

Anticancer Medicinal Mushrooms Can Provide Significant Vitamin D₂ (Ergocalciferol)

Paul Stamets¹ & Gregory A. Plotnikoff²

¹Fungi Perfecti Research Laboratories, P.O. Box 7634, Olympia, WA 98507, USA; ²Keio University Medical School, Tokyo, Japan

Studies since 1966 have documented antitumor activities by the β -glucan and triterpene components of numerous Basidiomycetes mushrooms. However, these active ingredients may not explain all of the observed pharmacologic effects. To date, the potential pharmacologic role of vitamin D₂ (ergosterol) in medicinal mushrooms has not been examined. Vitamin D₂, when transformed by the liver into the potent vitamin D₃, is a seco-steroid that, like thyroid hormone, binds to a specific receptor within the superfamily of nuclear receptors for steroid hormones. The vitamin D nuclear receptor is found not only on intestine, bone, liver, and kidney tissues but also on lymphocytes, monocytes, and macrophages as well as hematopoietic, skin, muscle, heart, pancreas, adrenal, brain, reproductive, lung, pituitary, thyroid, and cartilage tissues. Vitamin D₃ regulates gene expression for multiple physiological functions, including those for the central nervous system and immune system. This study tested the hypothesis that in mushroom species with documented anticancer activity, mushroom ergosterol exposure to UV-B energy from sun drying significantly increases vitamin D₂ content.

Three specific medicinal mushroom species with strain-specific documented chains of custody were grown under standard conditions indoors. Fruiting bodies were harvested and dried indoors by commercial dryers or outside under the summer sun for 6–8 hours. The products were then subjected to standardized HPLC analysis in conformity with the Official Methods of Analysis of AOAC International (2000)

17th Ed., AOAC International, Gaithersburg, MD, USA, Official Method 982.29 (Modified).

Ganoderma lucidum (W.Curt.:Fr.) Lloyd (Reishi), *Lentinus edodes* (Berk.) Singer (Shiitake), and *Gri-fola frondosa* (Dicks.:Fr.) S.F.Gray (Maitake) dried indoors demonstrated D₂ content of 6, 134, and 460 IU per 100 grams, respectively. When dried by sunlight outdoors, the D₂ content increased to 2760, 21,400, and 31,900 IU per 100 grams, respectively.

These data have three important implications. First, the potential vitamin D₂ content of anti-tumor medicinal mushrooms must be considered as a confounding factor in mushroom research. Vitamin D₃ stabilizes chromosomal structure and prevents DNA double-strand breaks induced by either endogenous or exogenous factors. Vitamin D₃ induces cell cycle arrest, promotes differentiation, and induces apoptosis. Vitamin D₃ acts as an antiproliferation agent against many cancers, including breast, prostate, colon, and bladder. In addition, vitamin D₃ inhibits both tumor invasion and tumor angiogenesis.

Second, sun-exposed mushrooms may be an excellent dietary response for addressing the significant world-wide incidence of vitamin D deficiency. Inadequate vitamin D status not only places people at risk for osteoporosis, but appears to be a significant risk factor for development of cancer. For many cancers, a significant inverse correlation exists between mortality rates and UV-B radiation exposure. For example, the risk of fatal breast cancer in the major

urban areas of the United States is inversely proportional to the intensity of local sunlight ($r=-0.80$, $p=0.0001$), and such inverse correlations also exist for prostate, colon, bladder, ovary, non-Hodgkin's lymphoma, esophageal, kidney, lung, pancreatic, rectal, stomach, and corpus uteri cancers.

Third, this study challenges the USDA claim that the average edible mushroom contains 76 IU (1.9 μg) of vitamin D per 100 grams and that shiitake mushrooms contain 1550 IU per 100 grams. For retrospective studies of diet and nutrition, use of these standard references may undermine the scientific legitimacy of both the data and its analysis.

Vitamin D₂ is not as potent as vitamin D₃. For many years, vitamin D₂ was considered much safer than vitamin D₃ because of the additional metabolism required for activation. Thus, although the current RDA for vitamin D is 400 IU per day, prescription doses of ergocalciferol at 50,000 IU twice a week only slowly increase vitamin D levels in deficient adults. However, vitamin D in excessive doses can be toxic and even fatal. This is particularly true in persons with cancers and other diseases that predispose them to hypercalcemia. Further understanding of vitamin D₂'s pharmacokinetics and metabolite biologic activities is necessary.