

Cellulolytic microbes: Potential living resources for industrial applications in Sri Lanka

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Discovery of microbes: the emergence of an invisible world

The discovery of microbes dates back to 17th century. Simple microscopic observations, descriptions and depictions of protozoa and bacteria by Antoni van Leeuwenhoek; “the father of Microbiology”, and the initial illustrations of *Mucor*, a microfungus by Robert Hooke provided the most important preliminary insights on the existence of microbes. Since the discovery of this new world of microscopic inhabitants, scientists became more curious to learn further about these amazing living entities.

Initially, microbes were mostly known as accelerators of domestic food processing practices such as making bread, preparing wine, vinegar, toddy, pickles etc. and as causative agents of infectious diseases. Therefore, human–microbe interrelationship has a long history. Consequently, microbes were recognized as indispensable biological resources in more advanced

biotechnological applications. With the developments in science and technology, people were keen on finding out the underlying biochemical basis of these microbial processes. Accordingly, the role played by microbial enzymes was revealed. Currently, the worldwide recognition earned by microbial enzymes is enormous due to their widespread applications in various industries including agriculture, medicine, environmental conservation, bioenergy production, technical use, food manufacturing, animal nutrition, cosmetics, and as tools for research and development.

Cellulolytic microbes: the decomposers of cellulose

Imagine, what would happen in a world without cellulolytic microbes? There may be plant debris, fallen leaves, branches or twigs piled up everywhere on the earth’s surface without decaying. so, how do these cellulolytic microbes digest and remove plant waste materials? To answer this question, it is necessary to understand the general structural makeup of plants. The major structural component

of plant debris is cellulose, because it is the substance that forms most of a plant’s cell wall. Since it is present in all the plants, cellulose is probably the most abundant complex polysaccharide on earth.

Cellulolytic microbes produce “cellulase” which is the enzyme that catalyzes the decomposition of cellulose; that to, their carbon and energy source. Being a multiple enzyme complex, cellulase sequentially acts on the cellulose polymer, and breaks down its β -1, 4-linkages. This cellulose digestion process produces easily fermentable sugar forms like glucose, cellobiose and simple oligosaccharides. However, the complete enzymatic hydrolysis and hydrolytic productivity of cellulose require the synergistic action of three major enzymes: endoglucanase, exoglucanase and beta-glycosidase. Different microorganisms produce different quantities of these enzymes in a complex which directly affect the cellulose digestion efficacy of individual microbes. In nature, microorganisms do not act individually on cellulose; rather they carry out these reactions

synergistically in order to attain their daily energy requirements in a sufficient way. This synergism makes cellulose hydrolysis a very efficient process in the natural environment. Unsurprisingly, making these cellulolytic microbes to perform the same natural cellulose hydrolysis process in an industrial setting would demand both theoretical and practical interventions of science.

Microbial cellulases: current global trends

Cellulose could be utilized as a renewable and a cost-effective raw material in many industries through microbial cellulase. This is particularly the era during which the world makes an effort to implement sustainable development concepts. Hence, there is an enormous recognition

transformation of cellulosic biomass into sustainable biofuels is one of the emerging trends in the world. It is a promising alternative for fossil fuels as it would provide solutions to global increase in energy demand and depletion of fossil fuel stocks.

Using cellulases in the industrial sector however, is not a new concept. Cellulase has been commercially utilized for more than 30 years. In recent times the worldwide recognition earned by microbial cellulases is extensive due to their widespread applications in the textile industry for textile wet processing, bio stoning of denim fabric, biopolishing of textile fibers, softening of garments, removal of excess dye from fabrics, and production of laundry detergents. Additionally, cellulases are applied in pulp and paper industry, food

applications, protoplast production, genetic engineering and pollution treatment.

As cellulase is of microbial origin, even today, scientists all over the world are exploring the nature for more efficient cellulase producing microorganisms. There is a huge potential to extract the enzyme from these microbes, which could be applied in industries. A broad range of cellulases producing microorganisms including bacteria and fungi have been identified so far. They may be either aerobic or anaerobic microorganisms. However, aerobic microorganisms such as filamentous fungi are found to be more efficient in cellulase production.

Although an impressive collection of fungi such as *Trichoderma* spp., *Aspergillus* spp., *Penicillium* spp.,

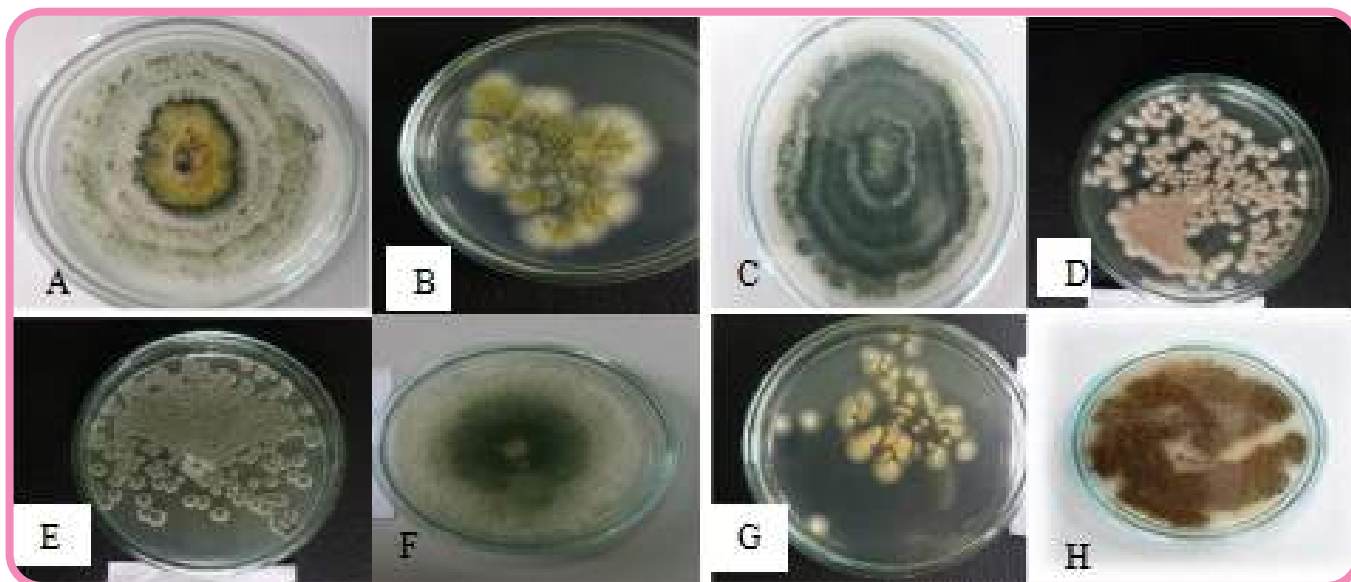


Figure 01: Locally isolated cellulolytic microorganisms. (A). *Trichoderma* sp. (B) *Aspergillus* sp. (C). *Trichoderma* sp. (D). *Fusarium* sp. (E). *Penicillium* sp. (F). *Trichoderma* sp. (G). *Aspergillus* sp. (H). *Aspergillus* sp.

for ecofriendly, microbial processes of converting cellulosic biomass into energy, It also has contributed to the expansion of global cellulase enzyme market. Especially,

processing, brewing, plant fiber extraction, animal feed, agriculture, olive oil extraction, carotenoid extraction, pharmaceutical and medical sciences, analytical

etc., have been studied for being cellulolytic, *Trichoderma reesei* is one of the main fungal species which is broadly utilized in industrial scale cellulase production. They

produce an extracellular cellulase enzyme complex which makes it easier harvesting the enzyme in the downstream process. Anaerobic microorganisms, for example, bacteria like *Clostridium thermocellum* produces a cell-attached cellulosome which has the ability to directly attack crystalline as well as amorphous regions of cellulose. In the above context, discovering more efficient cellulolytic microbes could be a better approach of meeting the huge demand for the enzyme in the global market.

Cellulolytic microbes: The Sri Lankan context

Sri Lanka imports cellulase as it is an indispensable ingredient in the denim stone-wash or enzyme washing plants in the apparel industry. As a consequence, the industrial expenditure on cellulase imports is significantly higher. Hence the production of cellulases from indigenous microbes would be a remedial action to decrease this huge outflow of funds from the country on cellulase imports. Moreover, establishment of biotechnological strategies to produce cellulase locally is a possibility because of Sri Lanka's rich biodiversity. Our natural habitats, including tropical rain forests are teeming with cellulase secreting microbes. Unfortunately, they are an underutilized natural wealth.

Several Sri Lankan scientists have already initiated steps to explore the natural environment for cellulolytic microbes, and are evaluating their potential applications. Many scientific investigations have been conducted and are continuing on isolation, identification and

studying the possible applications of microbial cellulases. In the context of cellulolytic microbes and their enzyme systems, Sri Lankan scientists are expected to contribute greatly to further discoveries. It is essential to study

essential to enhance microbial cellulase production efficiency. Currently, there are promising molecular biotechnological approaches to enhance cellulase production by microorganisms. If developed to large scale

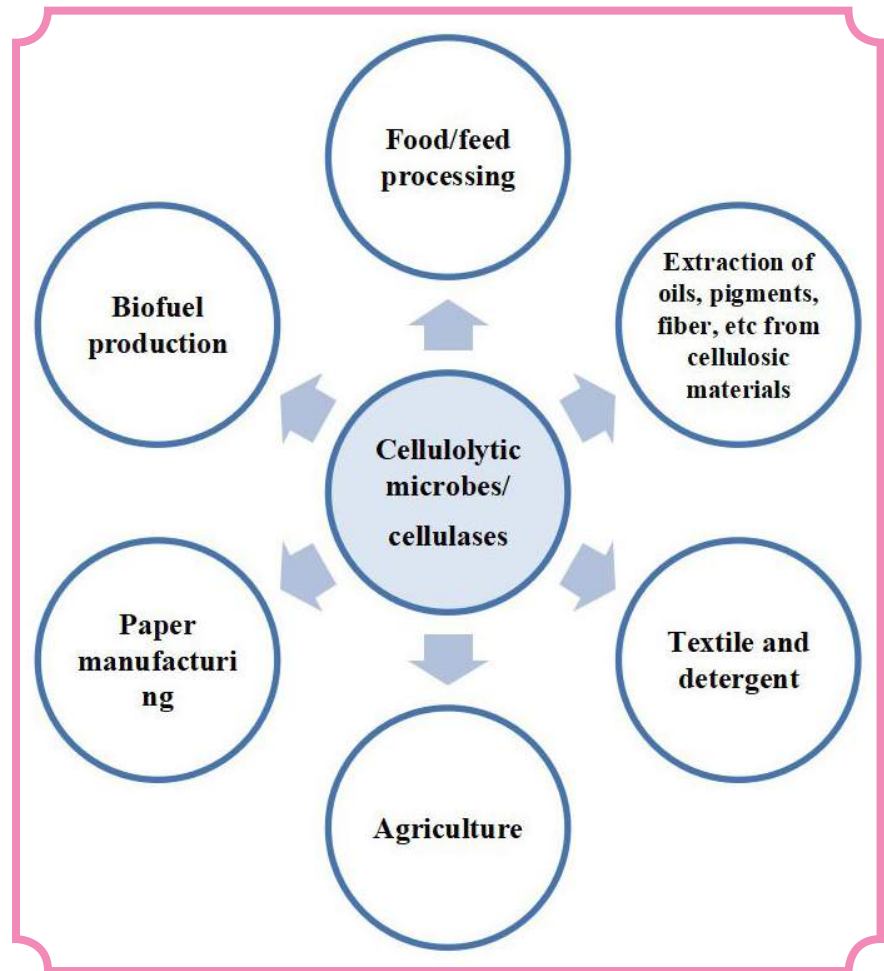
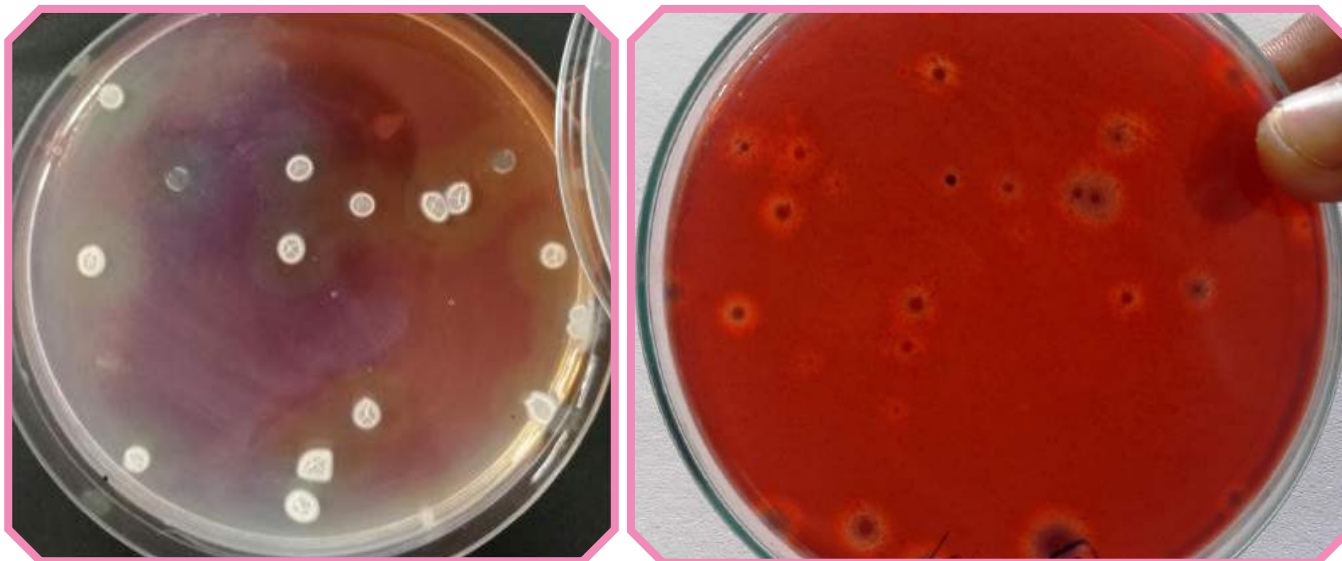


Figure 02: Potential industrial uses of cellulolytic microbes

diverse cellulase enzyme systems veiled by these microorganisms. In addition, well-organized application strategies (i.e. which include optimum reaction conditions, rate limiting factors, composition of cellulose, composition of cellulase, etc.) are required to utilize cellulase obtained from locally isolated microorganisms in industrially significant process. For this purpose, it is also

production it would open up new investment opportunities in the country beginning from cellulase production to a broad range of other industrial applications. They must also take initiatives to share the discovered knowledge with potential entrepreneurs, investors or industries that are capable of practically applying this knowledge.

Especially, as a solution for rising fuel demands in Sri Lanka,



the production and use of cellulosic biofuels could be popularized. Many countries in the world such as Brazil, USA, and Europe commercially use biofuels to fulfill their energy needs. Therefore, incorporation of these underutilized microbial resources into biofuel production is possible and it would be a great step forward in the advancement of Sri Lankan economy. However, it is impossible to ignore the fact that it is a time consuming process to establish a long lasting, well-functioning production process. It demands continuous research and development activities to maintain a productive industrial process.

Moreover, Sri Lanka has a rich history of cultivating their crops using organic fertilizer. Even without knowing the scientific mechanisms operating in the process, they traditionally used the natural microbial processes to add nutrients to their fields by incorporating cattle dung, paddy straw, rice husks, coir dust and leaves from different nitrogen rich plants like *Gliricidia* spp. Our ancestors increased

their harvests by applying these traditional agricultural techniques. Therefore, it is possible to use cellulolytic microorganisms in combination with other microbes such as nitrogen-fixing bacteria, and phosphate solubilizing bacteria to derive manure from cellulosic waste. However, returning to these eco-friendly microbial based agricultural systems cannot be achieved within a short period of time. At the same time, it is crucial to establish the most suitable, ecofriendly method that fits the modern-day agriculture. Moreover, the national paper manufacturing industry in Sri Lanka could be uplifted by introducing strategies to convert various cellulosic biomass into paper using locally isolated cellulolytic microorganisms. Additionally, locally produced cellulase could be used in local denim washing plants. Afore-mentioned are only a few examples for potential use of cellulolytic microbes in Sri Lankan industries. Apparently, there is a huge potential of utilizing locally isolated cellulolytic microbes and their enzymes for the development of industrial

sector. However, the prerequisite is to explore the natural habitat of Sri Lanka for these marvelous natural resources and institute a national policy for channeling those promising scientific findings to industrial scale applications.



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