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Mini Review

Phytopathogenic Fungi: Useful Tools to Degrade Plant Biomass for Bioethanol Production

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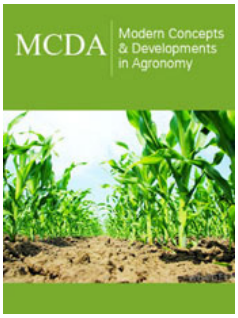

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Abstract

Phytopathogenic fungi are able to produce enzymes for cell wall degradation when they attack the hosts and there is a close relationship between the capacity of enzymatic secretion and the virulence of these microorganisms. These enzymes are promising for biotechnological purposes and plant biomasses play an important role for induction of their production by fungal species. Biomass is an economic alternative to reduce pollution and to produce renewable fuels. The fungal enzymes are mainly applied for the hydrolysis step of bioethanol production process, which is environmentally friend. Many phytopathogen fungi are considered promising for enzymes production such as *Chrysoporthe cubensis, Ceratocystis fimbriata* and *Fusarium verticillioides*.

Introduction

Plant biomasses

Residues from agriculture, forests and industries have highly increased with the expansion of the world population and studies stipulate that there will be around 8.5 billion of persons by 2030 in the planet, which could cause serious environmental and socio-economic consequences [1]. However, agricultural by-products, which are lignocellulosic wastes, constitute promising renewable resources for bioethanol production since they are widely available and rich in polysaccharides as cellulose and hemicellulose [2]. The use of plant biomasses as renewable energy reduces environmental problems such as pollution and fires [1]. For bioethanol production from plant biomass, three major steps are necessary: pretreatment, hydrolysis and fermentation. Pretreatment is required to alter the biomass structure and to facilitate the enzymatic access; enzymatic hydrolysis converts polysaccharides into monomeric sugars; and fermentation turns these sugars into ethanol [3]. The enzymatic hydrolysis is the major bottleneck of the process due to the reduced efficiency and the high costs of enzymes and fungi are the main producers of the enzymes for this step [3].

Phytopathogen fungi

Due to the expansion of planted areas, selection of most productive genotypes, climate changes and transit of people and products, the occurrence of biotic diseases, especially caused by fungi has increased, leading to great damages on crop yields [4]. Nearly 10 % of the identified fungal species can cause disease in more than 10,000 plants and they show different mode of actions since some fungi invade and colonize all tissues while others attack specific parts of the plants such as seeds, leaves, roots or stems [5]. Therefore, several alternatives are employed to control fungal diseases on plants, from the use of synthetic fungicides to the application of biological controls [6]. However, to cause a disease, phytopathogen fungi secrete enzymes to degrade hosts cell walls and there is a close relationship between the capacity of enzymatic secretion and the fungal pathogenicity [7]. The production of extracellular enzymes occurs not only to digest the polymers and to obtain nutrients for survival but also to degrade the cell wall barrier for penetration and spread through the plant tissue [8]. Thus, a more virulent phytopathogen shows great appeal for enzymes production.

Worldwide interest has focused on producing enzymes from phytopathogenic fungi for several biotechnological applications, including degradation of plant biomasses, i.e. agricultural residues, for bioethanol production. Sugarcane bagasse, rice husk, soybean hulls, powder toothpick yerba mate, corn and sorghum stover and wheat bran are some of the most used biomasses for enzymatic production by fungi [7,9,10]. The produced enzymes are mainly applied for bioethanol production, which between the alternative energy sources, is efficient and considered environmentally friend due to its sustainable properties [1]. It is worthy to mention that plant biomasses are used to cultivate fungi and to induce their enzymatic production, but also as substrates for bioethanol production, since they can be hydrolyzed into fermented sugars.

Enzymes from phytopathogenic fungi

Many phytopathogen fungi are promising for enzymes production applied in the hydrolysis step for bioethanol production processes. Recently, our research group has published data about *Chrysoporthe cubensis* (Bruner) Gryzenhout & Wingf MJ [11], *Ceratocystis fimbriata* Ellis & Halst and *Fusarium verticillioides* (Sacc.) Nirenberg. *Chrysoporthe cubensis* causes Chrysoporthe canker, one of the most important diseases of *Eucalyptus* spp. in tropical and subtropical areas of the world [10]. This fungus releases lignocellulolytic enzymes as cellulases, hemicellulases, laccases and accessory enzymes of interest capable of efficiently catalyze the hydrolysis of plant biomasses such as sugarcane bagasse [7,9,12-14]. *Ceratocystis fimbriata* was firstly described by Halsted in 1980, causing sweet potato rot, and it is largely found in several environments, mainly attacking crops in tropical climate areas [15]. This fungus is able to produce an accessory enzyme, β-xylosidase, essential for hemicellulose hydrolysis of sugarcane bagasse [16]. *Fusarium verticillioides* cause disease on maize plantations representing a serious economic threat to its production and quality [17]. This fungus is able to secrete endoglucanase, the first enzyme to act on cellulose, and a multienzymatic complex that contains two endoglucanases, one cellobiohydrolase and one xylanase for biomass degradation [18].

Final considerations

Although we recognize the negative impact of the phytopatogenic fungi on crop yields, concerning the serious consequences of the distinct diseases, it is important to emphasize that these microorganisms are useful for biotechnological purposes, especially production of enzymes for agricultural residues degradation. These enzymes are normally induced by biomasses, which is promising for the environment and the economy, since the lignocellulosic residues are highly available non-expensive resources. Applying enzymes from phytopatogenic fungi for generation of renewable fuels is a great possibility to regenerate waste and to extract useful metabolites from these microorganisms.

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