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Biotechnological applications of *Clostridium thermocellum* and *Bacillus coagulans*

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Abstract

Clostridium thermocellum and *Bacillus coagulans* both bacteria hold commercial biotechnological importance because of their capability to produce numerous industrial products such as *Clostridium thermocellum* due to its cellulose fermenting capability is used either as pure or in the form of co cultures to produce alternative sustainable *energy* sources such as biofuels including bioethanol, biogas, organic acid, acetic acid derivatives. On the other hand, *Bacillus coagulans* is a well-known probiotic incorporated in numerous food product such as yoghurt, juices etc and medicine. In addition, capable to produce biohydrogen from agricultural wastes.

Keywords: organic acid; probiotics; anaerobic; fermentation; biohydrogen

Introduction:

Clostridium thermocellum is a type of gram-positive, thermophilic, cellulolytic microorganisms in the family *Clostridaceae* [1]. This bacterium cell body possess a solitary lipid bilayer giving it a rod-shape morphology [2]. G+C content in their genome accounts approximately 21 to 54 percent [3]. In addition, these bacteria reproduce by forming spores and are capable of breaking down cellobiose and cellulose to ethanol through anaerobic fermentation [4,5]. *Clostridium thermocellum* offers industrial benefits since it have its cellulolytic and ethanologenic potential for transforming cellulosic substrate into ethanol i.e., convert biomass into a usable energy source [6,7]. The breakdown of cellulose is achieved with in the bacterium by means of extracellular cellulase framework called as cellulosome [8]. The cellulase framework of the bacterium varies from fungal cellulases because of its capability to solubilize translucent cellulose, e.g., cotton [9]. However, it produces low ethanol yield, because of extended fermentation pathways that produce acetic acid derivatives, formate, and lactate alongside ethanol [10,11]. New studies have been coordinated to enhance the ethanol-producing metabolic pathway in order to make more effective biomass transformation [12].

Application of *Clostridium thermocellum* in Biotechnology:

- Renewable resources can be transformed into biofuels and biosolvents by utilizing *Clostridium thermocellum* bacterial cultures or cocultures which provides functional factors more effectively than single cultures. For instance, in the co-culture of *C. thermocellum* JN4 and *Thermoanaerobacterium thermosaccharolyticum* GD17, the cellulase complex of *C. thermocellum* JN4 can hydrolyze xylan to xylobiose and xylose yet can't use xylobiose or xylose, however *T. thermosaccharolyticum* GD17 can use these substrates to produce hydrogen, natural acids and ethanol [13].
- Bioprocesses, in food manufacturing including cheese/yoghurt manufacture, Belgian beer production etc [14]
- Biodegradation in wastewater treatment and soil bioremediation [15].
- Biofuel production using cellulose or lignin-based feedstock including rice/wheat straw, corn/sorghum stalk, crude glycerol, banana agro-waste etc [16].
- Biosynthesis of organic acids including acetic acid, butyric acid, alcohols etc *Bacillus coagulans* is a bacterium also known as "helpful" bacteria but

sometimes is misclassified as lactobacillus since it produces lactic acid [18]. *Bacillus coagulans* is really showcased as *Lactobacillus sporogenes* in a few commercial products [19]. However it can easily be distinguished from other species from its spores [20].

Application of *Bacillus coagulans* in Biotechnology:

- *Bacillus coagulans* exhibits probiotic activity that is impervious to high temperatures [21]. In addition, *Bacillus coagulans* proteins have been utilized in food production or its incorporation as probiotics in food products [22].
- *Bacillus coagulans* incorporation in food matrix including probiotic yoghurt and juice products [23]
- Production of biohydrogen biofuel from agricultural wastewater and molasses using *Bacillus coagulans*[24].
- *Bacillus coagulans* incorporation in medicine for the treatment of diarrhea, constipation, stomach pain etc [25].

Conclusion:

Thus, both the bacterial species i.e., *Clostridium thermocellum* and *Bacillus coagulans* holds commercial importance in the industrial sector for producing diversity of products

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