MedPress
Nutrition & Food Sciences

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

Mini–Review

Nida Tabassum Khan[1,*]

[1] Department of Biotechnology, Faculty of Life Sciences & Informatics, Balochistan University of Information Technology, Engineering and Management Sciences (BUITEMS), Takatu Campus, Airport Road, Quetta, Balochistan, Pakistan.

***Corresponding author**

Nida Tabassum Khan, Department of Biotechnology, Faculty of Life Sciences & Informatics, Balochistan University of Information Technology, Engineering and Management Sciences (BUITEMS), Takatu Campus, Airport Road, Quetta, Balochistan, Pakistan, Tel: 03368164903;
Email: nidatabassumkhan@yahoo.com.

Article Information

Received: 05-08-2022;
Accepted: 24-08-2022;
Published: 29-09-2022.

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 are used either as pure or as co–cultures to produce alternative sustainable energy sources such as biofuels including bioethanol, biogas, organic acid, acetic acid derivatives. Bacillus coagulans are well–known probiotic incorporated in numerous food products, such as yogurt, juices and medicine. In addition, it can 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 *Clostridaceae* family [1]. This bacterium cell body possesses a solitary lipid bilayer, giving it rod–shaped morphology [2]. G+C content in their genome accounts for approximately 21 to 54 percent [3]. These bacteria reproduce by forming spores and can break down cellobiose and cellulose into ethanol through anaerobic fermentation [4,5]. *Clostridium thermocellum* offers industrial benefits, as its cellulolytic and ethanologenic potential to transform the cellulosic substrate into ethanol, i.e., to convert biomass into a usable energy source [6,7]. The breakdown of cellulose is achieved within the bacterium using an extracellular cellulase framework called 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, due to extended fermentation pathways that produce acetic acid derivatives, formate, and lactate with ethanol [10,11]. New studies have been coordinated to enhance the ethanol–producing metabolic pathway to make more effective biomass transformation [12].

Application of *Clostridium thermocellum* in Biotechnology

- Renewable resources can be transformed into biofuels and bio–solvents by utilizing *Clostridium thermocellum* bacterial cultures or cocultures which provide 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/ yogurt 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 [17].

Bacillus coagulans is a bacterium also known as "helpful" bacteria but sometimes is misclassified as lactobacillus since it produces lactic acid [18]. *Bacillus coagulans* are presented as *Lactobacillus sporogenes* in a few commercial products [19]. However, it can be easily distinguished from other species from its spores [20].

Application of *Bacillus coagulans* in Biotechnology

- *Bacillus coagulans* exhibit a probiotic activity that is impervious to high temperatures [21]. In addition, *Bacillus coagulans* proteins have been used in food production or incorporated as probiotics in food products [22].
- *Bacillus coagulans* are incorporated into the food matrix including probiotic yogurt and juice products [23].
- Production of biohydrogen biofuels from agricultural wastewater and molasses using *Bacillus coagulans* [24].
- *Bacillus coagulans* are incorporated into medicines for the treatment of diarrhea, constipation, stomach pain, etc [25].

Citation: Khan NT. Biotechnological applications of Clostridium thermocellum and Bacillus coagulans. Medp Nutr Food Sci. 2022; 1(1): mpnfs–202208001.

Conclusion

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

Conflict of interest

None

Source of Funding

None.

References:

1. McBee R. The characteristics of *Clostridium thermocellum*. Journal of bacteriology. 1954;67(4): 505–506.
2. Freier D, Mothershed CP, Wiegel J. Characterization of *Clostridium thermocellum* JW20. Applied and environmental microbiology. 1988;54(1): 204–211.
3. Bayer EA, Kenig R, Lamed R. Adherence of *Clostridium thermocellum* to cellulose. Journal of Bacteriology. 1983;156(2): 818–827.
4. Tyurin MV, Desai SG, Lynd LR. Electrotransformation of *Clostridium thermocellum*. Applied and Environmental Microbiology. 2004;70(2): 883–890.
5. Ng TK, Weimer PJ, Zeikus JG. Cellulolytic and physiological properties of *Clostridium thermocellum*. Archives of Microbiology. 1977;114(1): 1–7.
6. Lamed R, Bayer EA. The cellulosome of *Clostridium thermocellum*. Advances in applied microbiology. 1988;33: 1–46.
7. Akinosho H, Yee K, Close D, Ragauskas A. The emergence of *Clostridium thermocellum* as a high utility candidate for consolidated bioprocessing applications. Frontiers in chemistry. 2014;2: 66.
8. Johnson EA, Sakajoh M, Halliwell G, Madia A, Demain AL. Saccharification of complex cellulosic substrates by the cellulase system from *Clostridium thermocellum*. Applied and Environmental Microbiology. 1982;43(5): 1125–1132.
9. Zhang YHP, Lynd LR. Cellulose utilization by *Clostridium thermocellum*: bioenergetics and hydrolysis product assimilation. Proceedings of the National Academy of Sciences. 2005;102(20): 7321–7325.
10. Garcia–Martinez DV, Shinmyo A, Madia A, Demain AL. Studies on cellulase production by *Clostridium thermocellum*. European journal of applied microbiology and biotechnology. 1980;9(3): 189–197.
11. Chakraborty S, Fernandes VO, Dias FM, Prates JA, Ferreira LM, et al. Role of pectinolytic enzymes identified in *Clostridium thermocellum* cellulosome. PLoS One. 2015;10(2): e0116787.
12. Bayer EA, & Lamed R. Ultrastructure of the cell surface cellulosome of *Clostridium thermocellum* and its interaction with cellulose. Journal of Bacteriology. 1986;167(3): 828–836.
13. Ng TK, Ben–Bassat A, Zeikus JG. Ethanol production by thermophilic bacteria: fermentation of cellulosic substrates by cocultures of *Clostridium thermocellum* and *Clostridium thermohydrosulfuricum*. Applied and environmental microbiology. 1981;41(6): 1337–1343.
14. Lin PP, Mi L, Morioka AH, Yoshino KM, Konishi S, et al. Consolidated bioprocessing of cellulose to isobutanol using *Clostridium thermocellum*. Metabolic Engineering. 2015;31: 44–52.
15. Pérez J, Munoz–Dorado J, De la Rubia TDLR, Martinez J. Biodegradation and biological treatments of cellulose, hemicellulose and lignin: an overview. International microbiology. 2002;5(2): 53–63.
16. Balusu R, Paduru RR, Kuravi SK, Seenayya G, Reddy GJPB. Optimization of critical medium components using response surface methodology for ethanol production from cellulosic biomass by *Clostridium thermocellum* SS19. Process Biochemistry. 2005;40(9): 3025–3030.
17. Sato K, Goto S, Yonemura S, Sekine K, Okuma E, et al. Effect of yeast extract and vitamin B_{12} on ethanol production from cellulose by *Clostridium thermocellum* I–1–B. Applied and environmental microbiology. 1992;58(2): 734–736.
18. Jurenka JS. Bacillus coagulans. Alternative medicine review. 2012;17(1): 76–82.
19. Baliyan N, Kumari M, Kumari P, Dindhoria K, Mukhia S, et al. 4–Probiotics in fermented products and supplements. Elsevier: In Current Developments in Biotechnology and Bioengineering. 2022: 3–107.
20. Roberts CM, Hoover DG. Sensitivity of *Bacillus coagulans* spores to combinations of high hydrostatic pressure, heat, acidity and nisin. Journal of Applied Bacteriology. 1996;81(4): 363–368.
21. Konuray G, Erginkaya Z. Potential use of *Bacillus coagulans* in the food industry. Foods. 2018;7(6): 92.
22. Lavrentev FV, Ashikhmina MS, Ulasevich SA, Morozova OV, Orlova OY, et al. Perspectives of *Bacillus coagulans* MTCC 5856 in the production of fermented dairy products. LWT. 2021;148: 111623.
23. Jäger R, Purpura M, Farmer S, Cash HA, Keller D. Probiotic *Bacillus coagulans* GBI–30, 6086 improves protein absorption and utilization. Probiotics and antimicrobial proteins. 2018;10(4): 611–615.
24. Kotay SM, Das D. Microbial hydrogen production with *Bacillus coagulans* IIT–BT S1 isolated from anaerobic sewage sludge. Bioresource Technology. 2007;98(6): 1183–1190.
25. Cao J, Yu Z, Liu W, Zhao J, Zhang H, et al. Probiotic characteristics of *Bacillus coagulans* and associated implications for human health and diseases. Journal of Functional Foods. 2020;64: 103643.

Citation: Khan NT. Biotechnological applications of Clostridium thermocellum and Bacillus coagulans. Medp Nutr Food Sci. 2022; 1(1): mpnfs–202208001.