Effect of oxygen transfer coefficient on the crude polysaccharide content by *Ganoderma lucidum* in a stirred fermenter

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Abstract

Ganoderma lucidum, (a mushroom-like fungus "Lingzhi"), is used as a traditional medicinal herb in the orient and a popular health food. The *Ganoderma* mycelial growth by submerged fermentation only takes several days for production of biomass and polysaccharide. The objectives of the study were (1) to measure the oxygen transfer coefficient (K_La) of 5% grain medium in a 5 L stirred fermenter by changing air flow rate and impeller rotation speed, (2) to investigate the effect of K_La on *Ganoderma lucidum* submerged fermentation. The K_La of grain medium was measured by the dissolved oxygen electrode. The nitrogen gas was initially passed through the medium to eliminate oxygen, and the dissolved oxygen values of the medium were measured during the air inputting the fermenter at controlling air flow and impeller rotation speed. The K_La values at constant air flow rate of 1 vvm and controlling at different impeller rotation speeds of 50 rpm to 300 rpm were 11.5-88.2 (hr^{-1}). When the air flow was increased in the fermenter, the K_La values at constant impeller rotation speeds were slightly increased. However, the K_La values were significantly affected by impeller rotation speed than air flow rate. The pre-activation *Ganoderma lucidum* was operated at PDB medium, 30 ℃, 150 rpm in a 500 ml shaking flask. Then it was mixed with 5% grain medium in the stirred fermenter. The crude polysaccharide concentration of 5% grain medium by *Ganoderma lucidum* submerged fermentation in a stirred fermenter controlling at 1 vvm and impeller rotation speed changing from 150 rpm to 300 rpm were 9.9 to 6.4 mg / ml Increasing K_La values did not improved the crude polysaccharide production, but may increased the mycelia biomass for more oxygen supply.

Keywords: *Ganoderma lucidum*, K_La, stirred fermenter, polysaccharide

Materials and Methods

5% grain medium with glucose, yeast extract

Sterilization

Purged air by N_2

Different air flow (1, 1.5, 2 vvm) and impeller speed (50-300 rpm) to measure oxygen by oxygen electrode vs time

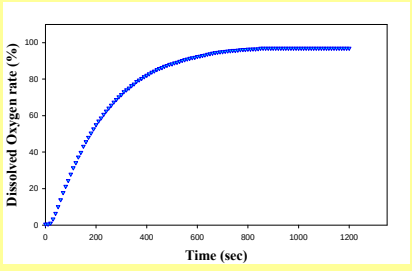


Fig 1. Dissolved oxygen tendency under 150 rpm.

K_La values by linear regression

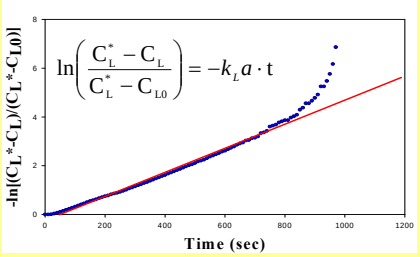
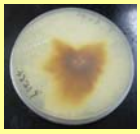


Fig. 2. The K_La is a slope (m) of $-\ln[(C_L^*-C_L)/(C_L^*-C_{L_0})]$

5% Grain medium with 10% mycelia with impeller speed 150-300 rpm at 1 vvm

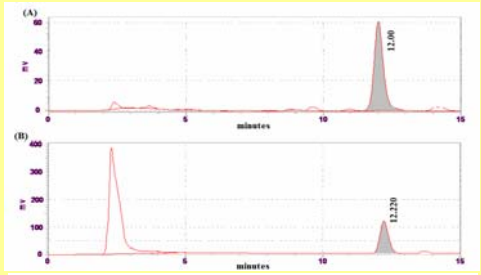
Analysis of mycelia at 7-days fermentation by HPLC of ergosterol

Ganoderma lucidum BCRC 36123



Pre-activity 7 days in PDB by shaking flask

Analysis of crude polysaccharides by phenol-sulfuric acid at 3-days fermentation



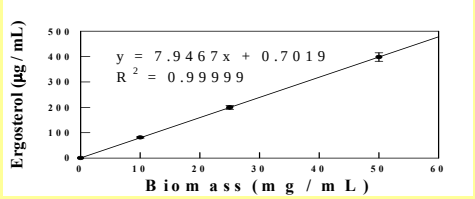


Fig. 3. chromatography spectrum of ergosterol standard (A) and *G. lucidum* mycelia (B), and standard curve of biomass v.s. ergosterol.

Introduction

Ganoderma lucidum is used as a traditional medicinal herb in the orient and a popular health food. Wild *Ganoderma* is rare and very expensive herb. The fruiting body of *Ganoderma* by an artificial cultivation takes several months to harvest in a solid culture, and the yield is very low. Submerged fermentation for *Ganoderma* mycelial growth only takes several days for efficient biomass production and valuable metabolites. Medium formula and oxygen supply significantly affected polysaccharide and biomass production. Complex grain medium obtain more *Ganoderma* mycelial growth and active compounds (Xu et al., 2008). Higher K_{La} and dissolved oxygen tension improved biomass and inside cell polysaccharide production (Tang & Zhong, 2003). Moreover, when the oxygen pressure of *Monascus rubber* submerged fermentation was near zero, the biomass decreased and glucan increased (Hajjaj et al., 1999). Therefore, the objectives of this study were (1) to investigate the effect of impeller speed and air flow rate on K_{La} of grain medium in a 5 L stirred fermenter (2) to analyze the effect of impeller speed on crude polysaccharide and *Ganoderma* mycelia production.

Results and Discussion

The dissolved oxygen values of the grain medium were measured by oxygen electrode during the air inputting the fermenter at controlling air flow and impeller rotation speed. The K_La values at constant air flow rate of 1 vvm and controlling at different impeller rotation speeds of 50 rpm to 300 rpm were 11.5-88.2 (hr^{-1}) (Fig. 4). The K_La values were significantly affected by impeller rotation speed than air flow rate. The highest polysaccharide appeared at the third fermentation day (Fig. 5). When impeller rotation speeds changed from 150 rpm to 300 rpm, the crude polysaccharide concentration of 5% grain medium by *Ganoderma lucidum* submerged fermentation in a stirred fermenter controlling at 1 vvm were 9.9 to 6.4 g / L (Fig. 6). However, the higher impeller speed obtained significantly higher biomass (Fig. 7). Increasing K_La values did not improved polysaccharide production, but increased *Ganoderma lucidum* mycelia biomass due to more oxygen supply.

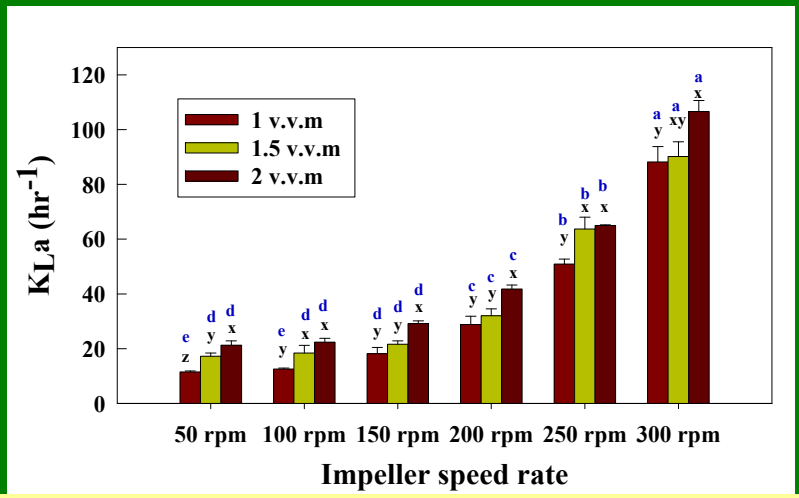


Fig 4. Effect of impeller speed rate on K_La values of 5% grain medium.
a-e different letters represent significantly different ($p<0.05$) between different impeller speed.
x-y different letters represent significantly different ($p<0.05$) between different air flow rate at the same impeller speed.

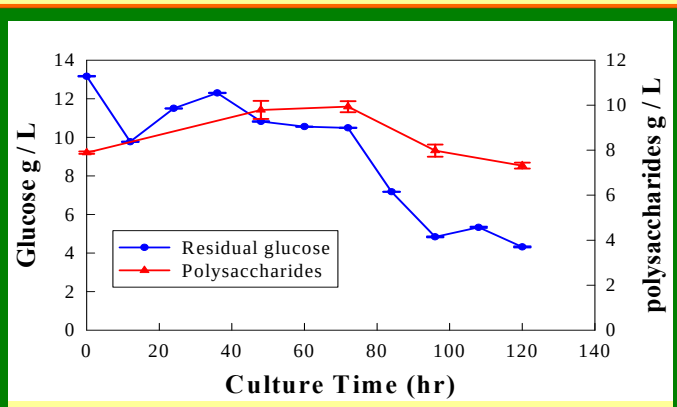


Fig. 5. The residual glucose and crude polysaccharide changes during *Ganoderma* fermentation.
Error bars represent standard deviation.

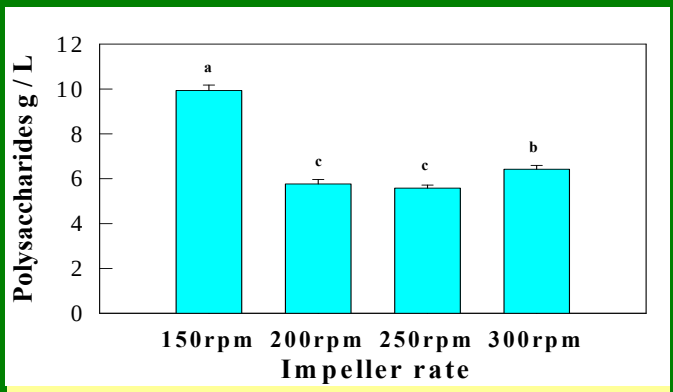


Fig. 6. Effect of impeller speed on crude polysaccharide concentration in grain ferment at 1 vvm.
a-c different letters represent significantly different ($p<0.05$)

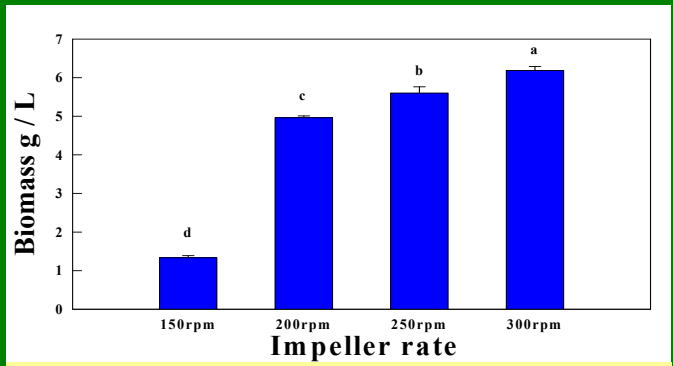


Fig. 7. Effect of impeller speed on mycelia biomass.
a-d different letters represent significantly different ($p<0.05$)

References

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Conclusions

The K_La values of grain medium were significantly affected by impeller rotation speed than air flow rate in a stirred fermenter. Increasing K_La values did not improved polysaccharide production, but increased *Ganoderma lucidum* mycelia biomass due to more oxygen supply.

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