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Applying the Taguchi Method in Improving the Production of Bacterial Cellulose

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Bacterial cellulose (BC) is a type of widely used biopolymer. The production rate of BC can be developed using the Taguchi method and a jar fermentor. By setting and processing the tests of $L_{18}(3^6)$ orthogonal arrays, the critical factors affecting the BC production are the initial pH and glucose concentration. The optimal factors of a modified YPD medium are the *Gluconacetobacter xylinus* ATCC 23768, initial pH = 4.5, YPD medium, acetic acid concentration = 1.5% (v/v), glucose concentration = 5% (w/v) and liquid height = 7.2 cm, and can increase 39.0% of the wet film thickness to 3.92 mm. After the two-stage cultivation, the modified YPD-glucose medium can achieve the maximal pellicle thickness of 5.56 mm. With the modified YPD-molasses medium, the BC production rate is higher than that of the glucose medium. A high-cultured volume fraction can obtain a higher thickness and BC production rate. By introducing the two-stage cultivation strategy, the incubation duration can be shortened from 10 days to less than 8.5 days for BC thickness.

Keywords: Bacterial Cellulose, Taguchi Method, *Gluconacetobacter xylinus*, Two-Stage Cultivation, Pellicle Thickness.

1. INTRODUCTION

Bacterial cellulose (BC) is composed of polysaccharides produced by different genera of bacteria such as *Acetobacter*, *Gluconacetobacter*, *Agrobacterium* and *Pseudomonas*. Regarding these genera, whose inoculated environments vary between strains, previous studies have discussed the application of BC composed from *Gluconacetobacter xylinus*, also known as *Acetobacter xylium*.[1]

From *G. xylinus*, BC is composed by pure polysaccharide, containing no lignin and hemicellulose.[2] Moreover, produced BC consists of nano-structures, high tensile strength, a high Young's modulus, a high water conservation property, and cellulose purity.[2–4] The applications of this biomaterial are diverse in food industry, papermaking, organic electroluminescence displays, filtrated membranes, artificial blood vessels, and the cosmetic industry.[5–9] For example, nata de coco is a food product produced by fermenting of coconut milk using *G. xylinus*. Several media can be applied in the production of BC, such as different types of fruit juice,[10] tea,[11] formulaic compounds,[1] and processing agricultural waste.[12, 13]

The Taguchi method is an experimental design used to optimize the performance of industrial design.[14] The signal-to-noise ratio and orthogonal arrays are two major tools used in this methodology.[15] For solving problems and optimizing product design, the Taguchi method is effective and economical in saving experimental time.[16] Many fields have used this method to optimize products and processes, such as selective laser sintering,[17] polymer production,[18] wastewater treatment,[19] wind power,[20] and uncertain analysis.[21]

The production of BC has been reported to be affected by several factors, such as strains, pH, temperature, nutrients, and cultivation time.[2, 22] To obtain a superior production rate of BC, the pH range is from 3.5 to 6.5 and the temperature range is from 25 °C to 30 °C in most cases.[1, 3, 23] In conventional methods, the one-stage static cultivation strategy for obtaining BC requires a long incubated duration of as much as 14 days. However, few studies have addressed the most sensitive factor of BC production.[22] This study used the Taguchi method to determine the major influential factors in producing of the BC pellicle and improving the BC production rate. Moreover, the two-stage (stirring/static) cultivation strategy was used to shorten the duration of the entire process.

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