

Solid Medium Sterilization by Steam Explosion in Solid-State Fermentation Process



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Abstract

Large-scale solid medium sterilization has been an obstacle in industrial solid-state fermentation because longer sterilization time (caused by low thermal conductivity of solid medium) leads to nutrients destroy. In this review, a novel steam explosion sterilization strategy is discussed. It is a high-temperature short-times strategy which can completely inactive microbe without generating inhibitors in solid medium with an optimized operation parameters. Besides, steam explosion sterilization enriches nutrients by degrading macromolecular in solid medium and provides driving force for solid medium transportation in industrial level. Therefore, steam explosion sterilization is promising strategy in large-scale industrial application.

Keywords: Steam explosion sterilization; Solid medium; Solid-state fermentation

Introduction

Medium sterilization has been the essential operation in modern fermentation industries, providing a pure culture environment. In submerged fermentation, many strategies such as dry heat sterilization, moisture heat sterilization and filtration sterilization have been applied successfully, boosting fermentation industrial development greatly. Solid-state fermentation is considered as a favorable process for producing various products, including enzymes, bio-pesticide and bio-fertilizer. Compared with submerged, solid-state fermentation has the advantages of less waste water, abundant economic raw materials (such as agricultural residue) and environment-friendly [1,2]. However, solid medium sterilization is one of the key barriers in solid-state fermentation industrialization. Currently, traditional autoclaving is employed in solid medium sterilization. Due to low thermal conductivity of the solid medium, large intensity reflected by longer sterilization time are demanded for complete sterilization of the solid medium. The increased sterilization intensity will lead to nutrients destruction. Therefore, new effective solid medium sterilization strategies which cause less nutrient destruction while killing microbes should be developed. Theoretically, less activation energy is required in microbial inactivation than that of chemical degradation, resulting in greater influence of temperature on chemical than chemical degradation [3].

Hence, high-temperature short-time sterilization can be a useful guideline for new sterilization strategies development.

Steam explosion sterilization

Based on nearly 20-years research on steam explosion [4], the author has proposed steam explosion sterilization. Steam explosion is a highly autonomous strategy for solid medium sterilization. Parameters (pressure, temperature, and retention time) can be manually regulated according to chemical or physical properties of the target solid materials so as to get better sterilization performance. Features of steam explosion are described as follows.

High-temperature short-time sterilization

Mechanism of steam explosion can be attributed to high temperature cooking and mechanical tearing. At the beginning, solid medium undergoes the similar procedure to that in traditional autoclaving (i.e. the heating medium transfer thermal energy into solid medium, resulting in increasing temperature of the solid medium). In order to reduce nutrients damage while getting complete sterilization performance, higher temperature is demanded in steam explosion sterilization than that in autoclaving. After a same temperature maintaining process as that in autoclaving, high pressure in steam explosion tank is

discharged immediately, resulting structural change of solid medium. Besides, microbe can be also inactivated because of mechanical tearing.

Improving solid-state fermentation performance by enriching nutrients and changing physical properties of solid medium. Due to autohydrolysis in steam explosion sterilization process, chemical nutrients and physical properties can be changed which is favorable for microbial growth. In previous research [5], it was found that polysaccharides were degraded into glucose and xylose, enriching nutrients in solid medium. Compared with conventional autoclaving, glucose and xylose contents increased 80.0% and 58.8% respectively after steam explosion sterilization at 128 °C for 5min. It should be noticed that the parameters for steam explosion sterilization must be systematically optimized because excessive sterilization intensity can lead to inhibitors generation. Most of generated inhibitors are usually derivatives of the chemical nutrients such as glucose xylose and arabinose. Moreover, physical properties of the sterilized solid medium were characterized using FI-IR by Zhao et al. [6]. At structural level, enlarged pores and cavities was observed. The improved porous solid medium exposed more accessible active sites (pores where capillary water located). In conclusion, steam explosion sterilization improved solid-state fermentation performance by enriching nutrients and providing more accessible active sites.

Medium transportation

Medium transportation is an important step because large volume solid medium is easily contaminated by microbes. With steam explosion sterilization strategy, high pressure difference in sterilization tank can be the driving force of the solid medium transportation. Sterilization tanks are connected with mixing tank via telescopic pipe and the solid medium can be transported into mixing tank under the push of pressure differential. This operation

model has been successfully applied in industrial production of bio-fertilizer.

Conclusion

Steam explosion sterilization is a promising method for large-scale solid medium sterilization with the advantages of high efficiency. It improves solid-state fermentation performance and proving driving force for solid medium transport while killing the undesired microbes. However, further researches are still needed to get a deep knowledge on microbial inactivation at pressure discharge stage during steam explosion sterilization.

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