Chapter 12
Application of Extremophiles in Food Industries

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ABSTRACT

Extremophiles have adapted themselves at extreme environmental conditions like high or low temperature, pH, salinity, and pressure. Extremophiles may be either acidophilic, alkaliphilic, halophilic, thermophilic, psychrophilic, oligotrophic, endolithic, and xerophilic. There extremozymes are found to be biocatalysts and producers of novel enzymes which can be employed in many industries like food, cosmetics, chemical, pharmaceuticals, etc. Currently the researchers have developed keen interest in studying and utilizing the abilities of these extremophiles in food industries. Metabolic pathways and extremozymes are being studied by the researchers and they are trying to utilize its characteristics and also engineer these extremophiles. In food industries, one of the extremophiles, Rhodothermus marinus, which has been an excellent biocatalyst producing lipase as an enzyme, could be utilized to improve to aroma of food and add natural flavour to food. So, the current chapter will deal with the various applications of these extremophiles.

INTRODUCTION

Organisms are found to be omnipresent in universe. Many organisms have adapted themselves to various environmental conditions like low temperature (psychrophiles), high temperature (thermophiles and hyperthermophiles), high salinity (halophile), low pH (acidophiles), high pH (alkaliphiles), low nutrient concentration (oligotrophs), low water activity (xerophile), heavy metal concentrations (metallotolerant), high pressure (barophile or piezophile), high radiations (radioresistant), low oxygen concentrations, (Gomes and Steiner, 2004; Cowan *et. al.,* 2015), high antibiotic concentrations, high concentration of carbon (Capnophile), etc. Such organisms are termed as extremophiles. The term extremophile was given by MacElroy in 1974. Taxonomic classification includes prokaryotes, eukaryotes, bacteria and archaea. (Woese *et. al.,* 1990; Zhang, 2018). They have adapted themselves to survive in ecological niches that are unsuitable for others, for example, deep-sea hydrothermal vents, hot and cold deserts, soda lakes,

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inland saline systems, solar salterns, environments highly contaminated with nuclear waste or heavy metals, as well as lithic or rock environments and hot springs. (Raddadi *at. el.,* 2015).

They are found to be potential source of biomolecules which can be utilized for many industrial purposes. Nowadays they have been in the limelight as the researchers have found them to be a treasurer of industrially utilizable metabolites and its products. But only 1-2% of the extremophiles have been utilized uptil now and in future the expanding research may help to exploit them. *(*Gomes and Steiner, 2004).

Extremophiles have been found to produce extremozymes which are protein that can function under extreme conditions. These enzymes possess some unique characteristics like extreme thermal stability, resistance against chemical denaturants such as detergents, chaotropic agents, organic solvents and extremes of pH. (Gupta *et. al.,* 2014). Proteases, pectinases, keratinases, cellulases, amylases, xylanases, lipases, esterases, catalases, peroxidases, phytases, etc. are few examples of extremozymes produced them. They can be a good biocatalyst and can be employed in various biotechnological processes. (Gomes and Steiner, 2004). More than 300 different enzymes have been identified and have been employed in industrial and biotechnological processes. (Singh *et. al.,* 2021)

According to *Raveendran et. al. 2018* microorganisms such as bacteria, yeast, fungi and their enzymes are widely used in the food industries. These microbial enzymes are used because they are found to be more stable than plant and animal enzymes. They are utilized to improve the texture and taste of in food industry.

BACKGROUND

Extremophiles are a group of organisms that survive under extreme environmental conditions such as high or low temperature, pH, salinity, and pressure. These organisms have evolved and developed strategies and mechanisms to survive under extreme conditions. These extremophiles mainly belong to the genus *Acidithiobacillus, Arthrobacter, Bacillus, Caldicellulosiruptor, Clostridium, Coprothermobacter, Enterobacter, Geobacillus, Micrococcus, Paenibacillus, Penicillium, Picrophilus, Pseudoalteromonas,* and *Thermobifida.* (Zhu *et. al.*, 2020)

Recently researchers are utilizing the enzymes produced by the extremophiles and have still developed keen interest in searching novel enzymes produced by them. Many research companies have been working to develop the strategies to genetically modify or design the extremophiles to take maximum advantage for utilizing extremozymes produced by them in biotechnological processes and food industries. For improvement in food and the food products constant efforts are made by the food industries to employ these enzymes. Thermophiles, psychrophiles, acidophiles and alkaliphiles, halophiles, piezophiles, toxitolerant and radiophile are the extremophiles which can be employed in the food industries.

Thermophiles

Thermophiles can be classified into moderate, extreme and hyperthermophiles. Moderate thermophiles grows at optimum 50–60 °C, extreme thermophiles grows at optimum 60–80 °C whereas hyperthermophiles grows at optimum 80–110 °C. Thermophylic microorganisms are good source of thermostable enzymes. (Singh *et. al*., 2011). Thermophilic enzymes can increase reaction rates during high temperature processing of food. More than 40 extremophilic enzymes, characterized from the hot springs of Yellowstone National Park are found to be active at high temperatures and have also been found to have