Open Access Scientific Reports

Research Article Open Access

Keywords: Xylanase; White rot fungi; SSF, LSF; Biobleaching

Introduction

ere has been an unprecedented expansion in our knowledge of the use of microorganisms, their metabolic products, and enzymes in a broad area of basic research, and their potential industrial applications. Xylanolytic enzymes have attracted a great deal of attention, and are applied in manufacturing of bread, food and drinks, improvement of nutritional properties of agricultural silage and grain feed, textile industry to process plant bres, pharmaceutical and chemical applications, and cellulose pulp and paper [1,2]. Recently, the interest in xylanases has focused on bleaching processes [3-5], wherein, enzymes began to be used during the last two decades, ever since peroxidases were applied to the degradation of lignin [6,7]. Enzyme application improves pulp brillation and water retention, reduces beating time in virgin pulps, restores bonding and increased freeness in recycled bres, and selectively removes xylans from dissolving pulps. e application of xylanases in prebleaching of pulps is gaining importance as alternatives to toxic chlorine-containing chemicals [8-10], where xylanases o er an attractive and commercially viable option to eliminate chlorine in they excrete the enzymes into the medium, and their enzyme levels are much higher than those of yeast and bacteria [16]. Both the so-called brown and so rot fungi decompose principally the polysaccharides. A third group, the wood-rotting basidiomycetes causing white-rot decay

*Corresponding author: Shalini Singh, Lovely Professional University,

Incubation period	Fungal Isolates	(Q]\PH SUR¿OH XQGHU GLIIHUHQW PRGHV RI FXOWLYDWL					
		SSF			LSF		
		Xylanase activity (IU/mL)	Cellulase activity (IU/mL)	Laccase activity (U/mL)	Xylanase activity (IU/mL)	Cellulase activity (IU/mL)	Laccase activity (U/mL)
5	A	0.80 ± 0.04	0.08 ± 0.03	0.131 ± 0.05	0.666 ± 0.16	0.55 ± 0.16	0.100 ± 0.02
	B	58.32 ± 0.21	0.970 ± 0.26	0.028 ± 0.03	31.23 ± 3.11	0.83 ± 0.21	0.021 ± 0.03
	C	670.38 ± 10.17	0.601 ± 0.23	0.180 ± 0.04	40.60 ± 3.32	0.52 ± 0.09	0.100 ± 0.34
	D	55.60 ± 1.32	0.621 ± 0.03	0.478 ± 0.21	22.11 ± 3.00	0.40 ± 0.13	0.127 ± 0.05
	E	119.49 ± 5.33	0.580 ± 0.16	0.249 ± 0.03	28.98 ± 2.05	0.30 ± 0.05	0.176 ± 0.10
	F	50.02 ± 2.10	5.450 ± 1.01	0.021 ± 1.32	8.70 ± 1.01	4.21 ± 0.13	0.020 ± 0.01
	G	8.34 ± 1.12	2.542 ± 0.78	0.111 ± 0.07	2.92 ± 0.09	1.78 ± 0.21	0.980 ± 0.13
6	A	1.15 ± 0.14	0.141 ± 0.10	0.210 ± 0.10	0.750 ± 0.05	0.112 ± 0.06	0.198 ± 0.05
	B	80.41 ± 1.19	0.700 ± 0.26	0.234 ± 0.04	55.20 ± 1.32	0.521 ± 0.20	0.212 ± 0.03
	C	658.12 ± 11.18	0.940 ± 0.18	0.431 ± 0.13	72.10 ± 2.11	0.750 ± 0.12	0.187 ± 0.04
	D	91.48 ± 2.87	0.925 ± 0.13	0.700 ± 0.21	28.90 ± 1.59	0.800 ± 0.13	0.245 ± 0.10
	E	131.25 ± 3.15	0.712 ± 0.32	0.581 ± 0.20	49.25 ± 4.65	0.380 ± 0.15	0.301 ± 0.13
	F	54.89 ± 4.01	1.324 ± 0.21	0.100 ± 0.03	12.90 ± 0.21	0.890 ± 0.23	0.102 ± 0.05
	G	9.10 ± 0.42	1.101 ± 0.23	0.123 ± 0.05	3.21 ± 0.13	0.807 ± 0.26	0.100 ± 0.02
7	A	4.51 ± 1.01	0.298 ± 1.02	0.423 ± 0.05	3.00 ± 0.98	0.192 ± 0.07	0.410 ± 0.13
	B	70.43 ± 1.54	0.610 ± 0.03	0.332 ± 0.11	31.22 ± 5.03	0.459 ± 0.12	0.290 ± 0.10
	C	697.00 ± 0.21	0.802 ± 0.26	0.640 ± 0.10	97.90 ± 8.97	0.117 ± 0.02	0.590 ± 0.12
	D	94.00 ± 5.21	1.450 ± 0.23	0.932 ± 0.	131.25 ± DC		

the fungal isolates was also studied. When enzyme production by the test isolates was compared under di erent modes of cultivation, it was found that there was a decrease in enzyme activity under LSF as compared to SSF. A decrease of 33.48% in LSF as compared to SSF for isolate A, a decrease of 31.35% in LSF as compared to SSF for isolate B, a decrease of 85.95% in LSF as compared to SSF for isolate C, a decrease of 54.25% in LSF as compared to SSF for isolate D, a decrease of 64.69% in LSF as compared to SSF for isolate E, a decrease of 76.49% in LSF as compared to SSF for isolate F, and a decrease of 56.98% in LSF as compared to SSF for isolate G, was observed. us, SSF was found to be the preferable mode of cultivation for all the test isolates. e greater xylanase production under SSF compared to LSF might be because SSF provided the fungus with an environment closer to its natural habitat (wood and decayed organic matter). is might have stimulated these strains to produce more hemicellulolytic enzymes [33]. Generally, in submerged cultivation, the growth form of lamentous fungi varies between pelleted and lamentous. Each form has its own characteristics and can a ect the rate of enzyme production by in uencing the mass transfer rate [33]. In Liquid State Fermentation (LSF), the fungus is exposed to hydrodynamic forces, while in SSF; growth is restricted to the surface of the solid matrix, with no such negative e ects [32]. Also, the hyphal mode of growth gives the lamentous fungi, the power to penetrate into the solid substrates. e cell wall structure is attached to the tip and the branching of the mycelium ensures a rm and solid structure. e hydrolytic enzymes are excreted at the hyphal tip without large dilution, as in the case of LSF. is makes the action of hydrolytic enzymes very e cient, and allows penetration into moist solid substrates. Penetration increases the accessibility of all the available nutrients within particles [34], and thus, enzyme production is higher in SSF. Also, catabolite repression and protein degradation by proteases that are severe problems in SmF, have o en been reported to be reduced or absent in SSF [35].

As is evident from table 2, the isolate C showed the highest xylanase activity (697 IU/mL), a er incubation period of 7 days, followed by isolates E (131.25 IU/mL)>D (94 IU/mL >B (80.41 IU/mL)>F (54.89 IU/mL)>G (17.90 IU/mL)>A (4.51 IU/mL), in that particular descending order, under conditions of SSF. e isolates showed poor cellulase activity and none of the isolates were found to be a non-cellulase producer. All the isolates also showed laccase production. Still the isolates can be employed for pulp biobleaching, as the cellulase activity reported was minimal in all the cases. Out of 7, 6 isolates (A, C, D, E, F, and G) showed maximum xylanase production a er