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Marine microbes as a valuable resource for brand new industrial biocatalysts

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ABSTRACT

The marine environment is one of the most important sources of bioactive compounds in the world. Marine microbial communities from marine environments secrete variety enzymes based on their habitat and their ecological roles. They are considered important ecological components in marine environments due to their performance in biogeochemical processes. Marine microbial enzymes including protease, lipase, collagenase, agarase, cellulose and Tother enzymes are important in different industrial due to their properties and applications. The biochemical diversity of marine microbial makes them reasonable sources of a wide variety of enzymes for use in different industrial including food, medicine and other biotechnological systems. Therefore, marine microbial enzymes preparations due to a special applications and functions in the biotechnology projects, also these can suggestion novel catalysts of biological and biochemical reactions with unique properties and functions. In this review, we focus on microbial enzymes from marine derived and their biochemical significance and their increasing importance in biotechnology.

1. Introduction

The marine with more than 70% of Earth's area, not only has rich biodiversity but also a source for the microorganisms with potential is vast. Marine environment are including diverse communities of plants, animals and microbes that marine microbial communities including bacteria, fungi, viruses and etc. have several advantage in marine environments due to their performance in biotechnological processes (Sowell et al., 2008). Marine environment contains huge potential of microorganisms, fungi, plants and animals are a rich source of biodiversity, which have the capability to extract enzymes from marine sources. A marine enzyme may be a unique protein molecule not found in any terrestrial organism or it may be a known enzyme from a terrestrial source but with novel properties (Dadshahi et al., 2016; Homaei, 2015b; Homaei et al., 2016a, 2016b). Microbial enzymes have more advantages than the enzymes are derived from plant or animal because these enzymes have advantages such as broad biochemical diversity, the ability to mass culture, ease of genetic manipulation, a more catalytic activity, lower costs, equipment and sustainability are relatively more abundant (Bull et al., 2000). With the advancement of marine science, biotechnology and microbial fermentation technology, demand and interest researchers to identify and characterize microbial enzymes have been more sea (Sharifian et al., 2017; Zeinali et al., 2015). Marine environment with extreme chemical conditions, including high salinity, high pressure, low temperature and special lighting conditions, microorganisms in the marine environment compared to their unique living environments and habitats genetic properties (Stach et al., 2003). Marine microbes of different habitats and the habitats shelter a diverse range of microbes, including archaea, cyanobacteria, eubacteria, Actinomycetes, yeasts, filamentous fungi, microalgae, algae and protozoa. Almost all this potential source of enzymes that are beneficial to their potential has not been fully understood. The main goal of modern enzyme technology and storage of food components, effective use of raw materials, improve food quality, food diet, raw food use in the preparation of animal feed and process optimization is to reduce costs. The oceans, huge library of unique compounds and natural products and bioactive substances enzymes promising and surprising such as protease, amylase, lipase, chitinase, cellulose, ligninase, pectinase, xylanase, nucleases (DNAase, RNAase, restriction enzymes), and so are the potential application, which will never be found in a dry environment (Mohebbi et al., 2014). For example, marine actinomycetes not only in terms of ecological and taxonomical but also in terms of production and new biochemical bioactive compounds such as antibiotics, anti-tumor, suppress the immune system, enzymes, enzyme inhibitors (Dharmaraj, 2010), antimicrobial compounds, including aminoglycosides, antracyclines, the glycopeptide, beta-lactams, macrolides, nucleosides, peptides, made of them, polyester, polyketoides, actinomycin and tetracyclines are important (Berdy, 2005). Marine actinomycetes are virtually unlimited sources of novel compounds and streptomyces the most economical and the most

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Table 1
Industrial and commercial applications of numerous marine microbial enzymes.

Enzymes	Applications	References
Lipase	Food flavoring, organic synthesis, cosmetic production, detergents, paper production, biodiesel industry and textile industry	(Chi et al., 2009; Ferreira-Dias et al., 2013)
Protease	Detergent industry, leather industry, pharmaceutical, commercial liquid and solid detergents	(Chanalia et al., 2011; Ilona and Zdzislaw, 2007; Sawant and Nagendran, 2014)
Chitinase and chitosanase	Increase immune function, improve digestive function, drug delivery, agriculture, wound care application, metal capture from wastewater and prevent tumor cell growth	(Je and Kim, 2006; Kumar et al., 2014; Ngo et al., 2008)
Agarases	Additive in moisturizing cosmetic	(Martin et al., 2014; Oren, 2004)
Carrageenase	Aoagulant, adhesives, stabilizer, gelation and emulsifier	(Zhao et al., 2012)
Amylase	Added to flour at the mill or bread making and oxidized gluten for improved dough properties	(Gupta et al., 2003)
Cellulase	Biotextile, cotton and linen products processing and biofertilizer	(Sukharnikov et al., 2011; Zhao et al., 2012)
xylanase	Useful in textiles, paper and pulp industry, decrease the usage of Cl_2 and ClO_2, reduce pollution and cleavage some polysaccharides in juice or beer industry	(Doi, 2008; Nishiyama et al., 2002)
Tannase	Usage of antioxidants in fats and oils in the food industry, wines and beer, treated green tea, use of tannase as an ingredient of animal feed, treatment of fruit juices to reduce the bitterness and coffee flavored, discolor the tooth surface	(Chávez-González et al., 2012; Du-Thumm et al., 2005; Van de Lagemaat and Pyle, 2006)
Phytase	Use in bakery and sweeteners	(Jorquera et al., 2008; Lei and Porres, 2003)
Esterase	Degradation of plastic, usage of food, textile industries and deinking	(Sayali et al., 2013)

valuable biotechnology are prokaryotes. Studies have shown that bioactive compounds derived from the genus *streptomyces*. In fact, *stereptomysis* genus alone is capable of producing more than 80% of natural products actinomycetes and analysis of complex biological polymers, and in this regard remains unrivaled in the world of microbes (Manivasagan et al., 2014).

According to recent problems such as high population most countries, the waste of resources and pollution, identify the marine sources is important biological development. Marine microbial enzymes, particularly enzymes that have the ability to survive in extreme conditions such as heat-resistant enzymes used in PCR thermal vents near the ocean floor of the bacteria obtained the importance and more application (Grace, 1997). This review wills briefly discus potential uses of properties marine microbial enzymes with novel chemical biodiversity for its various industrial and medical applications (Table 1).

2. Properties, importance and biotechnological applications of marine microbial agarases

Agarases a colloid extracted from seaweed, which is used in the decomposition of agar. Agar or agar-agar is a jelly-like substance, obtained from algae is a mixture of agarose and agaropectin which is extracted from red algae *Gelidium robustum*. Agarose, a polysaccharide with a molecular weight of 120 kDa, which is a duplicate of D-galactose and 3,6-anhydro-L-galactose β1 → 4 and α1 → 3 connected with the gangs have been formed (Chi et al., 2012; Fernandes, 2014; Fu and Kim, 2010).

Agar pectin a heterogeneous mixture of small molecules with a backbone, such as agarose, but shows the ionic nature of the acid groups (such as sulphate, pyruvate) is covered is as natural compounds (Delattre et al., 2011). Alpha and beta agarases has two classes that according to research conducted by researchers in various marine organisms, most agarases been detected β-agarases category (Chi et al., 2012; Han et al., 2013).

In 1902, Gran isolated agar-degrading *Pseudomonas galatica* from seawater (Zhang and Kim, 2010). In 1987, Mervyn found the *Streptomyces* agarase gen (dagA) (Buttner et al., 1987). Marine bacteria *Vibrio* sp. (JT0107) the ability to bond hydrolysis α-l, 3 glycosidic agar is by α -Neoagaro-oligosaccharides (Sugano et al., 1993b). Rosert studied on agaA gene of *Pseudomonas* and agarases gene sequencing (Belas, 1989). In 1993 by Yasushi, agaA gene from *Vibrio* cloned and sequenced. Suzuki et al. (2003) purified a new type beta-agarase agaropectin of bacteria *Bacillus* sp. MK03, enzyme hydrolysis neoagarohexaose ability to produce neoagarotetraose and its neoagarobiose.

Agarases have been isolated from several marine source, most notably *Vibrio* sp., *Pseudomonas stutzeri, Aeromonas* sp, *Cytophaga, Bacillus, Alteromonas, Pseudoalteromonas, Streptomyces* (Aoki et al., 1990; Hosoda et al., 2003; Sugano et al., 1993b) and *Alteromonas agarlyticus* GJ1B (P. Potin et al., 1993), *Thalassomonas* sp. JAMB-A33 (Ohta and Hatada, 2006), *Alteromonas* sp. E-l (Kirimura et al., 1999), *Microscilla* (Naganuma et al., 1993), *Streptomyces coelicolor* A3 (Buttner et al., 1987), *Pseudoalteromonas* sp. BL-3 (Lee et al., 2005), *Vibrio* sp. AP-2 (Aoki et al., 1990), *Pseudomonas atlantica* (Belas, 1989), *Bacillus* sp. MK03 (Suzuki et al., 2003), *Catenovulum agarivorans* (Cui et al., 2014), *Microbulbifermaritimus* (Vijayaraghavan and Rajendran, 2012), *Alteromonas* sp. C-1 (Leon et al., 1992), *Vibrio* sp. JT0107 (Sugano et al., 1993a), *Agarivorans* sp. HZ105 (Hu et al., 2009), *Bacillus cereus* ASK202 (Kim et al., 1999), *Alteromonas* sp., *Cytophaga* sp., *Agarivorans gilvus* and *Pseudoalteromonas* sp. (Chi et al., 2012; Fu and Kim, 2010). *Halococcus* sp. is capable to production of β-agarases with molecular weight 55 kDa and optimum pH 6 (Minegishi et al., 2013). Also gram-negative bacteria *Microbulbifer maritimus* were detected in capable of producing extracellular enzymes agarases with molecular weight 75.2 kDa and K_m 3 mM (Vijayaraghavan and Rajendran, 2012).

Agarase is an enzyme with systematic name agarose 4-glycanohydrolase that found in agarolytic microorganisms (Parro and Mellado, 1994). An agarase marine bacterium are able to control many applications including red algae bloom, avoid biofouling on sea levels as a food additive in food and cosmetics moisturizing additives, and has a high level of activity for depolimerization the complex polysaccharides such as agar and agarose. In addition emulsification capabilities, the gelatinized and particles are stable, they also can be found in the food industry in the manufacture of soft drinks, confectionary, jelly, bread and produce some low-calorie foods used (Rasmussen and Morrissey, 2007; Yaphe and Morgan, 1959). Agarase in genetic science is important and necessary; also have applications in gene technology and agarose gel electrophoresis to separate DNA fragments (Table 2).

3. Extremozymes

The sea is extremely complex environment with a variety of different physicochemical conditions of extreme conditions such as large fluctuations in temperature, strong alkaline, strong acid, high hydrostatic pressure and nutrient status is very poor. Microorganisms such as fungi, bacteria, algae and other microorganisms that are able to grow in extreme situations have been called extremophilic (Table 3). The extremophilic microorganisms in biotechnology research are a topic of interest by many researchers (Danson and Hough, 1998).

Alteromonas, psychrotrophs and other microorganisms that are psychrophilies due to resistant to low temperatures are very useful and has