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Vitamin D in Mushrooms

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Abstract

Mushrooms are one of the few plant foods which contain ergosterol, a precursor to vitamin D_2. The two major physiological forms of active vitamin D for humans are ergocalciferol (D_2) and cholecalciferol (D_3). The current recommended Adequate Intake (AI) for Vitamin D for most adults is 5 µg (200 IU). The amount of vitamin D_2 in mushrooms can be significantly increased by exposing mushrooms to ultraviolet (UV) light; UV-treated mushrooms are now entering some retail markets. To provide vitamin D data for the USDA National Nutrient Database for Standard Reference (SR) for mushrooms treated with this new processing method as well as baseline data for untreated mushrooms, a study to analyze white, portabella (treated and untreated), maitake, enoki, shiitake, oyster, crimini, morel, and chanterelle mushrooms was undertaken in cooperation with the Mushroom Council. Samples of commonly available mushrooms were collected in 12 cities according to the sampling plan for USDA's National Food and Nutrient Analysis Program. Two lots of other mushrooms, including UV-treated mushrooms, were obtained directly from producers. Vitamin D_2 was determined by HPLC separation with UV detection. Treated portabella mushrooms contained 11.2 µg (446 IU)/100g vitamin D_2; untreated mushrooms 0.3 µg (11 IU)/100g. Average results from two producers of UV-treated portabella mushrooms ranged from 3.5 µg (140 IU)/100g to 18.8 µg (752 IU)/100g D_2. For maitake mushrooms—samples ranged from 0.1 µg (4 IU)/100g, to 56 µg (2242 IU)/100g D_2, The higher value results from the use by one producer of a proprietary growing method that exposes the mushrooms to a UV light source. The vitamin D_2 content of non-UV-treated white, morel, and chanterelle mushrooms was 0.1 µg (4 IU), 5.1 µg (204 IU), and 5.3 µg (212 IU)/100g, respectively. These data are included in Release 22 of SR and add to the body of data available to assess the vitamin D content of the U.S. diet.

Introduction

Mushrooms are one of the few food sources where the precursor to vitamin D occurs naturally. Ergosterol, found in mushrooms (21-107 mg/100 g) is converted to ergocalciferol or vitamin D_2 by exposure to UV light. Small amount of vitamin D_2 are synthesized in the mushrooms by exposure to naturally occurring UV light during growing or processing. This conversion can be accelerated by exposing the mushrooms to UV light for 15-20 seconds during processing. The dose and length of treatment can affect the amount of D_2 synthesized during exposure (Roberts *et al*, 2008).

Chanterelle

Maitake

Methods

This study used the infrastructure established by USDA's Nutrient Data Laboratory (NDL) for the National Food and Nutrient Analysis Program (NFNAP). NFNAP incorporates procedures to: prioritize foods and nutrients for analysis; develop statistically valid sampling plans; analyze food samples at qualified analytical laboratories; and maintain a rigorous quality control program.

Sampling

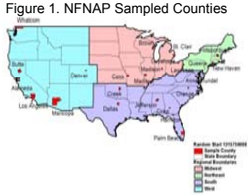
- Samples of crimini, enoki, oyster, portabella, shiitake, and white mushrooms were collected from 12 retail outlets around the country.
- States where samples were procured were selected proportional to the state population (US Census, 2000).
- Sample counties within states dispersed over the 48 conterminous states, were selected proportional to the county population.
- Sample Consolidated Metropolitan Statistical Areas (CMSAs) selected proportional to CMSA population.
- Retail outlets with over $2M sales were selected in 12 primary locations (Figure 1).
- Untreated chanterelle, maitake, and morel mushrooms and portabella mushrooms treated with ultraviolet light were not available in retail outlets identified in the sampling plan; samples from two lots were obtained from each of two growers; untreated crimini, oyster, and shiitake mushrooms were not found in all of the retail outlets, so additional samples were obtained from two growers.

Reference: (Pehrsson *et al,* 2003).

Sample preparation:

- Samples were shipped overnight to the Food Analysis Laboratory Control Center (FALCC) at Virginia Polytechnic Institute and State University in Blacksburg, Virginia, where composites were prepared.
- Samples were homogenized, packed under nitrogen and shipped frozen to a qualified commercial analytical lab under USDA contract, for analysis.
- Composites of both raw and grilled Portabella mushrooms treated with UV light were prepared.
- All samples were analyzed for vitamin D.
- Chanterelle and morel mushrooms, not previously studied, were analyzed for a full profile of nutrients.

Figure 1. NFNAP Sampled Counties



Methods of Analysis for Vitamin D (Horst, 2009)

- The sample was spiked with an internal standard (tritiated vitamin D), saponified in methanolic KOH for 20 minutes at 60°C, and extracted with hexane.
- Hexane extract washed with dilute methanol and dried.
- Sample re-suspended in hexane/methylene chloride, applied to silica SPE cartridge, eluted with methylene chloride/2-propanol (99.8/0.2) and dried.
- Sample re-suspended in hexane/methylene chloride/alcohol (85/15/0.2), applied to HPLC ZORBAX SIL column (5µ), vitamin D fraction collected, and dried.
- Sample re-suspended in hexane/ 2-propanol (99.5/0.5), applied to a HPLC ZORBAX SIL column, vitamin D fraction collected, and dried.
- Sample is applied to a Vydac ODS column in acetonitrile/methylene chloride (75/25).
- Vitamin D_2 quantified by comparison of the UV peak areas with standards and corrected for recovery. Vitamin D_2 is baseline resolved.
- NDL's quality control panel reviewed results from the labs for both the analytical samples and the quality control materials included in the sample stream. Once approved, the data were migrated into NDL's Nutrient Databank System for processing.

White

Oyster

Enoki

Table 1. Vitamin D content of portabella mushrooms exposed to UV light

Mushroom / Sample Location	Vitamin D_2 (µg/100 g)	Vitamin D_2 (IU/100 g)
Portabella, exposed to UV light, grilled		
Producer 1, Lot 1	3.4	138
Producer 1, Lot 2	3.1	124
Producer 2, Lot 1	20.3	812
Producer 2, Lot 2	25.6	1022
Portabella, exposed to UV light, raw		
Producer 1, Lot 1	3.4	134
Producer 1, Lot 2	3.6	146
Producer 2, Lot 1	16.8	671
Producer 2, Lot 2	20.9	835

Table 2. Vitamin D content of Mushrooms

Mushroom/ Sample Location	Vitamin D_2 (µg/100 g)	Vitamin D_2 (IU/100 g)
Chanterelle, raw		
Producer 3, Lot 1	2.2	87
Producer 3, Lot 2	8.4	336
Crimini , raw		
CA_1, CA_2, NC*	0.03	1
CO, IN, VA	0.06	2
Producer 1	0.08	3
Producer 2	0.05	2
Enoki, raw		
MI	0.4	16
Producer 1, Lot 1	0.04	2
Producer 1, Lot 2	0.04	2
Producer 2, Lot 1	0.07	3
Maitake , raw		
Producer 1, Lot 1	0.08	3
Producer 1, Lot 2	0.12	5
Producer 4, Lot 1	63.2	2529
Producer 4, Lot 2	48.9	1956
Morel, raw		
Producer 5, Lot 1	4.5	181
Producer 5, Lot 2	5.4	217
Producer 6, Lot 1	4.4	176
Producer 6, Lot 2	6.3	250
Oyster , raw		
CO, VA	0.1	5
FL, MO, NY	2.6	103
MI, VA	0.07	3
Producer 1	0.08	3
Portabella , raw		
CA_1, MI	0.1	4
CA_2, NC, OK	0.8	31
CO, CT, IN	0.05	2
FL, MO, NY	0.1	4
Shiitake, raw		
CO, IN, VA	1.2	46
FL, MO, NY	0.4	16
NC, MI, VA	0.15	6
Producer 1	0.03	1
White button, raw		
AL, CA_1, MI	0.2	9
CA_2, NC, OK	0.07	3
CO, CT, IN	0.1	4
FL, MO, NY	0.06	2

* State abbreviations indicates NFNAP pickup locations for composites (Fig. 1). Blacksburg, VA was used to fill in some missing locations.

Shiitake

Morel

Results

- All mushrooms contain varying levels of ergosterol; exposure to incidental UV light during growth and processing causes the conversion of some portion of the ergosterol to ergocalciferol or vitamin D_2.
- Exposure to UV light for 15-20 seconds causes much higher levels of vitamin D_2 in portabella mushrooms (11.2 µg; 446 IU/100 g) than those not exposed (0.2 µg; 10 IU/100 g) (Table 1).
- Samples of portabella mushrooms from Producer 2 (3.5 µg; 140 IU/100 g) were noticeably lower than those from Producer 1 (18.8 µg; 753 IU/100 g). Differences can be caused by the length of exposure or the type of light (Roberts *et al,* 2008).
- Vitamin D_2 levels in samples of maitake mushrooms from Producer 2 (56.1 µg; 2242 IU/100 g) were substantially higher than those from Producer 1 (0.1 µg; 4 IU/100 g). Producer 4 uses a proprietary growing method employing special lights and conditions (Table 2)
- Samples of crimini, enoki, oyster, shiitake and white mushrooms had low levels of vitamin D_2, though occasionally one composite had somewhat higher levels, possibly due to inadvertent exposure to UV light.
- Chanterelles and morels, which are grown and harvested in the wild, had higher levels of vitamin D_2 (5.2 µg; 206 IU/100 g and 5.3 µg; 212 IU) respectively, than most untreated mushrooms.

Conclusion

- Exposing mushrooms to UV light whether by design or unintentionally causes measurable increases in the vitamin D_2 content.
- As a result, mushrooms can provide appreciable amounts of vitamin D_2 to the diet.
- Amounts will vary depending on the type of light and duration of exposure.
- Data from this study has been used to update Release 22 of the USDA National Nutrient Database for Standard Reference and is available on NDL's Web site: http://www.ars.usda.gov/nutrientdata

References

Horst, R. 2009. Personal Communications. Heartland Assays, Inc. Ames, IA.

Pehrsson PR, Haytowitz DB, Holden JM. 2003. The USDA's National Food and Nutrient Analysis Program: Update 2002. J Food Comp Anal 16:331-341.

Roberts, J.S., Teichert, A., and McHugh, T.H. 2008. Vitamin D_2 formation from post-harvest UV-B treatment of mushrooms (*Agaricus bisporus*) and retention during storage. J. Agric. Food Chem. 56:4541-4544.

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