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Some thoughts on the development of polar microbial resources

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Polar microorganism resource development can be accomplished as long as its inherent characteristics, that is, biota quantity, diversity, and low temperature adaptability, as well as market demands and product feasibility, are considered.

1 Characteristics of polar microorganisms

Most importantly, the quantity and diversity of terrestrial and aquatic microorganisms in the polar regions is abundant (Abakumov and Mukhametova, 2014), and species quantity and diversity in eutrophic polar areas can even become comparable to that in temperate climate regions (Hoovera and Pikutab, 2010). This large, diverse polar region microbial biomass can become the basis for the development of novel resources. Second, low temperature adaptability, an overriding characteristic of most polar microorganisms and consequent products, can be a problem that requires special attention in development and application processes. For example, the culture temperature of polar microorganisms and the optimal temperature for producing enzymes from those organisms are 10–30℃ lower than that of microorganisms found in temperate climate regions (Spring et al., 2003). Presently, commercial products derived from polar microorganisms are very rare. In contrast, many products have been derived from thermophilic microorganisms, including *Taq* (Rampelotto, 2016) and other thermophile polymerases and high-temperature amylases. Furthermore, many thermophilic bacteria and archaea are used in scientific research, paper processing, oil exploration, and other fields. Therefore, from this point of view, the resource advantages of polar microorganisms has thus far been drastically underutilized.

2 Restrictive factors in the development and application of polar microorganisms

Foremost, low temperature enzymatic activities are applicable to many fields. Cold-adapted enzymes with the same activities as conventional meso- and thermophilic counterparts perform better in cooler temperatures. This is particularly relevant for conserving energy usage, especially in the winter, and even more so in further northern and southern latitudes. For example, cold-adapted proteases and lipases can be used in detergents. Other examples include the application of cold-adapted cellulases in the preparation of cellulose ethanol through simultaneous saccharification and fermentation. The bioremediated degradation of terrestrial and aquatic oil pollution sites and even sludge in sewage treatment systems can be facilitated in the winter and other low-temperature conditions using appropriate low-temperature adapted microorganisms. I believe that cold-adapted microorganisms have great potential and

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broad application prospects for actual production and use in everyday life.

Second, advantages and disadvantages always exist simultaneously, and limiting factors toward the development of polar microbial resources are almost all caused by low temperature adaptability. Generally, low temperatures are required to maintain cultivation and activity in the production and storage processes of cold-adapted microorganisms and corresponding products, which leads to additional energy consumption and higher cost.

Adaptation to low temperature is often accompanied by intolerance to high or even medium temperatures. Many procedures exist for raising and lowering temperatures in industrial production, and enzymes with high thermal stability (Banerjee et al., 1999; Nidhi Goyal et al., 2005; Gogou et al., 2010) such as starch saccharase, xylanase, protease, and cellulase, play an important role in food, chemical, pharmaceutical, paper making, pulp processing, and wastewater treatment industries. However, cold-adapted enzymes have not traditionally been used in these endeavors, which is a disadvantage toward the industrial application of cold-adapted microorganisms in the future. For historic reasons, the research, development, and derived capabilities of meso- and thermophilic enzymes has far surpassed that of low-temperature-adapted enzymes. Cold-adapted enzyme development needs to take advantage of recent biotechnological developments. On one hand, we should learn from successful previous experiences, but on the other hand, we need to catch up with the development of new technologies, such as synthetic biology (Zhang and Nielsen, 2014).

Getting rid of heat, throughout the cultivation, extraction, and application stages, is the biggest challenge in the commercial development of polar microorganisms and associated products. We should respond appropriately in terms of equipment, process, and application.

3 Research and development guidance for polar microorganisms

The first consideration is the market. The great fact to remember is that ‘market is king’. When it comes to the development of polar microorganisms and associated products, the most important thing to consider is to make full use of existing markets and places suitable for low temperature applications. These include the application of cold-adapted proteases, lipases, and amylases in detergents, the application of low-temperature pectinases in the food industry, and the application of transglutaminases in meat processing.

A second consideration is the production process itself. This is often completely different than ideal laboratory conditions and is mainly determined by cost and efficiency. Furthermore, additional factors need to be considered in actual commercial production, including investments, the service life of equipment, process efficiency, quantity of operators, and the treatment of tail gases and other waste products. The experimental method employed should be determined according to the characteristics of the microorganism and its desired product, and the selection of production processes must be the result of comprehensive evaluation.

The third aspect that needs to be considered is product positioning. Scientific researchers, who are accustomed to working in the laboratory, are often committed to pursuing higher purity and activity in their research products. Sometimes, however, this is not necessary or practical in actual industrial production settings. Market positioning and the scale of products at different levels are not all the same, which is a key reason for developing novel products. Some products expand market scale mainly through marketing means, such as fast-moving consumer goods, like beverages. Other market expansions mainly depend on product performance, such as *Taq* and other thermophile polymerases. Different methods need to be adopted under different conditions.

The final consideration is which product will be chosen: The new product or the old product? This issue is just a coin toss with two sides—advantages and disadvantages. For new products an advantage is that there is less competition, and thus the market can easily grow. Developmental freedom is greater, and the market is more easily exploited in the future. Disadvantages include a higher probability of premature market failure, and a greater resistance to market promotion, because it is not easy to change from existing products in terms of production investment and consumer acceptance. Another key factor is market access, which requires much product testing.

It is much easier to develop products with a relatively clear research background, which argues for the importance of polar microbiota research and its funding. This ensures more advanced levels of research and saves time in process exploration. Additionally, the market access of existing products may diminish. Of course, disadvantages also exist. One is, in general, the costs, development, production, and sales of a new product is always higher than that of existing products.

Summarizing, we need to make research interests and judgments according to product characteristics, market conditions, and interest levels. Finally, if we want to develop cold-adapted market products, the entire process needs to go to industry as soon as possible. The needs of enterprise and the market are often different from our work in the lab. The market is the best mentor toward your research and development efforts.

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