Enzymes from *Aspergillus niger*-a review

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Abstract

Generation of large amount of agro-industrial wastes resulted in environmental pollution. This problem of environmental pollution can be resolved by conversion of these wastes into valuable products using microbial enzymes. Microbial enzymes are gaining importance in various industries such as food, brewery, textile, paper and pulp, leather etc. *Aspergillus Niger* proves to be an excellent source of various enzymes. This is an overview of the enzymes produced by *Aspergillus Niger* and their applications.


Introduction

A large amount of agro industrial wastes are generated every year and their accumulation in the environment causes serious problem of pollution, as they serve as a source of pollution because of their improper management.

The recent thrust in bioconversion of agricultural and industrial wastes to chemical feedstock has led to extensive studies on cellulytic enzymes produced by fungi and bacteria (Baig et al., 2004). Large quantities of lignocellulosic wastes are generated through forestry, agricultural practices and industrial processes, particularly from agro-allied industries such as breweries, paper pulp, textile and timber industries. These wastes generally accumulate in the environment thereby causing pollution problem (Abu et al., 2000).

These agro-industrial wastes are the very useful and renewable resources which can be used for the production of different valuable products such as befouls, chemicals, cheap energy sources for fermentation, improved animal feeds and human nutrients (Belewu and Afolabi, 2000; Solomon et al., 1999; Wu and Lee, 1997; Howard et al., 2003). The elimination of these lignocellulosic wastes can leads to more friendly environment and also helps in the economic growth as these are cheap and almost inexhaustible source of raw material.

The agricultural wastes are composed essentially of cellulotic or lignocellulosic matter. These are considered to be the cheapest source for the production of different utilizable products throughout the world (Ali et al., 1991). Lignocelluloses are the most abundant natural materials present on the earth. The polysaccharide component includes cellulose and hemicelluloses, which comprises of about 65 - 75% of the total system. All lignocelluloses materials are formed predominantly of three components: cellulose, a structural carbohydrate responsible for strength and flexibility; lignin, a polyaromatic heteropolymer conferring decay resistance and hardness; and hemicelluloses, a structural carbohydrate intimately associated with lignin (Eaton and Hale, 1993).

In addition to cellulose, hemicelluloses and lignin plant cell wall contains extraneous components including extractives and no extractives. Extractives consist of fats, waxes, tannins, resins, etc. The non-extractives of extraneous components mainly consist of inorganic components such as...
silica, carbonates, oxalates etc (Kodali and Pogaku, 2006). Cellulose has enormous potential as a renewable source of energy (Coral et al., 2002). A great variety of fungi and bacteria can fragment these macromolecules by using hydrolytic or oxidative enzymes and use as a carbon source.

Plants and micro-organisms are likely to prove as more suitable tools for pollution control due to their versatility and adaptability. As compare to plant microbial hydrolysis of lignocelluloses wastes is more efficient strategy for the proper utilization of these wastes. (Dale 1999, Lynd et al. 1999).

Enzyme technology is an area of considerable current interest and development because of escalating market trends. In nature, microbes have been provided with vast potentials. They produce an array of enzymes, which have been exploited commercially over the years. Microbial enzymes are produced both from fungi as well as bacteria.

Many fungi from Asco- and Basidiomycetes can produce extra cellular enzymes that enable them to break down polysaccharides such as cellulose and convert these polymeric compounds into sugars. Certain bacteria such as those from genus Bacillus have enzymatic potential.

Most commonly used fungi for enzyme production are Trichoderma, Aspergillums, Penicillium, Fusarium, Myrothecium and Chaetomium (Clarke, 1997). Among these Aspergillus and Tricoderma (Godfrey and West, 1996; Uhlig, 1998) produces enzymes that account for approximately 20% of world enzyme market. (Mantyla et al., 1998)

Filamentous fungi belonging to the genus Aspergillus are commonly associated with biomass degradation and produce wide range of secreted hydrolases, including native endoand exo-acting enzymes involved in the degradation of plant cell walls. Strains of particularly the black aspergilli (Aspergillus niger group including well-known industrial strains of A. niger, Aspergillus aculeatus, and Aspergillus awamori) (Parenicova, 2000) have been used successfully as industrial host for the production of various plant cell wall degrading enzymes with cost-effective applications in the food and beverage, animal feed and paper-and-pulp industries. (De Vries, 2003).

Specific features that favour Aspergillus spp. for the production of industrial enzymes include its high secretion capacity, GRAS (Generally Regarded as Safe) status, rapid growth on inexpensive media and the large range of native enzymes produced. These features render Aspergillus spp. ideal for commodity enzyme applications on inexpensive media. Aspergillus species is the most common fungi which is present in human’s environment because it is capable of utilizing every type of substrate due to their greater variety of enzyme production (Lynd, 2002).

The members of Aspergillus species are major agents of decomposition and thus possess the ability to produce a range of enzymes. These enzymes liberate small molecules from polymers within the substrate that can be taken up to serve as nutrients. Apart from these enzymes, Aspergilli secrete high amounts of organic acids (e.g. citric acid, Taconic acid, gluconic acid and tartaric acid) (Nout et al., 2000). This secretory capacity in combination with the established fermentation technology and molecular biology makes Aspergillus species such as A. niger and A. oryzae attractive cell factories. Commercial citric acid production with the use of A. niger was already initiated at the starting of the twentieth century (Bennett et al., 1998), while partial purified amylase of A. oryzae was patented in 1894 as a substitute for malting enzyme in beer production and as a digestive aid for the treatment of dyspepsia (Takamine, 1894). Nowadays, glucoamylase is produced at 30 grams per litre (Finkelstein et al., 1989). This enzyme, which is used for the production of glucose syrups, is only one of the examples of enzymes from Aspergilli that are used in the food and feed industry.

**Enzymes of Aspergillus niger and their applications**

1. **α-Amylase**

α-Amylase have been used for the preparation of starch syrup and dextrose; in preparation of alcohol and beer. (Wong and Robertson, 2003) It is also used in food, baking, brewing, fermentation, detergent applications, textile desizing, paper industries, etc. (Pandya et al., 2005; Alwa et al., 2007).
2. **Catalase**
Diehl et al., 1936 describes the use of catalase for the preservation of colour, texture, flavour, taste and aroma of frozen foods. It is also used in removal of oxygen from foods, in diagnostic enzyme kits. (Berka et al. 1992).

3. **Cellulase**
Tenkanen et al., 2003 also reported the use of cellulase in brewing and baking; wine and juice production; improvement of digestibility of feed. Cellulolytic enzymes play an important role in nature's biodegradation processes where plant lignocellulosic materials are efficiently degraded by cellulolytic fungi and bacteria. There are several applications of cellulases in various industries, including food, brewery and wine, animal feed, pollution treatment, textile and laundry, pulp and paper, agriculture waste management, protoplast production, genetic engineering as well as in research and development. (Bhat, 2000; Tarek and Nagwa, 2007; Beguin and Anbert, 1993; Coughlan, 1985; Mandels, 1985) Cellulase production has attracted a worldwide attention due to the possibility of using this enzyme complex for conversion of abundantly available renewable lignocellulosic biomass for the production of carbohydrates for numerous industrial applications (Hayward et al., 2000).

4. **Feruloyl-esterase**
Williamson, 1998 reported the use of Feruloyl-esterase for the release of ferulic acid for vanillin production.

5. **Glucoamylase**
Glucoamylase have been used for the saccharification of steamed rice and potato; preparation of glucose syrup. (Reilly, 2003) Glucoamylase is one of the most important enzymes in food industries (Soccol, 1992), as it is used for the production of glucose and fructose syrup from liquefied starch (Nguyen et al., 2002). It is also employed in baking, juice, beverage pharmaceuticals, and many fermented foodstuffs industries for commercial production (Hesseltine, 1965; Rainbault, 1981), in some cases textile, leather and detergents industries (Whistler et al., 1984; Reed and Rhem, 1987).

6. **Glucose oxidase**
Glucose oxidase have been used for the removal of residual glucose or oxygen to increase shelf life; flavor and color stability; reduction of alcohol percentage in wine. (Frederick et al., 1990). Also used in diagnostic enzyme kits for glucose detection, for production of gluconic acid, (Berka et al. 1992).

7. **Lipase**
Wong, 2003, describes the application of lipase in manufacturing of cheese, cheese flavours and other dairy products. Lipase have several other applications such as, as additives in detergents, additives in detergents, the elaboration of dietetic foods for use in the food industry, obtaining bioactive molecules in the pharmaceutical industry and pure optical compounds in chemical synthesis processes (Hernaiz, 1999), as well as modifications of fats and lipids by hydrolysis and esterification reactions (Kazlauskas, 1994).

8. **Pectinase**
Pectinases were used in the food industry as early as 1930 (Kertesz, 1930). They are used in wine and fruit juice production to reduce juice viscosity before pressing and improve clarification (Grassin and Fauguenbergue, 1999; Kaur et al., 2004), Degumming of plant bast fibers (Kapoor et al., 2001), Retting of plant fibers (Hoondal et al., 2000), Coffee and tea fermentation (Carr, 1985), Improvement of chromaticity and stability of red wines (Revilla and Ganzalez, 2003).
9. **Phytase**
Misset, 2003 reported the use of phytase in degradation of phytate in animal feed and in starch processing.

10. **Proteases**
Proteases have been used in food industry for softening of dough; improvement of texture, elasticity and volume of bread; brewing; production of miso and tofu; flavour development in cheese; improving digestibility of animal feeds; preparation of soy bean milk and dehydrated soups; clarification of wine. (Whitaker, 2003)
They have diverse applications in a wide variety of industries, such as in detergent, pharmaceutical, leather, silk and for recovery of silver from used X-ray films (Ward, 1983; Gupta et al., 2002).

11. **Urease**
Urease has many industrial applications, e.g. in diagnostic kits for measuring urea, in alcoholic beverages as a urea reducing agent (Fujinawa and Dela, 1990; Fumuyiwa and Ouch, 1991), and in biosensors of haemodialysis systems for determining blood urea (Smith et al., 1993).

12. **Xylanases**
Xylanases have been used in the production of food-additives; improvement of digestibility of feed; preparation of baking products; clarification of fruit juices. (Biely, 2003)

**REFERENCES**


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