in ascorbic acid concentration of apple juice at all the UV wavelengths tested. The highest loss in ascorbic acid (Viatmin C) was observed at 254 nm (45.3 percent). The color changes caused by 254 nm and 282 nm were unnoticeable whereas the color changes resulted from 222 nm and were slightly noticeable. However, the triangle sensory test showed no significant color changes between samples before and after UV irradiation at all three wavelengths. The results of this study were published in Journal of Food Protection (Zhou et al 2014).

In summary, the research results provided a strong evidence of the validation and feasibility of UV technique for the patulin decontamination of apple based products. The rate of patulin photo-degradation is wavelength dependent. Among three wavelengths of 222 nm, 254 nm and 282 nm, the UV lamp with wavelength at 222 nm is the most effective UV source which causes no significant changes in pH, total soluble solids, and does not impact on the overall sensory characteristics in apple juice.

REFERENCES

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