Fungi as Food

Taking advantage of Cosmic Radiation

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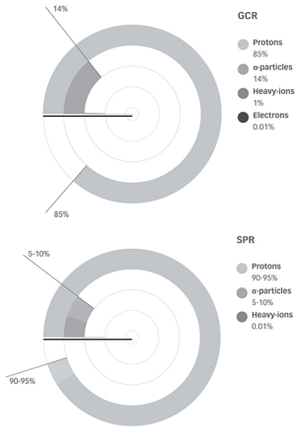
The currently work has the aim to evaluate the possibility to produce fungi as food in the space by seizing on cosmic radiation as an energy source. To manage this project it has been necessary to base conclusions on disseminate information about mycoprotein production, space conditions and some biological strategies and mechanisms from fungi towards radiations source.

Space Radiation

Space radiation is primarily ionizing radiation which exists in the form of high-energy charged particles. There are three naturally occurring sources of space radiation: trapped radiation, galactic cosmic radiation (GCR), and solar particle events (SPE).

GCR is composed of the so-called HZE particles (High charge Z and energy E) and its composition also depends on its passage through the galaxy and its interaction with solar wind, obtaining its peak level during minimum solar activity and its lowest during maximal solar activity. SPR, radiation produced during SPE, have similar components in different proportions.



However cosmic ionizing radiation in interplanetary space represents a dose of 0.25 Gy/a or less, while in Earth orbit that number can increase till 3000 Gy/a thanks to the trapped particles by the Earth's radiation belts.

At the distance of the Earth from the sun (1 AU), solar irradiance amounts to 1360 W/m2, the solar constant. A 7% of this irradiance corresponds to the ultraviolet range, that includes UVC (200-280 nm) and UVV (100-200 nm) which are lethal to most microorganisms, including fungi, yeast, bacteria, viruses, protozoa and algae by causing a physical shifting of electrons and breaking of bonds in DNA.

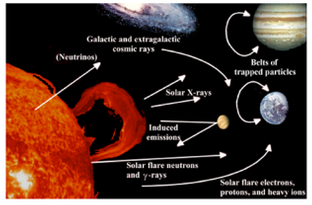


Figure 1.

Melanin as a survival strategy

Earth is a huge system with a lot of different climates and environments, some of them really extreme. This way, live organisms are constantly exposed to mutagen agents that are absorbed or created inside the cells. However, that fact has not avoided the apparition of life and thus, the expansion of the biosphere.

One of the survival strategies showed by most organisms is the development of pigment, such as melanin, to act as radiation shields. Melanized microbial species has been found in hot and col d deserts, highly radioactive environments such as the inside of the nuclear reactor at Chernobyl, reactors cooling pool water, stratosphere and in space stations.

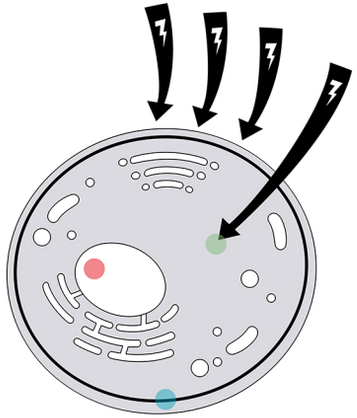
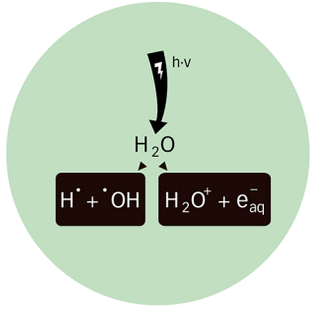


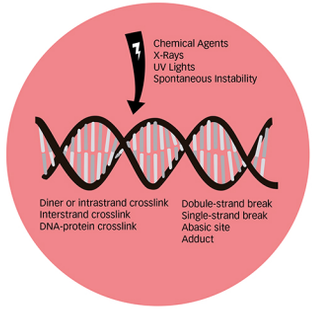
Figure 2.

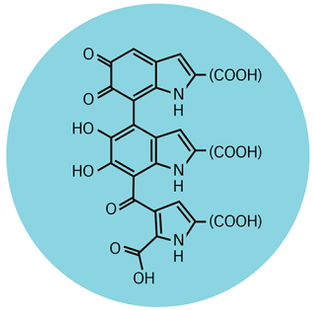
Melanin properties and functions towards radiation include:

-Shielding the cell by increasing electron transference.
-Quenching cytotoxic new free radicals .
-Enhancing the growth.
-Up-regulating expression of ribosomal biogenesis and transporter genes.

Furthermore, ionizing radiation by itself can enhance cell growth because it can provoke changes in the cell cycle and also elevates expression of genes involved in membrane fluidity, water transport, desaturases and genes involved in metabolism of glycerophospholipids.







Seizing on the advantages

With the previous exposed properties of melanin, knowledge acquired about the fungi production as meat analogue and taking to account how hostiles or not can be the space conditions, it makes clear that the possibility to take profit of cosmic radiation for the production of melanized filamentous fungi as space meat analogue is not just an illusion, but a reality. To develop this future technology it would be necessary to overcome some difficulties step by step:

1. Strain selection.

Selection of a melanin rich filamentous fungi and study of the following parameters:

-Safety for human consumption.
-Protein content
-Nutritional quality.
-Mycotoxins production.
-Substrate utilization.
-Substrate yield.
-Growth rate.
-Radiation range for growth.

2. Production.

Liquid culturing to produce high mass in limited space. Some fungi, like F. venenatum in different forms, influencing rheological properties of the fermentation broth such as viscosity, increasing oxygen transfer rate problems, and production of an undesirable product.

Rheological properties can be influenced by dry weight,hyphae length, degree of branching and mycelial flexibility of the fungal culture.

3. Resources limitations.

Resources on space are limitated. To deal with this problem is necessary introduce the melanized fungi fermenter in a recycle system that would provide the system with a constant and unlimited source of nutrients.

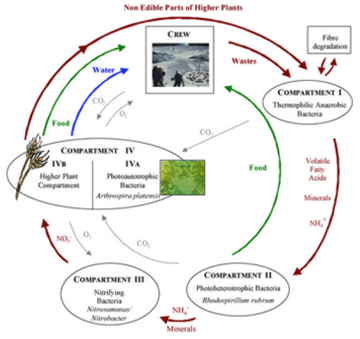


Figure 6.

4. General limitations.

Graviperception and response of fungi in space. Control and regulation of the space radiation exposure to optimize the process.

New fermenter design appropriate to control radiation entrance, flowing of nutrients, broth homogeneity, cell growth and efficiency exposure from all the cells to the radiation.

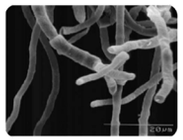


Figure 3.

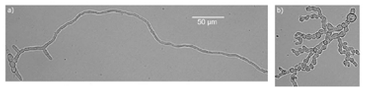


Figure 4.

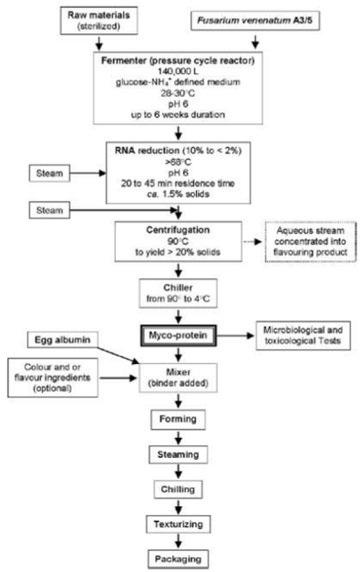


Figure 5.

Figure 1.
Astrobiology (Horneck and Baumstark-Khan, 2002, figure 17.1, page 262).

Figure 2.
Melanin as a survival strategy.

Figure 3.
Miri T., Barigou M., Fryer P.J. and Cox P.W. 2005. Flow induced fibre alignment in Mycoprotein paste. Food Research International 38, 1151–1160.

Figure 4.
Wiebe M.G. 2002. Myco-protein from Fusarium venenatum: a well-established product for human consumption. Applied Microbiology and Biotechnology 58, 421–427.

Figure 5.
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Figure 6.
ESA website (http://www.esa.int/Our_Activities/Technology/MELiSSA_s_future_in_space consulted at day 28 of May 2013).

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Acknoledgments

Thanks to Bogdan Crintea, president SA UAB (Societat Astronòmica de la UAB), who provides me with useful high qualities space pictures.

Thanks to Iván García, graphic designer, for the design of figure "b" and his patience during this project.