Chitinase enzyme and its potential applications

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Abstract

Chitin is the most abundant nitrogen containing biopolymer with a high turnover in nature, i.e. that most necessary in the carbon cycle. Chitinases are current in a vast vary of organisms, along with these that do no longer contain chitin, such as bacteria, viruses, greater plant life and animals the place they are recognized to play essential physiological and ecological roles. Chitinases have industrial and agricultural applications. In this mini review various functions of chitinases have been discussed.

Keywords: *Chitin, Chitinase, Biocontrol, Industrial application*

Introduction

The carbon cycle is one of the most important pathways on earth, maintaining the flux of raw materials and energy through varied living members of systems. Plants using the energy from sunlight, together with water, fix a considerable fraction of the total carbon dioxide in the atmosphere. Microbes such as bacteria and fungi are able to recycle the fixed carbon with their specific extracellular enzymes.

Chitin is the most abundant nitrogen containing biopolymer with a high turnover in nature, *i.e.* that most important in the carbon cycle. The abundance of chitin biomass is second only to cellulose, but when it comes to recycling, chitin degrades much faster though it is much insoluble polymer. Chitin is found among microorganisms and commonly distributed in invertebrates as structural components. In plants, chitin-derived molecules play a significant role in growth regulation. Approximately ten gigatons (1.10^{13} kg) of chitin are synthesized and degraded each year in the biosphere (Stevens, 1996; Muzzarelli, 1999).

It is fascinating to uncover the secrets of nature that allow the breakdown of such hard materials as cellulose and chitin. Most microorganisms, such as bacteria and fungi, have the appropriate tools, *i.e.* enzyme like chitinases to degrade such polymers. In most cases, there are multiple copies of the same type of enzyme (isozymes) with relatively small differences. The reasons for the occurrences of multiple copies of the same enzyme have yet to be fully disclosed, although it is presumed that such advantages do exist.

The agents needed for polymer breakdown, *e.g.* cellulases and chitinases, have become even more useful due to our ability to chose or tailor them to suit to our needs. Apart from the value of understanding the enzymology and carbon recycling, we gain information that has vast industrial and economic value by studying these enzymes. Chitin-active enzymes are important in chitosan production, and in obtaining smaller chitin-based compounds, as well as in plant protection and the production.

Chitin

In 1811 Henri Braconnot discovered it and was named by A. Odier in 1823, as *chitine* from the Greek *chiton* which means tunic or coverage. Chitin is an insoluble linear biopolymer of *N*-acetylglucosamine (GlcNAc). Chitin (Figure 1) consists of 1,4 glycosidic bonded units of 2-acetamido-2-deoxy-□-D-glucan (*N*-acetylglucosamine, GlcNAc). It is the second most common organic molecule next of biological origin found on our planet, after cellulose. The estimated annual production of this renewable biosource is in the order of 10 gigaton (Muzzarelli, 1999; Keyhani and Roseman, 1999).

In 1859, C. Rouget discovered Chitosan (Figure 1), the deacetylated form of chitin. The polysaccharides, chitin and chitosan show interesting physical and physicochemical properties. Peculiar glycosidic linkage of the polymer imparts relatively rigid structure.

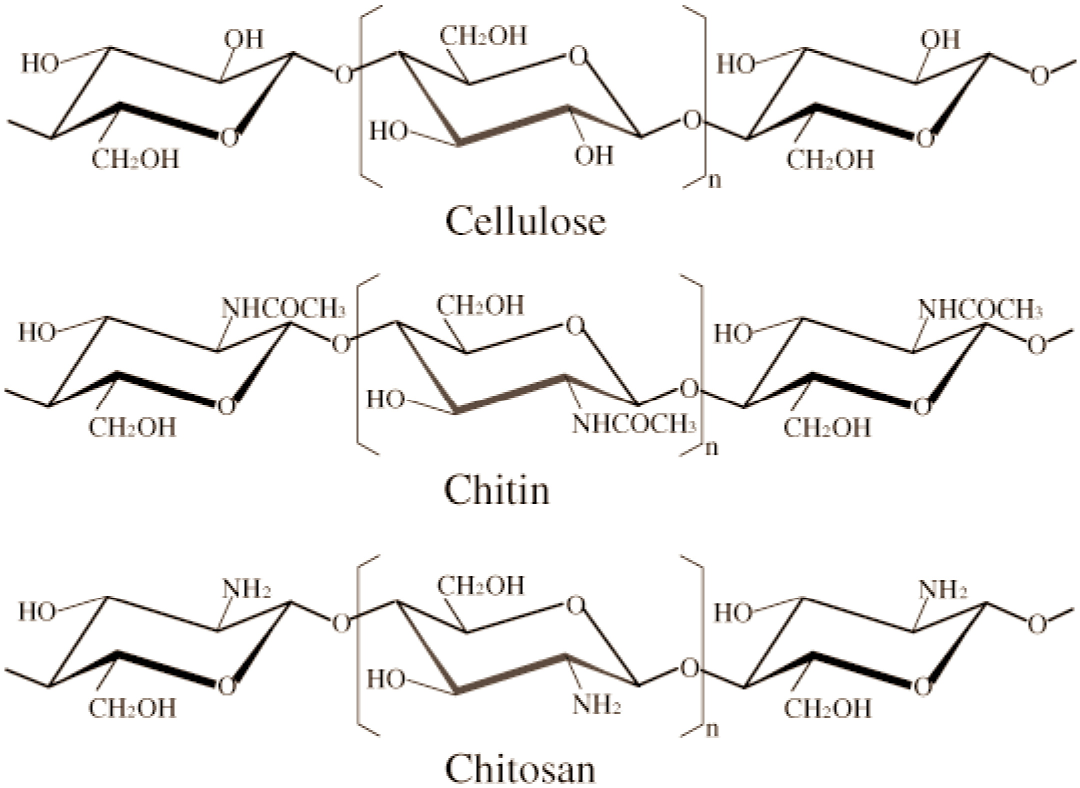

Figure1. Chemical structure

Occurrence of chitin

It is found as a component of many spores of streptomycetes and stems of prosthetic microorganisms (Gooday, 1995). Chitin is a key component of the cell phone wall and the partitions of most fungi. Its presence together with that of the different polysaccharides has been used as a criterion for mushroom taxonomy. The polysaccharide characterizes fibrils of a single length depending on the species and the cellular region (Gow and Gooday, 1983). The composition of the fungal movable wall has been described (Bartnicki-García, 1968). Chitin is present in cysts, some ciliate partitions, amoebas, Chrysophyta, algae and diatoms, the purest form of chitin is isolated from the diatom fluvitalis Thalassiosira (Bartnicki-Garcia and Lippman, 1982). In animals, it is as structural and limited to a few organs, such as integuments of arthropods, nematodes and molluscs and in the intestinal mucosa and the exoskeletons of insects.

Insect exoskeletons are mainly composed of chitin protein complexes, while shells of crustaceans incorporate gigantic proportions of $CaCO_3$ plus proteins (Kramer and Muthukrishnan, 1997). Chitin in nature exists between acetylated chitin and completely deacetylated chitosan. It has been observed that the mucor body Absidia has chitosan coerulae as a cell wall component (Muzzarelli et al., 1994).

Chitin degradation

A range of organisms possess chitinolytic ability. These are microorganisms such as bacteria and fungi, arthropods, additionally plants and greater animals such as amphibians, fish and mammals. Chitinase is one of the predominant weapons for the protection towards pathogens no longer solely in greater vegetation and seaweeds however additionally in fish and mammals. Microorganisms hydrolyze the chitinous substrates for vitamins or for phone proliferation, while arthropods such as bugs and crustaceans produce chitinase in order to degrade the exo-skeleton at some point of eckdysis (Koga two et al., 1999). Chitinases are categorized into GH families 18 and 19, and therefore possess exo appearing holding mechanism and endo acting inverting mechanism, respectively (Henrissat, 1999).

Chitinases

In 1911 Bernard reported chitinases, as thermosensitive and diffusible antifungal biochemical, following investigations by means of Jeauniaux (1961) rejuvenated interest in chitinases. Chitinases are present in a extensive range of organisms, along with those that do now not include chitin, such as bacteria, viruses, greater plant life and animals the place they are recognized to play necessary physiological and ecological roles Wang et al., 2005).

Occurrence

Chitinases are observed in a range of living organisms such as snails, crustacea, bugs

(Waterhouse et al.,1961), vertebrates (Jeuniaux, 1961) such as human serum (Escott two et al., 1996) and bean seeds (Jeuniaux, 1961). But the most handy source is the microorganisms (Nawani and Kapadnis, 2003).

Microorganisms: Chitinase production is widely dispensed amongst micro organism like, Chromobacterium, Klebsiella, Pseudomonas, Clostridium, Vibrio (Clarke and Tracey, 1956; Wang et al., 2005), and specifically Streptomycetes (Reynolds, 1954; Hoster et al., 2005). Chitinases are additionally produced by molds and fungi particularly Lycoperdon (Tracey, 1955). Chitinases can also be synthesized in the absence of substrate, constitutive enzyme (Claus, 1961) or in its presence adaptive enzyme (Reynolds, 1954). However, addition of chitin to way of life medium significantly enhances enzyme manufacturing (Reynolds, 1954; Cosio et al., 1982).

Animals: Chitinases are synthesized by way of some protozoans, and through exclusive glandular tissues of the digestive system of many coelenterates, nematodes, polychaetes and oligochaetes, molluscs, and arthropods. In vertebrates, chitinases are secreted through the pancreas and the gastric mucosa of insectivorous fishes, amphibians, and reptiles, as properly as with the aid of the gastric mucosa of some insectivorous birds and mammals (Jeuniaux, 1961; Manson et al., 1992).

Functions of chitinases

Microorganisms produce chitinase to digest the chitinous nutrient or to partially hydrolyze the chitinous phone wall for cellphone proliferation (Flach et al., 1992). In greater plants, chitinases are used for protection in opposition to plant pathogens and pests (Stinzi et al., 1993). The seaweed chitinases also play a role in defence comparable to plant chitinases (Sekiguchi et al., 1995). In insects and crustaceans, chitinase acts via degrading the exoskeletal chitin in the cuticle or shell for ecdysis (Kramer and Koga, 1986). Fish and mammals also use chitinase for protection (Flach et al., 1992). Thus, these residing organisms produce and use chitinase for their own unique and organic purposes.

Genetics of chitinase

Studies on the genetics of chitinase were initiated with Serratia liquefaciens (Joshi et al., 1988). It has been found that the genes chi B, C chi, chi D and E are accurately Chi Chi Un tied to the chromosome in a separate neighborhood. The code chi A and chi B codes for chitinases and the C code for quitobiase. Transposon mutagenesis and evaluation revealed that chi D removal encodes a repressor and chitinase expression quitobiasa while chi and encodes an inducer. Suzuki et al. (1998) expressed the presence of CBP21 (chitin binding protein) in the important protein supernatant when Serratia marcescens 2170 was cultured in the presence of chitin. Comparing the amino acid sequence with other proteins confirmed that CBP21, similar to olivaceoviridis Streptomyces CHB1, suggesting a protein binding distribution as chitin in chitinolytic microorganisms. Although natural organisms provide an important supply of chitinolytic enzymes, genetic improvement plays a vital role in their biotechnological applications. The traditional processes for the improvement of tension are the mutation and fusion of protoplasts (Patil et al., 2000). The simplicity gain mutation requires little understanding of the physiology and genetics of the essential pathways involved in the biosynthesis of the favored product and requires minimal technical manipulations (Rowlands, 1984). In addition to the fusion of protoplasts and mutation, molecular cloning is effectively used to acquire chitinase overproduction (Patil et al., 2000).

Application of chitinase

Chitinases have industrial and agricultural purposes (Shaikh and Deshpande, 1993). Biocontrol of pathogenic fungi of plants and insects. The chitinase-producing organisms are used in agriculture as a good biological control agent for a variety of phytopathogenic fungi. Trichoderma harzianum chitinase used to be placed in energy to the widest range of pathogens and terricolous fungi (Lorito et al, 1998). Aeromonas pollution cavy polluted by Fusarium solani oxysporium and Rhizoctonia on cotton and Sclerotium rolfsi in chitinase grains that produce (Inbar and Chet, 1991). Fucarium chlamydosporium a micoparasite of rust mushroom peanuts, Puccinia arachidis produces endocitinasa by inhibiting uredospores germination of the fungus of rust (Mathavanan et al, 1998). Mirothecium verrucaria produced high levels of extracellular myolithic enzymes, viz. chitinase β-1,3-glucanase and protease (Viyas and Deshpande, 1989), the raw micolítica practice used to be gentle Sclerotium rolfsii, a fungus that infects peanut roots. insect fungal pathogens, Beauveria bassiana, Beauveria brongniartii and Verticillium lecaniii produced enzymes that degrade the cuticle when grown in soil containing chitin, pre-treatment of insects such as aphids and beetles with the enzymatic response used (Patil et al., 2000). In enzyme chitin insects, he described chitinases Bombyx mori, Manduca sexta and several other species. Likewise, chitinases have been implicated in special morphological occasions in fungi.

Transgenic plants

The chitinase effort compared to mushrooms makes it a good candidate for the development of resistant varieties of agricultural crops vital for agriculture. Once established that a tobacco hybrid Nicotiana glutinosa and Nicotiana debneyi is more resistant than both guardians to a sufficient number of fungal pathogens due to excessive levels of expression of chitinase (Ahl et al., 1992). High resistance was expressed in contrast to the fungal pathogen Sphaerotheca humuli in the transgenic strawberry expressing a rice chitinase gene (Asao et al, 1997). Furthermore, Tabei et al. (1998) declared the transgenic cucumber vegetation that houses a rice chitinase gene that shows a more desirable resistance to Botrytis cinerea. Furthermore, Chen et al. (1999) described the late development of grain crust signs in transgenic plants that constitutively expressed a chitinase gene in rice. Datta et al. (2000) have shown that transgenic rice cultivars carrying the category I rice chitinase gene show a more advantageous resistance to the bacterial pathogen of rhizoctonia solani pod. Mosquito control Mirothecium verrucaria, a saprophytic fungus, produces a complete complex of degrading enzymes of the insect cuticle (Shaikh and Deshpande, 1993). It was determined that the larvae of Aedes aegypti mosquitoes of the first and fourth stage are killed within 48 hours after the application of the instruction of the raw enzymes of Myrothecium varrucaria (Mendonsa et al., 1996). Quito-oligosaccharide production. There is a growing perception of the possibility that biologically active quito-oil-saccharides can be used as inductors, antibacterial products vendors (Jeon and Kim, 2000) and immuno-inhibitors (Suzuki et al., 1986). It has been said that chitohexaose and chitoheptaosa exhibit antitumor activity. GlcNAc itself is also an anti-inflammatory agent (Patil et al., 2000).

Bioconversion

To comply with environmental regulations, shrimp processing equipment has been forced to reflect preferences on internal dumping or the transport of waste materials to the sea. To overcome this discomfort and make the environment compliant, Serratia marcescens chitinase used to hydrolyse in the chitinous tissue (Revah-Moiseev and Carroad, 1981).

Various applications

One of the main aspects of the enzyme complex of lysis of the fungal cell wall. (it was discovered that chitinase and chitosanase) allow the positive degradation of fungal mycelia (Vyas and Deshpande, 1989) and the formation of protoplasts (Gokhale, 1992).

Giambattista et al. (2001) described the use of chitinase Penicillium janthinellum P9 to improve the germination of the lyophilized spores. Thanks to their particular binding properties to monosaccharides, lectins can be used to find sugar residues in thin sections of plants and fungi. Likewise, hydrolytic enzymes such as chitinases can also be used to detect fungal pathogens with chitinous cell walls. The chitinase-gold complex was proposed for this reason (Benhamou and Asselin, 1989).

Disease remedy

The chitinases had been determined as natural antimicrobial agents (Fusetti et al., 2002). The enzymes in tablets have two important aspects that distinguish them from different types of drugs. Firstly, enzymes bind regularly and act on their ambitions with extraordinary affinity and specificity. Secondly, the enzymes are catalytic and convert more than one target molecule into the preferred products. These two characteristics make the enzymes special and powerful drugs that can reach a therapeutic biochemistry in the body that small molecules can not. These traits have led to the development of many enzymatic pills for a wide variety of problems (Vellard, 2003).

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