Vitamin D_2 Enrichment In Fresh Mushrooms Using Pulsed UV Light

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Introduction

Vitamin D is a fat-soluble vitamin commonly occurring in the D_2 (ergocalciferol) or D_3 (cholecalciferol) forms (NIH 2007). Vitamin D_2 is synthesized from the fungal sterol ergosterol through exposure to ultraviolet light while Vitamin D_3 is synthesized, in humans, through skin exposure to ultraviolet light and subsequent conversion of cholesterol (Linus Pauling Institute 2008).

Vitamin D is converted in the liver and kidneys to the active form 1,25 dihydroxyvitamin D. The active form then plays a role in maintaining blood levels of phosphorus and calcium and also promotes bone mineralization and calcium absorption. Deficiency of Vitamin D has been linked to rickets in children and osteomalacia in adults. Individuals at risk for Vitamin D deficiency include infants who are exclusively breastfed, older individuals, people with limited sun exposure, people with greater skin melanin content, and people with fat malabsorption. (NIH 2007)

Vitamin D has also been linked to aiding in maintaining a healthy immune system and regulation of cell differentiation and growth (NIH 2007). A recent study (Cannell 2008) has also shown a link to several diseases including cancer, CHD, hypertension and stroke, MS, RA, inflammatory bowel disease, mental illness and chronic back pain.

Vitamin D_2 has long been thought to be not as useful in the body as Vitamin D_3 (NIH 2007). However, recent research suggests that both forms are converted to the active 1,25 dihydroxyvitamin D form in the body and show no significant changes in blood levels of the active form when consumed (Hollick, 2008).

Previous research (Matilla, 1994) has shown that small amounts of Vitamin D_2 are found in wild mushrooms. Work has also been done on increasing the Vitamin D_2 content in cultivated mushrooms through ultraviolet light exposure. A recent pilot study (Feeney, 2006) showed that while Vitamin D_2 could be increased with postharvest exposure of *Agaricus bisporus* (white button mushroom) to UV-C light to a level of over 800% of the Daily Value (DV), the exposure time to achieve such levels was 5 minutes.

Pulsed UV light is a technology that uses a broad spectrum (100-800 nm) lamp along with high intensity pulses, delivering energy at a high peak power in a short amount of time (XENON, 2008). Compared to continuous UV light systems, the time for the same amount of UV light irradiation is much shorter.

This study aims to determine the effectiveness of Pulsed UV-B lamp treatment on increasing the Vitamin D_2 levels in four commonly consumed mushroom varieties, *Agaricus bisporus* (white and brown button mushrooms), *Pleurotus ostreatus* (Oyster), and *Lentinula edodes* (Shiitake).

Materials and Methods

Mushrooms were obtained from several Pennsylvania Mushrooms farms. All mushrooms were protected from extraneous light exposure throughout the experiments.

A Steripulse®- XL 3000 (Xenon Corporation, Wilmington, MA) was used for Pulsed UV light exposure. A B-type lamp was used. The system generated 505 Joules per pulse. At 1.25 inches from the window the broadband energy was 0.873 J/cm^2 per pulse. The system generates 3 pulses per second.

Brown and white button mushrooms were sliced to expose gill tissue. They were placed in 150g lots into polystyrene containers. Oyster and Shiitake mushrooms were divided into 150g lots and were arranged in the system so that there was a single layer of mushrooms. All samples were placed in the Pulsed UV system at a distance of 1.25 inches from the quartz window.

Brown and white button mushrooms were exposed for 0, 1, 2, 3, and 4 pulses. All treatments were repeated three times. Oyster and Shiitake mushrooms were exposed for 0, 1, 2, and 3 pulses. All treatments were repeated twice.

Samples were freeze-dried directly following treatment and ground into powder. The mushroom powder was sent to Medallion Labs (Minneapolis, MN) for Vitamin D_2 analysis.

Vitamin D_2 values are presented based on the % DV (Adequate Intake of 400 IU) in a serving (84g) of fresh mushrooms.

Results

The white button mushrooms showed an increase from an initial Vitamin D_2 level of 0% DV/serving to 325% DV/serving after just one pulse (figure 1). After 4 pulses the level of Vitamin D_2 increased to 824% DV/serving.

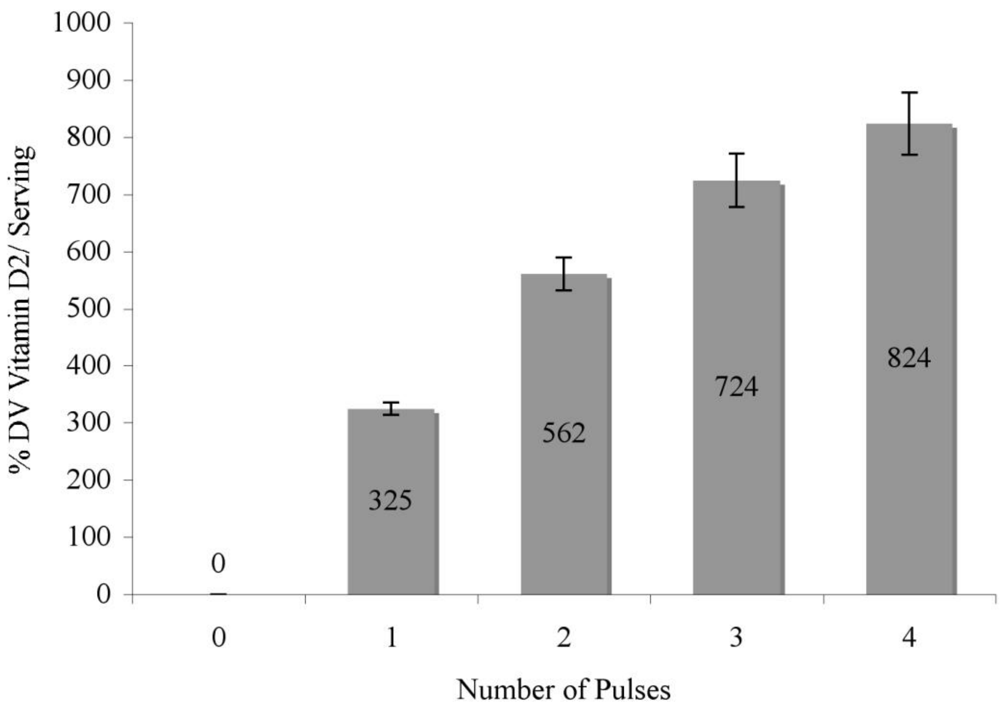

Figure 1. % DV Vitamin D_2 in one serving (84g) of white button mushrooms (*Agaricus bisporus*) after pulsed UV light exposure (B-type lamp). Error bars represent standard deviation of the three replications.

In the brown button mushrooms (figure 2) Vitamin D_2 went from an initial level of 4% DV/serving to 362% DV/serving after one pulse. The level increased to 899% DV/serving after 4 pulses.

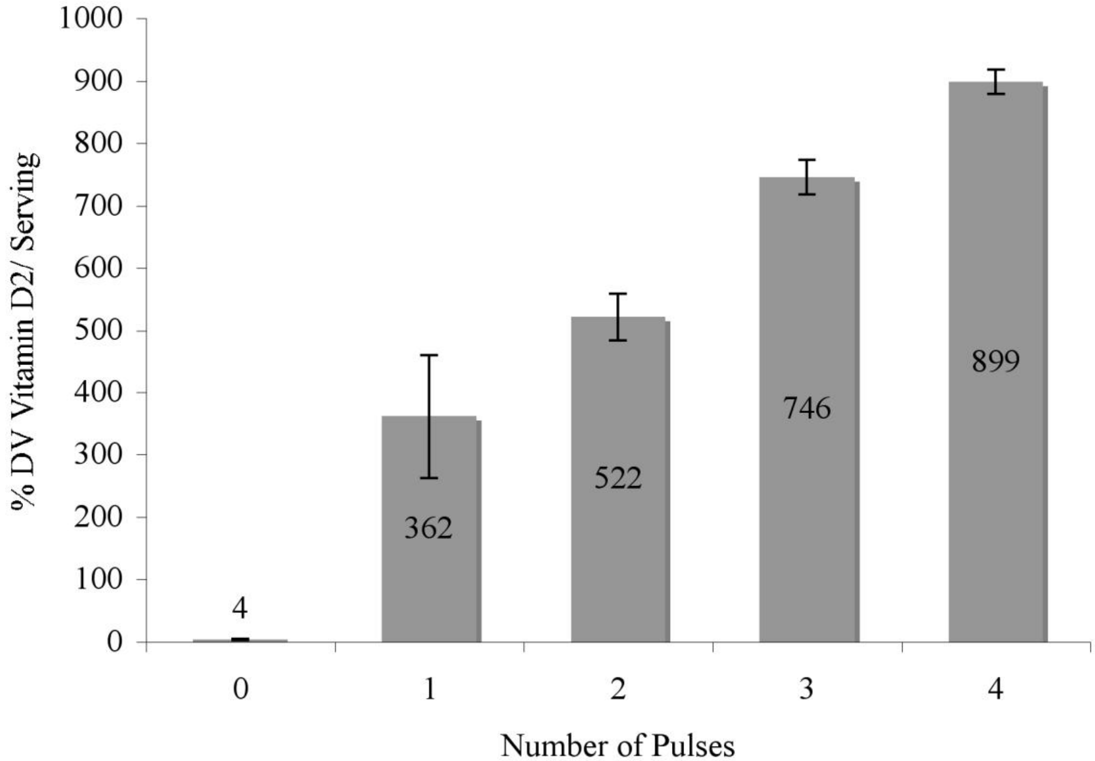

Figure 2. % DV Vitamin D_2 in one serving (84g) of brown button mushrooms (*Agaricus bisporus*) after pulsed UV light exposure (B-type lamp). Error bars represent standard deviation of the three replications.

After Pulsed UV treatment the Shiitake mushrooms (figure 3) showed an increase in Vitamin D_2 content from an initial level of 3% DV/serving to 490% DV/serving after one pulse. The Vitamin D_2 content after 3 pulses was 1200% DV/serving.

The Oyster mushrooms contained an initial level of Vitamin D_2 of 15% DV/serving to a level of 1618% DV/serving after 3 pulses.

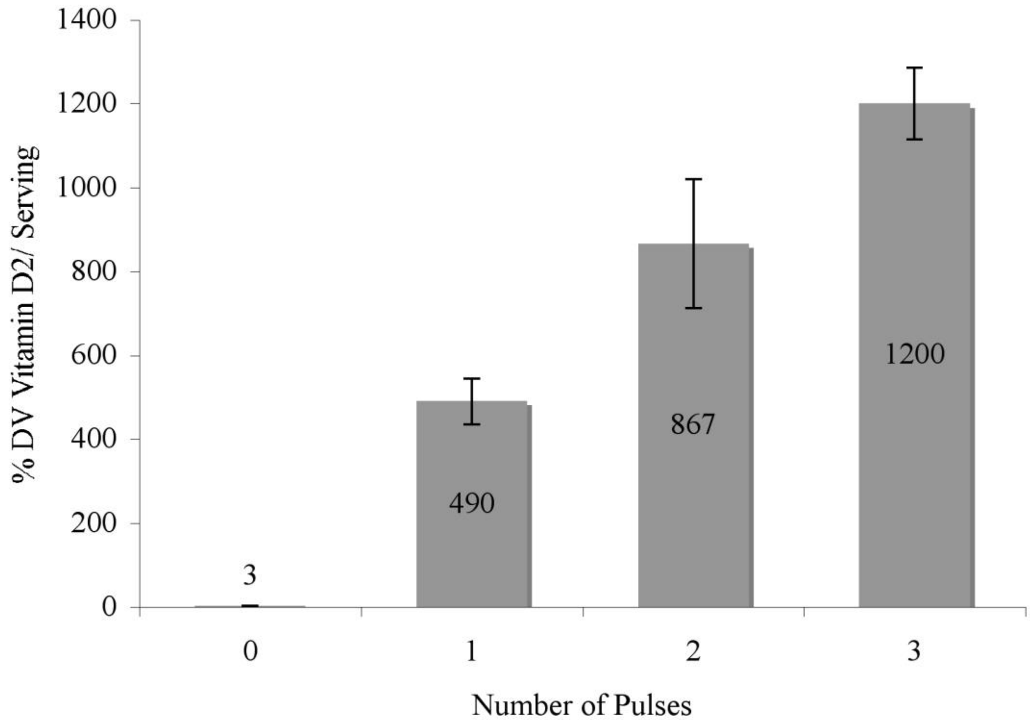

Figure 3. % DV Vitamin D_2 in one serving (84g) of shiitake mushrooms (*Lentinula edodes*) after pulsed UV light exposure (B-type lamp). Error bars represent standard deviation of the two replications.

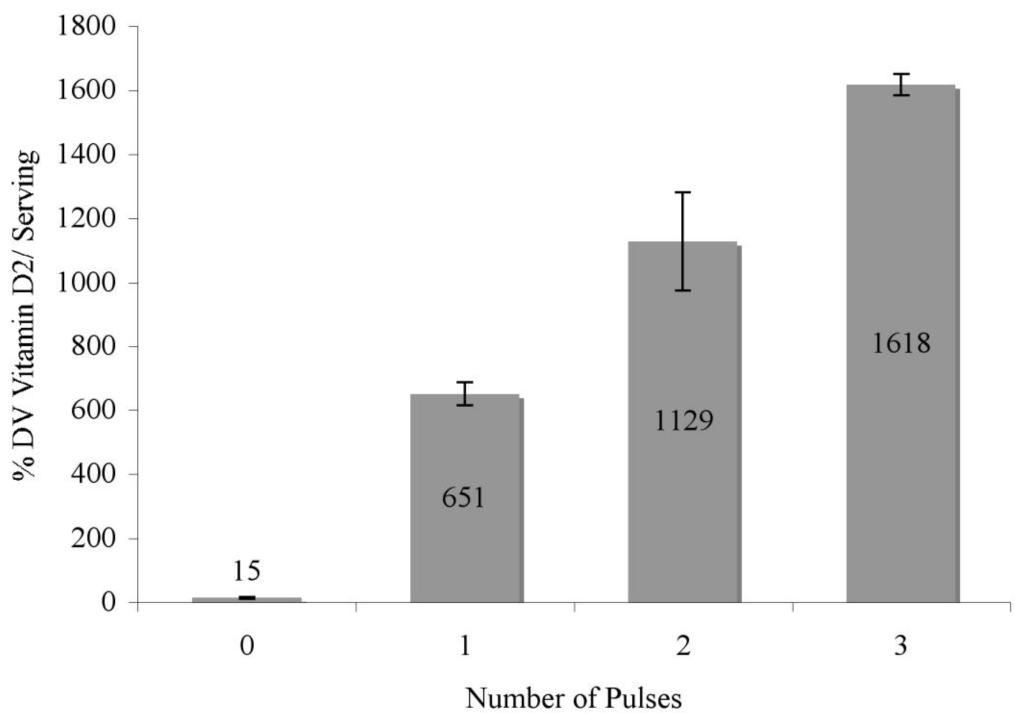

Figure 4. % DV Vitamin D_2 in one serving (84g) of oyster mushrooms (*Pleurotus ostreatus*) after pulsed UV light exposure (B-type lamp). Error bars represent standard deviation of the two replications.

Discussion

After exposure to increasing amounts of Pulsed UV light there was an increase in Vitamin D_2 content of every mushroom variety tested. With each additional pulse the mushrooms were exposed to increasing amounts of irradiation and thus more energy was available for Vitamin D_2 synthesis.

The oyster and shiitake showed higher amounts of Vitamin D_2 content after Pulsed UV light exposure than the brown and white mushrooms. This is most likely due to the thickness of the layer of mushrooms in the system. The brown and white button mushrooms were placed in polystyrene containers to simulate a package of sliced mushrooms being treated. The oyster and shiitake mushrooms were treated as whole mushrooms since their geometry did not permit for even distribution when packed together. The single layer of the oyster and shiitake mushrooms was similar to how these mushrooms would be treated if the Pulsed UV system were placed over a line where the mushrooms were being transported on a conveyor belt in a single layer. An additional study would be needed to directly compare the Vitamin D_2 content of the *Agaricus* mushrooms to the Oyster and Shiitake mushrooms.

This study demonstrates that after a very short exposure time of about 1 sec (system generates 3 pulses per second) the Vitamin D_2 content of these mushroom varieties can be increased from very little to upwards of 800% DV/serving. Previous studies using continuous UV light has been shown to take at least 5 minutes of exposure to obtain similar values (Feeney, 2006).

Pulsed UV technology has been shown to be a more practical method of UV irradiation of mushrooms for the mushroom industry than previous methods due to the shorter amount of time needed for exposure to achieve high amounts of Vitamin D_2. The UV-B bulb used in this study was found to be highly effective in converting ergosterol to Vitamin D_2 and would appear to more practical than UV-C bulbs for commercial use since there would be no generation of ozone that could compromise worker safety.

Acknowledgements

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