**Fungal Biotechnology: Role and Aspects**

**6.1 Introduction and Definitions**

Fungi belong to the lower class of eukaryotes according to contemporary biologist and sometimes are also regarded as the fifth kingdom on the basis of the mode of nutrition. Fungi project different types of enzymes into their surrounding and after the action of these enzymes engulf the pre-treated food. With assorted morphology, ecology and physiology, many eminent fungi still have an adverse effect on the well-being of humans as they are involved in different plant diseases (like blights, rusts, smuts and wilts) and biodeterioration (like mildews and rots) as well as pathogenic to animal (by producing mycoses and toxins). Range of fungi starts from the micro-sized moulds and yeasts to macro-sized truffles as well as mushroom. Large number of macro-sized species of fungi are believed to be delicate; thus they are grown and accumulated for human uses such as food or its supplements, whereas there are micro-sized fungi, comprising of genera like *Aspergillus*, *Penicillium* and *Saccharomyces*, which have positive influence in context to human activities as their regulated metabolisms are utilized for synthesizing enzymes as well as metabolites. These abilities have made fungi one of the foundation stones in modern biotechnology.

There are numerous ways by which the term biotechnology can be explained. The Spinks Commission, UK, was the first group to give a formal explanation: “Biotechnology is the application of biological organisms, systems, or processes to manufacturing and service industries”. On the other hand, the European Federation has quoted the similar definition but with a broad range of aspect: “the integrated use of biochemistry, microbiology and engineering sciences in order to achieve technological (industrial) application of the capabilities of micro-organisms, cultured tissue cells, and parts thereof”. Further, the National Institute of Health and Food and Drug Administration, USA, defined: “Biotechnology is the application of biological systems and organisms to technical and industrial processes. The technologies included in this area include genetic selection, in vitro modification of genetic material, e.g. recombinant DNA, gene splicing, cell fusion, hybridoma technology etc.” and other novel techniques for modifying genetic material of living organisms (Bennett et al. 1997).

**Premodern Fungal Technology**

The term “modernism” separates the twentieth century by violating the tradition set in the nineteenth century. Like in art, abstraction superseded by representation; in architecture, functionalization gets superseded by ornamentation; in literature, new style forms got superseded by conventional narrative. Daily the new applications are discovered for basic science to revolutionize the living standards of the people. Adjectives such as “premodern”, “modern” and “postmodern” are employed as descriptive terms for assessing the massive number of procedures as well as products which involves fungal biotechnology.

**Modern Fungal Technology**

Alcohols, enzymes, organic acids and different pharmaceutical products synthesized by fungi are the key for the advancement of the modern technology. Some of the chief industrial products produced by fermentation process along with synthesizing species are illustrated in Table 6.2. Another product synthesized by these filamentous fungi which is the centre of attraction in modern biotechnology is the citric acid. Formerly, the citric acid was isolated from the citrus fruit, but at end of the nineteenth century, it was enlightened that these filamentous fungi were responsible for citric acid production. Pfizer, Brooklyn, New York, USA, developed the conventional process which gained worldwide

recognition for its application in beverage and food industry. Further, these processes are utilized to produce antifoaming agents, cosmetics, detergents, tablets, textile treatment and preservatives for storing blood. Different approaches of modern fermentation technology were improved focussing on improving the yield of citric acid by amending the growing conduction and by exploiting the submerged process for enhancing the process of product recovery (Crueger and Crueger 1982).

The turning point took place in the industrial microbiology when penicillin was discovered, and further derivatives of penicillin were named as “wonder drug” (Wainwright 1990). Exploration of secondary metabolites with additional antimicrobial activity was elicited after the penicillin discovery. Beside that invigorating research on physiology of fungi, fermentation technology and development of

industrial strain was taking place. During 1940–1950, varied number of antibiotics was discovered, and this time is also regarded as the “golden era of antibiotics”. Great success was achieved by Selman Waksman and his colleagues, who were working in Rutgers University and Merck Corporation, New Jersey, as they were the only one to screen out the antimicrobial metabolites. Most of the antibiotics

found by Waksman group were synthesized by soil isolates, notably actinomycetes. As moulds and actinomycetes form the complex filamentous network, it emerged as a challenge for chemical engineers to remodel the industrial-level fermentation method perfectly for both batch and continuous procedure (Smith and Berry 1975; Demain 1981). During the revolution of rDNA technology, minor alteration in genetic material of microbes was done in order to synthesize the genetically engineered product of microbial origin.



**Postmodern Fungal Technology**

The advent of rDNA technology has transformed biology. Under the term “postmodern”, mycotechnology insinuates to recent improvements procreated by embracing the techniques like gene splicing along with the additional post-rDNA techniques other than the traditional industrial techniques. Few examples of this hybrid mix are depicted in Table 6.3. The regulation of heterologous protein.



Molecular analysis also acquiesced the secondary metabolic pathways. Certainly, penicillin family was the first family of antibiotic which gained the profit from innovative approaches. On cloning the gene encoding for isopenicillin N synthase, it was uncovered that various gene involved in the pathway were present in cluster; thus it accelerated the isolation process (Skatrud 1991). The strains showing high yield were determined to have multiple copies of the gene which code for the main enzyme involved in the penicillin pathway. In few instances, the researchers were able to engineer the fraction of the metabolic pathway with the help of atypical precursor or the host organism, hence exaggerating chemical diversity of the nature (Skatrud 1992). Molecular analysis has also benefited the group of secondary metabolites named polyketides. Till date, extensive research is done in actinomycetes targeting either mixing or matching of the polyketide synthases (Kao et al. 1994). Moreover, these strategies have benefited fungi a lot. The variation spawned by employing the diverse initiating units, by amending the oxidation as well as stereochemistry of chemical during elongation and by inducing different post-polyketide amendment which resulted in the synthesis of different theoretic molecules. By exploiting the genetically altered polyketide synthases, one is even able to synthesize the artificial natural product. The advances in the genetic transformation techniques have enabled to amend the fungal strain and provide them the potency as some of the species lacks sexual as well as parasexual cycles (Esser 1997). Enhancement in the conventional fermentation by fungi is observed along with that genetic modification that has enabled to amend the fungi to perform specific function. Incorporation of both homologous and heterologous gene into fungal host has improved the yield and properties of the enzyme. Now, the enzyme could be synthesized on the varied substrate and at different optimum temperatures (Kinghorn and Lucena 1994).