ORIGINAL SCIENTFIC PAPER

Enhancing the vitamin-D concentration in white button mushrooms by UV light

Anna Szabó, Júlia Győrfi, András Geösel

Corvinus University of Budapest, Faculty of Horticultural Sciences, Villányi street 29-43, Budapest, Hungary (gomba@uni-corvinus.hu)

Abstract

Vitamin D_2 is essential for a human body and mushrooms are proved to be one of the best sources of it. In our experiment, pre-harvest *Agaricus bisporus* were treated with UV light in order to increase vitamin D_2 level in the mushrooms, by transforming the natural ergosterol content into vitamin D_2.

Two different wavelengths (254 and 312 nm) and 6 time periods were used. After three days of treatments the yield were measured and samples were taken for vitamin D_2 analysis.

The results showed considerable increase in vitamin D_2 concentration at every time period on both wavelengths. Besides the changes in vitamin D_2 level, UV radiation caused a slight light brown coloration on the mushroom caps as well.

Keywords: vitamin-D, UV light, ergosterol, *Agaricus bisporus*

Introduction

Vitamin D has been recognized for almost 100 years as being essential for providing the proper functioning of a healthy human body. It plays a vital role in bone mineralization by promoting calcium absorption, and it supports the immune system as well. An adequate vitamin D level is necessary to prevent different kind of illnesses, such as heart diseases, obesity, diabetes, arthritis, etc. (Holick, 2006). Recent studies aimed at a possible role of vitamin D in cancer prevention and treatment (Mehta and Mehta, 2002; Bouillon et al., 2006).

Vitamin D exists in two different forms. Ergocalciferol (vitamin D_2) is found mainly in foodstuff and in supplements, while Cholecalciferol (vitamin D_3) is produced in the human skin by sunlight. The two types of vitamin D are together responsible for providing the adequate vitamin D level in human body. Vitamin D deficiency disorders are common all over the world. Certain groups of population are at risk because they are not enough exposed to sunlight: people living on northern or southern latitudes, people with darker skin and elderly persons (Jasinghe et al., 2006). In order to prevent diseases deriving from vitamin D deficiency (rickets in children, osteomalacia in adults) it is essential to consume food-products with high level of vitamin D (Mau et al., 1998).

There are only a few natural sources of Vitamin D_2. It is found mostly in seafood and animal products (fish and fish liver, milk, butter and cheese), but no plant-products (fruit or vegetables) consist any of it. Therefore vegetarians, who are not consuming even milk products, are at risk of vitamin D deficiency (Jasinghe et al., 2005; Mattila et al., 2000).

Different mushroom species contain distinct levels of vitamin D_2 and ergosterol. Ergosterol is the most abundant phytosterol in mushrooms. When exposed to UV light it undergoes photolysis and form previtamin D_2 and other photoirradiation products. Previtamin D_2 then yields vitamin D_2 by spontaneous thermal rearrangement (Mattila et al., 1994; Mattila et al., 2002).

Higher amount of vitamin D_2 is present in wild grown mushrooms, than in cultivated species. The reason for this derives from the fact that most cultivated mushrooms, such as *Agaricus bisporus* is grown in the dark, where the absence of UV radiation results a lower level of vitamin D_2. Although they consist less vitamin D_2, cultivated mushrooms contain more ergosterol than wild grown mushroom species (Teichmann et al., 2007; Jasinghe et al., 2007).
Number of studies proved that ergosterol content of post-harvest mushrooms can be converted into vitamin D_2 by artificial UV irradiation on a certain wavelength and radiation energy. Many tests confirm that vitamin D_2 concentration in cultivated mushroom can be enhanced up to nine folds by applying different UV irradiation methods (Jasinghe et al., 2005; Mau et al., 1998).
At the time there is no sufficient reference or published data which would indicate how ergosterol and vitamin D_2 concentration would change in cultivated mushroom, if they would be treated with UV irradiation not post-harvest, but before picking, still during their growing period.
In our study the aim was to irradiate mushrooms during cultivation, in pre-harvest stage, while they are still biologically active. We studied white button mushroom, *Agaricus bisporus* (LANGE/IMBACH), a species which is cultivated in the highest amount all over the world. We applied UV light in different wavelengths and time periods to study the changes in the vitamin D_2 level.

Material and methods

Strain 'A15' of *Agaricus bisporus* was used in this experiment.
Polyethylene modeling bags were filled with 2 kilograms of Phase III. mushroom compost respectively. One day later 5 centimeters casing was used that was made from a mixture of peat and grit.
The experimental cultivation and treatments took place in the test chamber of Department of Vegetable and Mushroom Growing, Faculty of Horticulture, in the Corvinus University of Budapest.
During the entire growing period, in every stage of the development of the button mushroom, we provided ideal ambient conditions.
UV lamps were used for irradiation treatments. Two wavelengths (UVB: 312 nm and UVC: 254 nm) were tested. We applied six different time periods (T1-T6). 'T' represents one unit of time and the number next to it shows how many time units we used on one type of treatment. For comparison we prepared an untreated control as well.
Every treatment was carried out in three repeats, while each repeat consisted 4 bags respectively. The UV irradiations went on from pinning until the fruiting bodies were ready for picking.
During the whole growing period we kept track of pests and diseases which could occur in a mushroom culture. We examined the effect of UV radiation on the appearing and spreading of these organisms.
In every case of treatments total yields were measured.

Results and discussion

The results are shown in percentage on Figure 1. where the vitamin D_2 content of the untreated control is considered 100%.
The vitamin D_2 level of the biologically active treated mushrooms increased substantially on both wavelengths. According to published data from previous studies on post-harvest material showed the same results.

In case of both UVB and UVC treatments even the shortest time period (T1) was enough to cause twice as high vitamin D_2 level in the mushrooms as in control.
UVB irradiation resulted a 140-730% increase in the vitamin D_2 content of the different types of treated mushrooms. It was not a steady growth, in spite of the fact, that in every treatment the irradiation time was exactly one unit longer than the previous one.
The highest difference between two UVB treatments is shown in case of T3 and T4. The vitamin D_2 production reached its highest level in case of treatment T4, where UVB light caused a 730% growth.
UVC irradiation did not cause as intensive change in vitamin D_2 content as we experienced in case of UVB radiation. On this shorter wavelength the highest level occurred in treatment T4 as well. The 340% growth in vitamin D_2 content here is just half of what we measured after UVB treatment for same irradiation time.
Treatments T5 and T6 resulted a decrease in vitamin D_2 concentration on both wavelength. After a certain irradiation time (T4) neither UVB nor UVC light enhanced the vitamin D_2 content. Jasinghe and Perera (2006) experienced the same decline of vitamin D_2 level during their studies of UV treatments on post-harvest mushrooms. This phenomenon can be explained by the fact that vitamin D_2 undergoes photo-degradation when exposed to UV radiation.

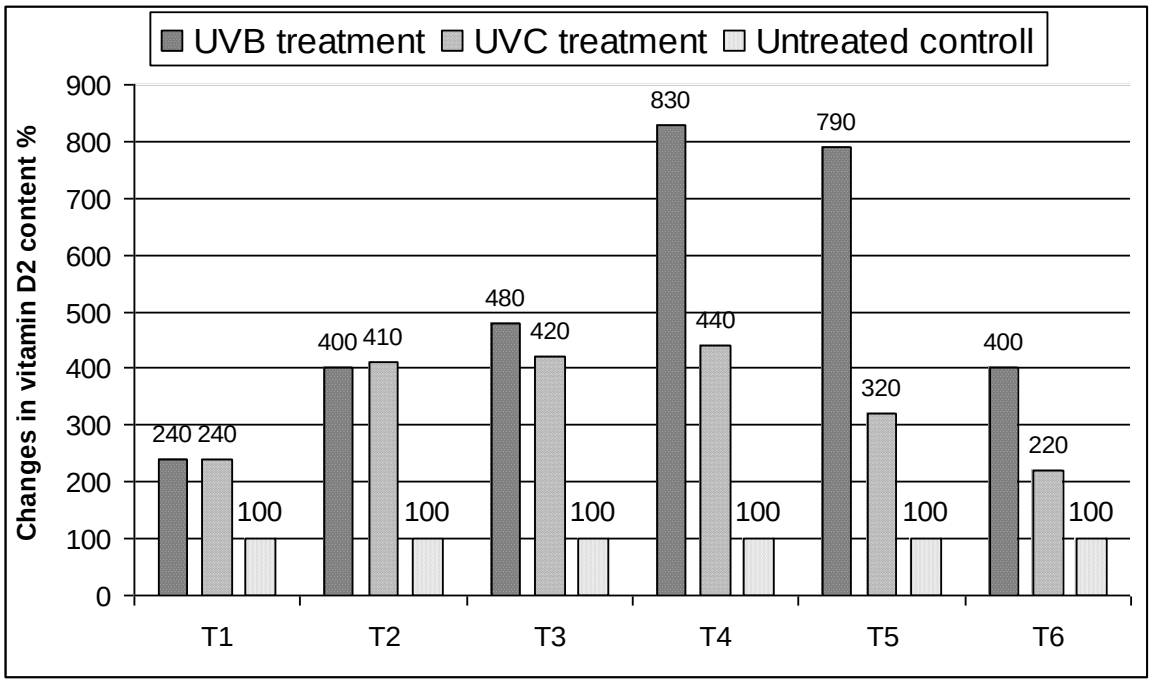

Figure 1. Changes in vitamin D_2 content in percentage after different UV treatments

A bacterial infection, the *Pseudomonas tolaasii* appeared on few fruiting bodies of UV treated bags. Later on the spots caused by the bacteria were observed on some bags of the untreated control as well. In spite of the continuous UV irradiation the spreading of the infection did not come to a halt or slow down. The bacteria grew on treated and non-treated mushrooms on the same intensity.
Pest detection was carried out by the use of yellow sticky sheets, placed all around the cultivating area. We observed the presence of *Phoridae* and *Sciaridae* flies for the first time before pinning. During the entire cultivation period only few mushrooms showed any sign of damage caused by the flies.

UV radiation on both UVB and UVC wavelength caused a slight, cream or light-brown coloration of the mushroom caps. Longer irradiation time caused more intense coloration. On those caps, which were in the shade of another cap and did not get any direct UV light, the color remained clear white.
Those parts of the mycelia on top of the casing soil, which suffered direct UV irradiation showed a brownish coloration as well. However the treatment apparently did not necrotize the mycelia, because in spite of the damage, healthy mushroom caps appeared on these parts as well later on.

Conclusions

According to the results of analysis, an obvious difference can be seen between the vitamin D_2 content of mushrooms treated with UVB or UVC radiation and the non-treated ones.
It can concluded that the vitamin D_2 concentration increased in case of all irradiation times. Comparing the results from the treatments of the two different wavelengths, we found UVB light over UVC to be more effective for enhancing the vitamin D_2 content of white button mushroom.
In case of both wavelengths, shorter irradiation time (T1-T4) gave better results, higher vitamin D_2 levels. Longer treatment caused a decrease in vitamin D_2 content at both wavelengths.
Pseudomonas tolaasii infected part of the mushroom culture. The spreading of the bacteria was not effected by the UV irradiation.
Two of the most abundant pests in mushroom cultivation, *Phoridae* and *Sciaridae* flies were present during the entire growing period.
Both UVB and UVC irradiation caused a slight coloration on the treated mushroom caps and on the mycelia, which grew on the surface of the casing.
It can be concluded that artificial UV irradiation can convert the natural ergosterol content of mushrooms into vitamin D_2 not only in case of post-harvest mushrooms, but during cultivation, in a pre-harvest stage as well.
Our study was an initial part of a longer series of experiments. A modified UV irradiation procedure is being prepared after these first promising results from the experiment with *Agaricus bisporus*. We are planning to study the vitamin D_2 enhancing effect of UV light on other commonly cultivated species, such as cream type button and oyster mushrooms.

Acknowledgement

The results presented in the paper are an output from research VITADFUN (TECH_08/2008) supported by NKTH.

References

Bouillon R., Eelen G. Verlinden L., Mathieu C., Carmeliet G., Verstuyf A. (2006). Vitamin D and cancer. Journal of Steroid Biochemistry & Molecular Biology. Vol (102): 156–162.

Jasinghe V. J., Perera C. O. (2005). Distribution of ergosterol in different tissues of mushrooms and its effect on the conversion of ergosterol to vitamin D_2 by UV irradiation. Food Chemistry. Vol (92): 541–546.

Jasinghe V. J., Perera C. O. (2006). Ultraviolet irradiation: The generator of vitamin D_2 in edible mushrooms. Food Chemistry. Vol (95): 638–643.

Jasinghe V. J., Perera C. O., Sablani S. S. (2007). Kinetics of the conversion of ergosterol in edible mushrooms. Journal of Food Engineering. Vol (79): 864–869.

Holick M.F. (2006). Vitamin D: Its role in cancer prevention and treatment. Progress in Biophysics and Molecular Biology. Vol (92): 49–59.

Mau J. L., Chen P. R., Yang J. H. (1998). Ultraviolet irradiation increased vitamin D_2 content in edible mushrooms. Journal of Agricultural and Food Chemistry. Vol (46): 5269–5272.

Mattila P. H., Piironen V. I., Uusi-Rauva E. J., Koivistoinen P. E. (1994). Vitamin D contents in edible mushrooms. Journal of Agricultural and Food Chemistry. Vol (42): 2449–2453.

Mattila P. H., Suonpää K., Piironen V. (2000). Functional properties of edible mushrooms. Nutrition. Vol (16): 694-696.

Mattila P. H., Lampi A.-M., Ronkainen R., Toivo J., Piironen V. (2002). Sterol and vitamin D_2 contents in some wild and cultivated mushrooms. Food Chemistry. Vol (76): 293–298.

Mehta R. G., Mehta R. R. (2002). Vitamin D and cancer. Journal of Nutritional Biochemistry. Vol (13): 252-264.

Teichmann A., Dutta, P. C., Staffas A., Jägerstad M. (2007): Sterol and vitamin D_2 concentrations in cultivated and wild grown mushrooms: Effects of UV irradiation. LWT 40 815–822.