EDITORIAL

Genomics of Extremophiles for Sustainable Agriculture and Biotechnological Applications (Part I)

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Survival of life in extreme environments has always caught the attention of scientists and researchers as it can lead to understand several mechanisms leading to humanity. A few groups of organisms, including animals, plants and microorganisms can survive against harsh environmental conditions such as extreme temperature (cold and hot), salt, pressure, pH (acidic and alkaline) and drought. The organisms surviving on these niches are individually called thermophiles, psychrophiles, halophiles, piezophiles, acidophiles, alkaliphiles and xerophiles. The collective term for all these organisms is extremophiles. The study of extremophiles has received significant interest in both environmental and industrial perspectives. It has already been reported that microorganisms are present in a huge diversity in extreme niches. A great interest in the exploration of extreme habitats with a diversity of extremophilic microbes and their survival mechanisms has been shown in recent years. Some microbes represented the very ancient life forms when the environmental conditions were totally different than today, hence studying about these microbial physiology helps to answer the evolution of life. In addition, extremophiles had also shown their role in astrobiology [1].

The genetic and metabolic machinery of these microbes has been adapted for harsh conditions. For instance, thermophiles, psychrophiles and piezophiles have thermostable proteins, cell wall and cell membrane that resist extreme temperature; halophiles and xerophiles possess osmolytes and antioxidants in high concentration and; acidophiles/alkaliphiles have specific ion transporters to pump out excess ions and maintain neutral pH. Extremophiles also maintain their cell membrane fluidity, which protects their genetic material. They have unique genes that produce important metabolites which are stable at extreme environments known as extremozymes. Such types of metabolites, including protein and enzymes, have proven their importance in the field of biotechnology. For example, a DNA polymerase enzyme used in Polymerase Chain Reaction (PCR) technique is extracted from thermophilic bacteria (*Thermus aquaticus*). A large number of extremozymes approximately 3000 have been recovered from different extremophiles and are being used in several biotechnological and industrial purposes. However, there are so many extreme niches as well as microbes and their metabolites which are needed to be explored and utilized for improving the quality of life.

The recent advances in genomics technologies have allowed for the investigation of extremophiles diversity and their survival mechanism as has never been seen before. Such advance genome-based studies will transform our understanding of physiology, genetic basis and genetic mechanisms of extremophiles and will reveal the importance of extremophiles and their products in multiple aspects of biotechnology including medicine, food technology, biofuel production, agriculture, waste management and many more [2]. The first part of this special issue explores genomic aspects of extremophiles including their survival mechanisms, gene expression and their applications in agriculture and other biotechnology purposes. The extremophiles have unique genetic material that is needed to be mined, which may be useful for genetic engineering in mesophillic microbes and their metabolites can be used in industries. The physiology and diversity of extremophiles including halophiles, psychrophiles and heavy metal tolerance will be presented in this special issue. Topics will also include the engineering of extremophiles and their application in pigment production, waste management and bioenergetic purposes.

In this sense, a research article by Mawad *et al.* [3] explored phenanthrene degrading bacteria *Pseudomonas fluorescens* AH-40 from oily sludge sample. This bacterium requires less time for degrading complete phenanthrene as compared to previously reported bacterial cultures. Mawadand colleagues quantified the expression of phenathrene degrading genes *i.e.* naphthalene dioxygenase (*nahAc*) and catechol 2,3-dioxygenase (C_23O) in AH-40 culture and found their increased expression during the degradation process. Authors suggested the role of *nahAc* and C_23O as a marker gene in phenanthrene degradation and recommend to AH-40 culture for bioremediation process. In a review, specific metabolic and genomic features of thermophiles and psychrophiles are discussed by Kohli *et al.* [4]. Kohli and colleagues reported the role of hydrophobic molecules in cell membrane structure, amino acid composition, tRNA structure, GC content in genomes and many more in the stability of extremophiles under harsh conditions. They also described some examples of different enzymes extracted from both thermophiles and psychrophiles and their applications for industrial purposes. Another review by Usmani *et al.* [5] described the importance of bioengineering technologies on microbes and their uses for producing microbial pigments using agricultural wastes as substrate.

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In this review, advance techniques such as Multivariate modular metabolic engineering (MMME) and Multiplex automated genome engineering (MAGE) are reported for modulation in secondary metabolism of extremophiles. These techniques are used for the production of carotenoid and anthocyanin compounds. In addition, use of different agro-wastes such as Apple pomace, Rice powder, Palm date waste, Sugar-beet molasses, Orange waste and many more in production of microbial pigments are reported.

AUTHOR'S CONTRIBUTIONS

All authors AV, JS, HBS, contributed in writing this Editorial article for the research topic "Genomics of extremophiles for sustainable agriculture and biotechnological applications".

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