

Extreme Cold Environments: A Suitable Niche for Selection of Novel Psychrotrophic Microbes for Biotechnological Applications

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Editorial

The microbiomes of cold environments are of particular importance in global ecology since the majority of terrestrial and aquatic ecosystems of our planet are permanently or seasonally submitted to cold temperatures. Earth is primarily a cold, marine planet with 90% of the ocean's waters being at 5°C or lower. Permafrost soils, glaciers, polar sea ice, and snow cover make up 20% of the Earth's surface environments. Microbial communities under cold habitats have been undergone the physiological adaptations to low temperature and chemical stress. Recently, these communities have attained the focus of applied research not only in terms of biotechnological prospects but also to understand the use of primitive analogues of biomolecules existed during early Earth environments [1,2]. The microbiomes of cold environments have been extensively investigated in the past few years with a focus on culture dependent and culture-independent techniques. Cold-adapted microorganisms have been reported from Antarctic sub-glacial, permanently ice-covered lakes, cloud droplets, ice cap cores from considerable depth, snow and ice glaciers [3-6]. Many novel microbes have been sort out from cold environments including *Halobacterium lacusprofundi* [7], *Sphingobacterium antarcticus* [8], *Octadecabacter arcticus* [9], *Hymenobacter roseosalivarius* [10], *Cellulophaga algicola* [11], *Flavobacterium frigidarium* [12], *Oleispira antarctica* [13], *Flavobacterium psychrolimnae* [14], *Psychromonas ingrahamii* [15], *Exiguobacterium soli* [16], *Pseudomonas extremaustralis* [17], *Cryobacterium roopkundense* [18], *Sphingomonas glacialis* [19], *Pedobacter arcticus* [20], *Sphingobacterium psychroaquaticum* [21], *Lacinutrix jangbogonensis* [22], *Massilia eurypsychrophila* [23], *Glaciimonas frigoris* [24] and *Psychrobacter pocilloporae* [25]. There are

several reports on whole genome sequences of novel and potential psychrotrophic microbes [26,27].

The novel species of psychrotrophic microbes have been isolated worldwide and reported from different domain archaea, bacteria and fungi which included members of phylum Actinobacteria, Proteobacteria, Bacteroidetes, Basidiomycota, Firmicutes and Euryarchaeota [7-25]. Along with novel species of psychrotrophic microbes, some microbial species including *Arthrobacter nicotianae*, *Brevundimonas terrae*, *Paenibacillus tylopili* and *Pseudomonas cedrina* have been reported first time from cold deserts of NW Himalayas and exhibited multifunctional plant growth promoting (PGP) attributes at low temperatures [5]. In a study by Yadav et al. [6], the microbial species *Alishewanella* sp., *Aurantimonas altamirensis*, *Bacillus baekryungensis*, *B. marisflavi*, *Desemzia incerta*, *Paenibacillus xylanexedens*, *Pontibacillus* sp., *Providencia* sp., *P. frederiksbergensis*, *Sinobaca beijingensis* and *Vibrio metschnikovii* have been reported first time from high altitude and low temperature environments of Indian Himalayas. Wheat associated psychrotrophic bacteria *Arthrobacter methylotrophus* and *Pseudomonas rhodesiae* have been reported first time from wheat growing in North hills zone of India [28]. In a specific search of economically important Bacillus and Bacillus derived genera (BBDG) at low temperature, Various BBDG such as *Bacillus psychrosaccharolyticus*, *B. amyloliquefaciens*, *B. altitudinis*, *B. Muralis*, *Paenibacillus tylopili*, *P. pabuli*, *P. terrae* and *P. lautus* with efficient PGP attributes have been reported first time by Yadav et al. [29].

Prospecting the cold habitats has led to the isolation of a great diversity of psychrotrophic microbiomes. The bacterial

diversity from the cold environment could serve as a database for selection of bio-inoculants with PGP ability and could be used for improving the growth and yield of crops grown at high altitudes with prevailing low temperatures [30-33]. Psychrotrophic PGP microbes have been shown to promote plant growth either directly by biological N₂-fixation; solubilization of minerals such as phosphorus, potassium and zinc; production of siderophores and plant growth hormones (Indole acetic acid and gibberellic acid) or indirectly, via production of antagonistic substances by inducing resistance against plant pathogens [29,34,35]. The psychrotrophic PGP microbes can have an impact on plant growth providing the plant with compound(s) of microbial origin for facilitating the uptake of nutrients from the environment. Psychrotrophic PGP microbes were found in several genera, including *Arthrobacter*, *Bacillus*, *Brevundimonas*, *Burkholderia*, *Pseudomonas*, *Citricoccus*, *Exiguobacterium*, *Flavobacterium*, *Janthinobacterium*, *Kocuria*, *Lysinibacillus*, *Methylobacterium*, *Microbacterium*, *Paenibacillus*, *Providencia* and *Serratia* [35-38]. Among these taxa, *Pseudomonas* and *Exiguobacterium* has been the best characterized for PGP at low temperatures [38,39]. There are several studies have demonstrated the benefits of PGP microbes on the growth and yield of different crops at different climates, soils, and temperatures. The use of PGP microbes improves plant growth by supplying plant nutrients, which can help sustain environmental health and soil productivity.

Psychrophilic/psychrotolerant microbes are important for many reasons, particularly because they produce cold-active enzymes. The enzymes from psychrophiles have become interesting for industrial applications, partly because of ongoing efforts to decrease energy consumption. These cold-active enzymes provide opportunities to study the adaptation of life to low temperature and the potential for biotechnological exploitation [2,40]. Most of the work that has been conducted on psychrophilic bacteria focused on cold-active enzymes such as amylase, protease, lipase, pectinase, xylanase, cellulase, β-glucosidase, β-galactosidase and chitinase [40]. Cold-active enzymes are produced by psychrophilic microbes namely, *Acinetobacter*, *Aquaspirillum*, *Arthrobacter*, *Bacillus*, *Carnobacterium*, *Clostridium*, *Cytophaga*, *Flavobacterium*, *Marinomonas*, *Moraxella*, *Moritella*, *Paenibacillus*, *Planococcus*, *Pseudoalteromonas*, *Pseudomonas*, *Psychrobacter*, *Shewanella*, *Vibrio* and *Xanthomonas* [27,41,42]. Psychrophilic microbes can be applied for biodegradation of agro wastes at low temperatures. Shukla et al. [43], have developed psychrotrophic microbial consortium of *Eupenicillium crustaceum*, *Paceliomyces* sp., *Bacillus atropheus* and *Bacillus* sp., for its potential applications towards degradation of agri-residues and conversion to a value added product like compost for enhancing soil fertility and decreasing environmental pollution caused by burning of agro-wastes. Psychrotrophic microbes produced anti-freezing compounds (AFCs) at low temperatures [1,27]. The AFCs are useful in cryosurgery and also in the cryopreservation of isolated organs, cell lines, tissues and whole organisms. In food

industry, anti-freezing proteins (AFPs) can be used to improve the quality of frozen food. Improved cold tolerance in fishes has been achieved in some cases by direct injection of AFPs and in another case by transgenic expression of an AFPs.

Conclusion

Cold-adapted microbes could be utilized for understanding adaptation at low temperatures, as they produce cold-active enzymes, fatty acids, carotenoids, cold acclimation proteins, cryoprotectants and anti-freezing proteins under extreme conditions of low temperature. Cold-active enzymes have applications in industry like those manufacturing cleaning agents or in leather processing. The other applications could be for bio-degradation of xenobiotic compounds in cold climes, food processing (bakery, cheese manufacture and fermentation) and molecular biology (heterologous gene expression). Cold-adapted microbes have attracted the attention of the scientific community due to their ability to promote plant growth and produce cold-active enzymes, with potential biotechnological applications in a broad range of industrial, agricultural and medical processes. Psychrotrophic microbes could be valuable in agriculture as bio-inoculants and biocontrol agents for low temperature habitats. The use of psychrophiles as biofertilizers, biocontrol agent and bioremediators would be of great use in agriculture under cold climatic conditions.

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