Chapter 4
Thermophiles: Physiology, Metabolism, Enzymology, and Adaptation Mechanisms

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ABSTRACT

Microorganisms are the diverse living things present on the Earth. India has numerous unique thermal habitats that comprise several diversity hotspots, such as hot springs, deep oceanic hydrothermal openings, anaerobic biodigesters. The existence of life at high temperatures is quite attractive. At both ends of the temperature range suited with life, only microorganisms can grow and survive. Thermophiles are a typical extremophilic microbes capable of existence in high temperature environments. At such high temperature, the ordinary cellular functions adversely affected for mesophiles. The thermophiles effectively manage instability of the plasma membrane, inactivation of enzymes instability of DNA, as well as other hostile physiological variations at such an elevated temperature. Heat shock proteins (Hsps) have established the most attention in thermophiles under stress condition, which is well described in this chapter. This chapter offers comprehensive information about thermophiles, physiology, metabolism, enzymes of metabolic pathways, and various adaptation mechanisms.

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INTRODUCTION

Extremophiles comprise members from each of the three areas of life such as bacteria, archaea, and eukaryote (Robb *et al*., 2008). Soon after finding of archaea in 1970s, the phylogenetic tree of life had one more branch of thermophiles and hyperthermophiles in both the domains of Bacteria and Archaea (Amend & Shock, 2001). Prokaryotes are considered as ubiquitous due to their simple dispersal and metabolic adaptability, smaller size, capacity to endure hostile ecosystems, usage of wide range of supplements and capacity to endure hostile ecosystems, hence they form a striking portion of a most of the environments (Kumar *et al*., 2014). Thermophiles inhabit in tropically heated conditions on the earth. Temperature significantly affects the evolution and distribution of biodiversity and microbial community structure in an ecosystem. Thermophiles are prokaryotic microorganisms show specific attention because of their capacity to endure the denaturing consequence of higher temperatures on biomolecules such as DNA and proteins (Li *et al*., 2005). Thermophiles are omnipresent and flourish in wide range of environments from marine habitats to hot springs to natural water bodies. In addition to these habitats, thermophiles are now being regularly identified in continental solfataras, heated sediments, mining sites, water heaters to the industrial dumping wastes. The microbes residing extreme environments evolve earlier because of high rate of horizontal gene transfer than those occupying normal habitats (Li *et al.,* 2014).

Temperature is one of the essential factors for the regulation of the activities of microorganisms. Thermophilic microorganisms endure the higher temperatures, yet they require such high temperatures for their optimum growth and survival. Thermophiles are categorized into moderate thermophiles (Topt, 50°C-60°C), extreme thermophiles (Topt, 60°C-80°C), and hyperthermophiles (Topt, 80°C-110°C) (Gupta *et al.,* 2014). The investigation in the Thermophile's arena has become a significant space of exploration and several novel microbial genera and species (Yoneda *et al.,* 2013**;** Cihan *et al.,*2014). Due to their increased importance, potential applications, and roles in different fields, scientists have concentrated their studies to discover new genus and species across the world (Yoneda *et al.,* 2013; Cihan *et al.,* 2014; Aanniz *et al.,* 2015). To study such a wide range of thermophilic bacteria, both culturable and unculturable methods have been utilized for comprehension study of microbial diversity in hot environments. At present, 16S rRNA sequence-based classification of bacteria appears to be significant for identifying novel taxonomic groups. In addition, more traditional taxonomic features such as G + C contents of DNA, DNA-DNA homology, morphology, and physiological characteristics may be used to separate characters from obtaining larger resolution of classification inside groups of a phylogenetic line of descent. To endure in such a harsh ecosystem, thermophiles produce several unique compounds, for examples, enzymes, stress proteins, chaperones, exopolysaccharides. Moreover, thermophiles have enormous biotechnological potential and industrial applications. From the finding of thermophilic microorganisms, they are the attractive tools for the biologist to understanding the basics physiological adaption and application of their metabolites. In this chapter, we have presented habitats, physiology, metabolism, enzymology and adaptation mechanisms including heat shock proteins and thermostable enzymes of thermophiles isolated from various thermal habitats.

THERMOPHILES FROM VARIOUS THERMAL ENVIRONMENTS IN INDIA

Natural activity has created different types of thermal biological processes where, the heat is formed due to geothermal activity, self-heating. Such habitats reside by thermophiles are different namely thermal