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How Does Heat Affect Fungi?

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The effects of heat on fungi depend on many factors, including the genus, species and strain of the fungus, the amount of available water, kinds of nutrients, and many other environmental factors. Of course, temperature is also a crucial factor. Most of the research on temperature relationships for the fungi has been done in the food industry where heat is commonly used to prevent fungal growth. Much of this research involves wet heat, which is more effective than dry heat.

Fungi can be divided into groups according to temperature requirements for optimal growth. Note that these requirements are dependent on water availability and nutrients, and are measured under carefully controlled conditions. These same terms are used for bacteria, but the temperature ranges differ.

The groups are as follows:

1. Psychrophiles: with optima less than 10°C
2. Mesophiles: with optima in the room temperature range (18-22°C)
3. Thermophiles: with optima at or above 37°C

There are also categories defining the ability of the fungi to withstand different temperature regimes. In this case, we have psychrotolerant and thermotolerant fungi, indicating that growth can occur at either low or high temperatures, but is not optimal. Thus, some mesophilic fungi may be able to grow or at least survive at either low or high temperatures, depending on the genetics of the strain and other environmental conditions. Another form of temperature tolerance lies in the spores, which can often withstand temperature extremes, and germinate when conditions return to normal. Finally, some fungi that are normally mesophilic have spores that require heat to stimulate germination. Temperature tolerance is strongly tied to the amount of water so that wet heat is much for effective at damaging spores than dry.

The effects of heat on fungi are related to the chemical reactions within the fungal cells. For optimum growth, temperatures must be in a range that allows the most efficient progression of the chemical reactions necessary for growth. As temperatures progress above the optimum temperature, the chemical reactions occur less efficiently, and growth slows. Eventually, the temperature can reach a point where growth stops, and cell components begin to be actually damaged by the heat. Enzymes are proteins that change structurally when heated to their limit of tolerance. Likewise, membranes, which contain lipids, change in structure, and their function of protecting and regulating the internal environment of the cell becomes compromised.

Most fungi are mesophilic, and have growth optima within the temperature range that people find comfortable. This is why so many fungi appear when moisture enters our homes, schools, and work environments. Because of air conditioning and heating, mesophilic fungi flourish in occupied environments in all climates. However, the fungal species that are abundant outdoors may vary considerably from one climate to another. In hot dry climates, fewer species of fungi are present, both because of the lack of water and the high temperatures. Thus, thermophilic and xerophilic (dry tolerant) fungi are likely to be more abundant than in cooler wetter environments. In tropical and subtropical places where both heat and moisture are present, thermophilic and thermotolerant fungi with mesophilic water requirements tend to be abundant. The incidence of fungal infections (including sinus infections) tends to be higher in these areas in part because the fungi that can withstand human body temperatures are more abundant than in temperate climates. Finally, continental climates that tend to swing from hot humid to cold dry conditions have a few overwhelmingly dominant fungi (e.g., *Cladosporium* species) with other mostly mesophilic fungi filling in the gaps. Of course, this is an over-simplification, especially since, as mentioned many times, an array of factors are necessary for optimal growth of all kinds of fungi. Also, fungi live in microenvironments that may have very different temperature/water conditions than are represented by climate.

Table 1 lists some of the fungal temperature relationships that have been reported in the literature.

Table 1:

Activity	**Temperature and Duration**	**Notes**
Hot dry air sterilization	170 °C (340 °F), 1 hour 160 °C (320 °F), 2 hours 150 °C (300 °F), 2.5 hours 140 °C (285 °F), 3 hours	Kills virtually all spores
Wood heat treatment for rot resistance	200 °C (392 °F), 24 hours	Changes structure and color of the wood
Whole house treatment for termites and/or fungi	71°C (160 °F), 4-6 hours	
Penicillium spore death in water	54.4 °C (130 °F), 30 minutes	
Ascospores activation in grape juice	70 °C (158 °F), 30 minutes	This is higher than the temperature which kills *Penicillium* in water
Germination of chlamydospores in *Cladosporium*-related species stimulated by moist heat	75 °C (167 °F), 30 minutes	This is higher than the temperature which kills *Penicillium* in water

The question sometimes arises about heating an entire structure as part of remediation. In this process, an entire house (or part of a building) may be heated to a temperature that should kill most of the spores remaining following structural remediation and any invisible growth. Clearly, using heat will help the building dry faster because it reduces the relative humidity and increases the vapor pressure of the water in the building. Heat may also damage some plastics, some types of electrical equipment, and other items; so, naturally, heat sensitive items will need to be removed prior to heating the structure. There may also be spores that are particularly resistant to heat, microclimates that do not attain high enough temperatures, or spores that are stimulated to germinate. Also, spores that are left may still remain allergenic. As we do not have expertise in this method of remediation, and the science in this area is still in its infancy, we do not feel qualified to provide “the answer” for if or when heat remediation is good or bad. Also, like many aspects of fungal investigations it depends upon many situation specific criteria. Finally, it is important to remember that spores are continually entering the structure and the only permanent fix for fungal contamination is the maintenance of dry conditions throughout any building.