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Review

Alkaline pectinases: A review

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ABSTRACT

Pectinolytic microbes have been industrially exploited for pectinases that are environment friendly enzymes and mineralize pectic substances present in the environment. This review provides structural understanding of the molecular determinants of pectin utilization, mechanisms driving catabolite selectivity and industrial applicability. The topology of pectinase with distinct catalytic machinery enables it to persist in harsh environment during infection and analysis of pectin degradation pathway has resulted in understanding the role of different pectinases in subsequent steps of substrate digestion in different cellular compartments. The pH has a definite role in altering enzyme properties. Acidic pectinases are utilized especially in food processing industries for extraction and clarification of fruit juices. Alkaline pectinases find tremendous applications in biotechnology based industries especially for cotton bioscouring and retting of plant fibers in textile processing, paper making and treatment of waste water containing pectinaceous material.

Contents

1. Introduction

There has been a great increase in industrial application of biocatalysts owing to their significant biotechnological potential with desirable biochemical, physico-chemical characteristics and low cost of production (Banu et al., 2010). Pectinases have attracted attention globally as biological catalyst in numerous industrial processes

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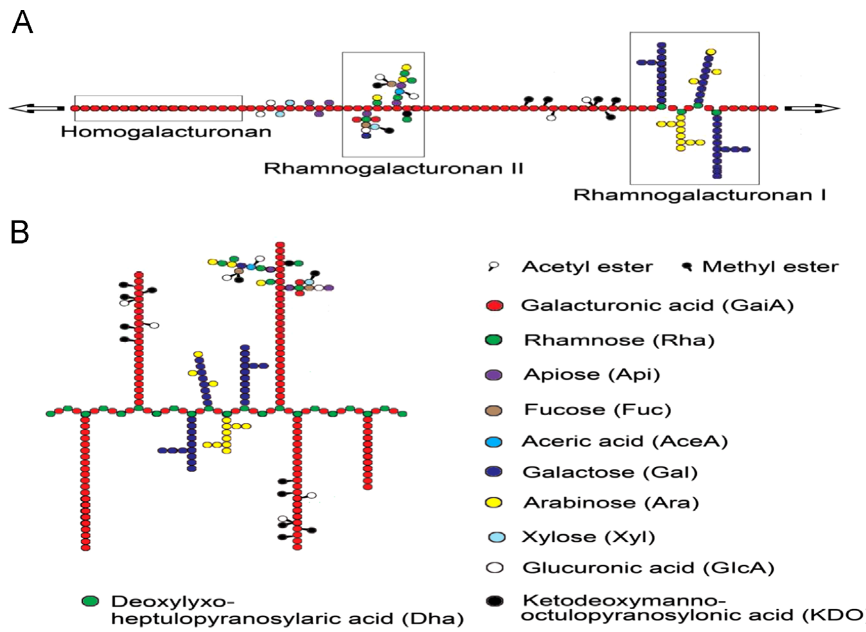

Fig. 1. The basic structure of pectin. Schematic representations of the conventional (A) and recently proposed alternative (B) structures of pectin. The polymers showing major domains found in most pectins rather than definitive structures (Willats et al., 2006).

(Rashmi et al., 2008). Pectinase catalyzes degradation of pectic substances through depolymerization (hydrolases and lyases) and deesterification (esterases) reactions (Tariq and Latif, 2012) and helps to understand the structure of pectin. Henri Braconnot in 1825 first isolated and described about pectin that is primarily made up of α (1 – 4) linked D-galacturonic acid residues. In the cell wall of fruits and vegetables, pectin is the predominant component (Anuradha et al., 2010). Among fresh fruits, currants contain highest percentage of pectin between 0.9 and 1.5%, but in case of dried fruits, lemon peel and pulp contain maximum percentage of pectin that is 35.5% and 32.0% respectively (Tapre and Jain, 2014). Pectin is a structural polysaccharide that forms the component of primary cell wall and middle lamella of fruits and vegetables. Pectin is involved in cross-linking cellulose and hemicellulose fibers, thus pectinases help to improve access of cellulases to their substrates (Giacobbe et al., 2014). Pectinases mainly include polygalacturonases, pectin esterases, pectin lyases (PNL), and pectate lyases with different substrate specificities (Ahlawat et al., 2009). Pectinases are efficiently produced by microbes and plants but there is no report on pectinase production by animals (Saranraj and Naidu, 2014). There are numerous reports on different type pectinases production from different pathogenic fungi and bacteria including pectin methyl esterase, whose isoforms are detected in all higher plants so far examined (Mareck et al., 2012). Pectinases act on plant cell wall decreasing the intracellular adhesivity and tissue rigidity (Pires and Filho, 2005). Microorganisms are naturally endowed with potential to produce numerous enzymes extracellularly such as *Streptomyces* GHBA10 is an efficient producer of pectinase that may be used industrially in extraction and clarification processes (Das et al., 2013). Samples for isolation of pectinolytic isolates have been soils rich in pectic waste, fruit waste processing area, sewage of juice centers of different locations, mud and pieces of long stored crop waste from pectin producing industry, and agroindusrial residues (Hoondal et al., 2002). Decomposing fruit materials after enrichment have been used to isolate pectinolytic bacteria (Kumar and Sharma, 2012). Applicability of pectinases is pH dependent such as acidic pectinases are mainly used in beverage industry for extraction and clarification of juice and wine (Gainvors et al., 1994; Hugouvieux-Cotte-Pattat et al., 1996; Pretel et al., 1997; Alkorta et al., 1998; Blanco et al., 1998) to remove pectic substances which are responsible for the consistency, turbidity and appearance of fruit juices (Bonnin et al., 2003). Alkaline pectinases have been used in textile processing (Phugare et al., 2011), pharmaceutical, leather, detergent and paper industry (Reid and Ricard, 2000) and maceration of vegetables to facilitate extraction of oils and pigments (Gupta, 2007). Alkaline pectinases are most suitable in textile industry especially for cotton bioscouring as they can be used for combined bioscouring and bleaching of cotton based fabrics (Hebeish et al., 2013). Alkaline pectinases are generally produced by bacteria, but are also made by some filamentous fungi and yeasts (Kapoor et al., 2001). Commercial enzymes producing bacterial strains are always preferred over fungal strains due to ease of fermentation process and implementation of strain improvement techniques or any modern technique to increase the yield of production (Prathyusha and Suneetha, 2011). Some of the bacterial species producing pectinases are *Agrobacterium tumefaciens*, *Bacteroides thetaiotamicron*, *Ralstonia solanacearum*, and *Bacillus* sp. (Jayani et al., 2005, 2010).

2. Pectic polysaccharides (substrate of pectinases)

Pectin is a high molecular weight heterogeneous and acidic structural polysaccharide (Doco et al., 1997) which is one of the major constituents of cereals, vegetables, fruits and fibers. It is the component of middle lamella and primary cell wall in plant cell wall and within the wall forms a matrix in which a network of cellulose and hemicellulose is embedded (Caffall and Mohnen, 2009). It is predominantly present in fruits and vegetables (Anuradha et al., 2010), supporting growth of pectinolytic isolates. Pectin has been characterized as having a backbone of D-galacturonic acid residues (Gummadi and Panda, 2002), linked by α(1–4) linkage with a small number of rhamnose residues in the main chain and arabinose, galactose and xylose on its side chains (Fig. 1). Galacturonic residues are bounded with carboxyl groups, which are sometimes modified by the addition of methyl groups forming methoxy groups and result in high degree of methyl esterification which plays an important role in the adhesion of adjacent cells (Yadav et al., 2009). The degree of esterification varies among plants, some plants also contain acetylated D-galacturonate residues. Non-esterified carboxyl groups may be linked through divalent cations such as Mg^{2+} or Ca^{2+}, causing