Effect of environment on fungal growth

Environmental factors influencing fungal growth

Fungal Growth

- Fungi have in the course of evolution diversified to exploit a wide variety of habitats
- Different species hence require different conditions for optimal growth.
- Microbial metabolism is significantly influenced by the physical and chemical environment

According to the site where fungi infest, can be divided into three groups

- **Field fungi:** includes species of plant pathogenic fungi, usually with high requirements of water, such as Fusarium, Alternaria and Cladosporium
- **Storage fungi:** with lower requirements of humidity, are principally the genus Aspergillus and Penicillium
- **Advanced deterioration fungi:** normally do not infest intact food, but easily attack damaged one and require high moisture content. Some examples are some other aspergilli species, Chaetomium, Scopulariopsis, Rhizopus, Mucor and Absidia

Environmental factors

Temperature:

- It is an important environmental factor affecting growth and mycotoxin production by moulds
- The temperature range usually reported for fungal growth is broad (10-35°C), with a few species capable of growth below or above this range
- Fungi can be divided according to their tolerance to temperature in psychrotolerant, psychrophilic, mesophilic, thermotolerant and thermophilic fungi
- Similarly, the growth temperatures ranges from Minimum growth temperature Optimum growth temperature Maximum growth temperature as per the tolerance limits

Water availability:

- Living organisms consist largely of water and to grow it has to take up water from the environment
- In microbiology, three measures of the water availability have been used: water potential (ψ), water activity (aw), and relative humidity (R.H.)
- Water potential is the sum of numerous components, of which the most important are osmotic, matric and turgor potential, and is measured in units of pressure
- Water activity is a fundamental property of aqueous solutions, and by definition is the ratio of the vapour pressure of the water in the substrate (p) to that of pure water at the same temperature (po): p0 p aw = Water activity ranges from zero (water absent) to 1.0 (pure water)

- **For an ideal solution aw is independent of temperature, and in actual practice, the aw of a given solution varies only slightly with temperature within the range of temperature permitting microbial growth**
- **The water content of the atmosphere is expressed in terms of relative humidity, the ratio of the water vapour pressure of the gas phase being considered, to that of a saturated atmosphere at the same temperature**
- **It is expressed as a percentage**

Hydrogen ion concentration (pH):

- Since fungal metabolism alters pH during their evolution, Hydrogen ion concentration in a medium could affect growth either indirectly by its effect on the availability of nutrients or directly by action on the cell surfaces
- The acid/alkaline requirement for growth of all yeasts and moulds is quite broad, ranging from pH 3 to above pH 8, with optimum around pH 5, if nutrient requirements are satisfied
- In general, Aspergillus species are more tolerant to alkaline pH while Penicillium species appear to be more tolerant to acidic pH
- It is seen that in situations near neutral pH, fungi must compete with bacteria for niches, and at higher aw values most fungi are not competitive in mixed culture
- However, where aw is below 0.90, fungi become dominant irrespective of pH
- In specialised niches where bacteria do not appear to have a role as pathogens, specific Fusarium and Penicillium species are dominant even at neutral pH and high aw

Light:

- There are some reports that illumination will increase or more commonly reduce the rate at which fungi spread across an agar surface
- Such effects are sometimes due to the photochemical destruction of components of the medium but in other instances a direct effect on metabolism seems likely
- The biosynthesis of pigments, mainly carotenoids, as consequence of light action has been demonstrated in some fungi

Availability of oxygen:

- Organisms can obtain energy by oxidative (respiratory) metabolism or by fermentation
- The effects for oxygen requirements for respiration, fermentation or both in a fungus divided them in **obligate aerobes, facultative anaerobes and obligate anaerobes**
- Food spoilage moulds, like almost all other filamentous fungi and yeasts, have an absolute requirement for oxygen
- However, many species appear to be efficient oxygen scavengers, so that the total amount of oxygen available, rather than the oxygen tension, determines growth
- The most oxygen demanding moulds will colonise the surface of the food, while the less exigents could be found inside the food

Biological factors

1. Competing mycoflora:

- The simultaneous presence of different microorganisms, as bacteria or other fungi, could disturb fungal growth and the production of mycotoxins
- Therefore, several microorganisms have been reported as biological pest control agents
- It is seen that Trichoderma harzianum produces a lytic enzyme, chitinase, which has an antifungal activity against a wide range of fungal strains
- A clear inhibition of the growth of A. carbonarius and other fungi by Bacillus thuringiensis has been reported

2. Strain variability:

- The growth production of any particular mycotoxin depends on the strain and not only on the species
- However, OTA biosynthesis of ochratoxigenic Aspergillus spp. is determined more by environmental conditions than by the inherent ability of the organism to produce OTA

3. Inoculum:

- The source of inoculum for most of the fungi affecting vegetal products is likely the soil
- Significantly higher populations of fungal propagules are found in summer months of the year, and mycotoxigenic fungi were recovered more frequently from crop residues in continuous culture
- It is known that the survival structure of most fungi in the soil may be in debris or in soil, as mycelium or as conidia, and depending on the fungi, as sclerotia

4. Insects and other vectors:

- Insects and other arthropods could function as vectors for dissemination and multiplication of fungal spores
- Many different insects have the capability of promoting infection of various crops with mycotoxigenic fungi
- A successful vector must naturally encounter the fungal agent and carry it to the crop/site in a viable condition
- This transport may be directly to the plant or in close enough proximity for the fungus to arrive at the plant site by other means, such as other insects, water or air
- They may transport primary inoculum, move inoculum throughout the commodity, disseminate spores within the food and/or facilitate colonization and infection by injuring the foodstuff
- Water and wind are other vectors that favour the dissemination of fungal spores among agricultural food commodities
- Airborne conidia of a wide range of fungi are present each year in the fields, although differing greatly across years
- Airborne conidia levels were higher in irrigated fields than in non-irrigated ones

Chemical factors

1. Nutritional factors:

- All forms of life, including moulds, require exogenous materials to build into biomass
- The availability and type of nutritional factors such as carbon source and nitrogen source can also affect both mycotoxin production and morphological differentiation
- As heterotrophs, the moulds require organic compounds for both the synthesis of biomass (anabolic metabolism) and to produce the energy to drive these reactions (catabolic metabolism)- primary metabolism
- Fungi can use a number of different carbon sources to fill their carbon needs for the synthesis of carbohydrates, lipids, nucleic acids and proteins
- Oxidation of sugars, alcohols, proteins, lipids, and polysaccharides provides them with a source of energy

- **Fungi require a source of nitrogen for synthesis of amino acids for proteins, purines and pyrimidines for nucleic acids, glucosamine for chitin, and various vitamins**
- **Depending on the fungus, nitrogen may be obtained in the form of nitrate, nitrite, ammonium or organic nitrogen**
- **Other major nutrients for fungi are sulphur, phosphorus, magnesium and potassium, which can be supplied to most fungi as salts**
- **Trace elements like iron, copper, manganese, zinc and molybdenum are required by nearly all fungi as cofactors for enzymes**

2. Antifungal agents:

- A wide range of antifungal agents are used in combating biodeterioration and in preventing or treating fungal diseases of plants
- They are commonly referred to as fungicides
- Others are used for treating disease in animals and man, and are simply referred to as antifungal agents
- Antimicrobial agents produced by means of a microbial fermentation, called antibiotics, by the plant on which the mould is growing, or added as biocides during crop management, are other factors interacting with the growth and metabolism of a mould