HEMICELLULOLYTIC ACTIVITY IN THE CROP RESIDUES

RAJ SINGH, ANJU RANI, PERMOD KUMAR, CHHAYA SINGH, GYANIKA SHUKLA, AMIT KUMAR

K.V. Faculty of Science,Swami Vivekanand Subharti University Meerut, UP, India, Shri Guru Ram Rai Institute of Technology and Sciences, Dehradun, Uttarakhand, India.

Email id : dr.rajsingh09@gmail.com, (M) 9897990346

ABSTRACT

The hemicelluloses are polysaccharides which prevail in close association with cellulose, These are constituents of the primary as well as secondary cell walls and form a bridge between pectic and cellulosic fractions. Hemicelluloses are one of the major constituents added to the soil, second only in quantity to cellulose and these consequently represent a significant source of energy and nutrients to the microflora. From time to time Several views have been given by scientists on the chemistry, biochemistry and microbial breakdown of hemicelluloses. A majority of fungi are known to be capable of degrading hemicelluloses and utilizing as C-source. All main groups of fungi are able to decompose hemicelluloses. A complete degradation of xylans requires the joint action of different enzymes including (i) endoxylanase: which attacks the xylan backbone to produce substituted and non-substituted shorter oligomers (xylobiose and xylose).);(ii) exoxylanase or β-xylosidase: converts oligomers to xylose; (iii) α-D-glu-curonidase: liberates 4-o-methylglucuronic acid from 4-o-methyl glucuronic acid-substituted xylo-oligomers; (iv) α-L-arbinofuranosidase : hydrolyses non-reducing a-L-arabinofuranosyl groups of α-L-furanosides arabinans, arabinoxylans, and arabinogalactans;(v) acetyl-xylan esterase: deacetylates xylan. The capability of a microorganism to grow by utilising hemicellulose as sole C-source is usually taken as an index of hemicellulolytic ability.

Keywords: Hemicellulose, Xylan, Xylanases, Microorganisms, Hemicellulolytic index.

INTRODUCTION

Hemicellulose

The term "hemicelluloses" was proposed by Schulze in 1891. It refers to the "plant cell wall polysaccharides which occur in close association with cellulose and are extractable by alkaline reagents (Viikari *et al.,* 1993). These are main constituents of the primary and secondary cell walls; and form a bridge between pectic and cellulosic fractions. These are short chains of branched heteropolysaccharides composed of both hexoses (like D-xylose, L-arabinose) and pentoses (like D-glucose, D-galactose and D-mannose). These include homopolymers (like xylans; β -1, 3- and (3 -1, 6, glucans) as well as heteropolymers (of xylose, glucose, mannose and other neutral sugars). The type and the amount of hemicelluloses varies widely depending upon the type of plant materials, tissues, growth stage, growth conditions, storage conditions and the method of extraction; even various parts of the same plant have different types of hemicelluloses (Viikari *et al.,* 1993). The sugars in the hemicelluloses occur as their respective anhydrides *i.e.,* xylan, araban, glucan, galactan and mannan (substituted with acetyl groups). In fact, these are usually named according to main sugar residues in the backbone (e.g., xylans,) glucomannans, galactans, glucans, xyloglucans. Xylans are the major constituents of the secondary walls of dicots, and primary cells walls of monocots. These constitute upto 30% of the cell wall material of annual plants (Wilkie, 1959; Sjostrom, 1981). Xylans consist of a main chain of D-xylopyranosyl residues joined by β-(1 4)-linkages with different side chains depending upon the source. The xylan chains are essentially linear polymers but 2-3 short branches may be present per molecule, furanosyl residues attached to C-3 of the xylosyl residues in β - (1 3) linkage; and (ii) 4-o-methyl D-glucuronsyl residues attached to C-2 of the xylosyl residues in α (1 2) linkage (Puls and Schuseil, 1993). In the cell walls of cereal plants, α -L-arabinofuranose units are attached to xylan backbone via α- (1- 3) and/or α- (1 2) linkages (Izydorczyk and Biliaderis, 1995).

Hemicelluloses are one of the major constituents added to the soil, second only in quantity to cellulose, and these consequently represent a significant source of energy and nutrients to the microflora. Because of their abundance and susceptibility to microbial degradation, these are important in dry weight loss of decomposing materials.

Hemicellulose degradation

Several reviews have appeared from time to time on the chemistry, biochemistry and microbial breakdown of hemicelluloses including that by Waksman and Diehm (1931), Pigman (1957), Gascoigne and Gascoigne (1960), Browning (1963), Timell (1964, 1965), Reese (1968), Whistler and Richards (1970), Aspinall (1973), Wood and Kellogg (1988), Coughlan and Hazlewood (1993), Viikari *et al.* (1993), Bajpai (1997), Kuhad *et al.* (1997) Pithadiya (2016), *et at.,* Patel *et al. (*2015), Kalim *et al.,(*2015),

Mondejar *et al.,*(2016).A wide range of fungi are known to be capable of degrading hemicelluloses and utilizing them as C-source (Hawkins, 1915; Treschow, 1944; Jermyn, 1953; Machlis, 1953; Biely, 1985; Wong *et al.*, 1988; Eriksson *et al.,* 1990.Singh and Charaya2003;Charaya and Singh,2005;Singh *et al.*2015 d). Species belonging to all major groups of fungi are able to decompose hemicellulose and the number of such fungi is far greater than those able to utilize cellulose. A list of some important microbial sources of hemicellulolytic enzymes has been provided by Kuhad *et al.* (1997).

Xylanases

Due to complex structure of the hemicelluloses, several different types of enzymes are required for their degradation. Thus, a complete degradation of branched xylans requires the concerted action of many different enzymes including (i) endoxylanase : which attacks the xylan backbone to produce both substituted and non-substituted shorter oligomers (xylobiose and xylose);(ii) exoxylanase or β-xylosidase : converts oligomers to xylose; (iii) α-D-glucuronidase : liberates 4-o-methylglucuronic acid from 4-o-methyl glucuronic acid-substituted xylo-oligomers; (iv) α-L-arbinofuranosidase : hydrolyses non-reducing a-L-arabinofuranosyl groups of α-L-furanosides arabinans, arabinoxylans, and arabinogalactans; (v) acetyl-xylan esterase : deacetylates xylan. Studies of a variety of fungal xylanases have revealed that these are small monomeric proteins with basic isoelectric points (PI 8-9.5). Yang et al.,(2005)revealed the recent advances in structures and relative enzyme properties of xylanase. The optimum pH for their activity is around 5.0 (Viikari et al., 1993). Available reports indicate that xylanases are inducible, at least in some fungi (Biely *et al.,* 1980; Hrmova et al., 1986).

Hemicellulolytic index

The capability of a microorganism to grow by utilizing hemicellulose as sole C-source is usually taken as an index of hemicellulolytic ability. Hemicelluloses are generally assayed by determining increase in reducing groups in reaction mixtures (Strobel, 1963; Reese and Shibata; 1965; Van Etten and Bateman, 1969). The insoluble xylan and mannan polymers are rendered soluble by preparing carboxymethyl or hydroxyethyl derivatives of the polymers, which facilitates their use as enzyme substrates (Hrazdina and Neukom, 1966).

Factors affecting hemicellulytic activity

The degradation of hemicellulose is governed by the physical and chemical characteristics of the habitat; pH and temperature also affect this process as in the case of other plant residue fractions. The rise in temperature increases the decomposition of hemicellulose (Abd-el-Malek and Monib, 1969).The nature of substrate, even different part of a individual plant show different rate of degradation of hemicelluloses (Charaya and Singh, 2005). The disappearance is less in water-logged conditions as compared to aerobic ones. Hemicelluloses of mature plants are degraded slowly than those in younger tissues (Alexander, 1977).The addition of phosphorus- singly and in combination have been reported to enhance the rate of decomposition of wheat residues(Singh and Charaya 2010; Singh et al.2015).

Conclusion

All types of organic residues including agricultural waste domestic waste are mainly consist of lignified cell wall materials- cellulose, hemicelluloses and lignin being the 3 main structural components. Out of these hemicelluloses is the second most dominant constituent after cellulose. A microbial technology is the pre request to convert these constituent into simpler and useful form, for human welfare. Xylan can hydrolyses into xylooligosaccharides and D-xylose.It has significant prospect for application in food, paper, pulp industry and environment. This paper reviews the research progress and trained in the structure correlating with the important properties of hemicelluloses and xylanases.

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