# Scaling-up strategies for controllable biosynthetic ZnO NPs using cell free-extract of endophytic Streptomyces albus: characterization, statistical optimization, and biomedical activities evaluation

*Shahira H. EL-Moslamy, Mohamed S. Elnouby, Ahmed H. Rezk & Esmail M. El-Fakharany*

**Abstract**

A cell-free extract of endophytic *Streptomyces albus* E56 was used to biosynthesize ZnO nanoparticles under fed-batch conditions. Process optimization using Plackett–Burman and response surface methods increased lab-scale yield from 4.36 to 7.59 g/L (~1.6-fold). Scale-up using a 7 L pre-culture and a 70 L stainless steel bioreactor with exponential pulse feeding achieved a 31.25-fold increase (~155 g/L). The resulting ZnO/$MnO_2$ composite showed strong antimicrobial activity.

**Winpact Model: FS-07& FS-V-D**

## Introduction

Microbial biosynthesis of ZnO nanoparticles offers eco-friendly and controllable alternatives to chemical methods. However, there's a gap in scalable processes. This study fills it by using fed-batch fermentation for bioprocess scale-up from lab to semi-industrial level with characterized antimicrobial efficacy..

## Materials and Methods

Cultivation was firstly optimized in lab fed-batch mode. Scale-up involved a stirred 7 L pre-culture followed by fed-batch fermentation in a 70 L stainless steel bioreactor, applying exponential pulse feeding with a 1:200 N/C ratio over 120–312 h. Dissolved oxygen was maintained above 20% via airflow and agitation.

**Results**

- Lab-scale yield increased ~1.6× (4.36 → 7.59 g/L ZnO NPs).
- Pilot scale fed-batch in 70 L reactor increased yield 31.25× (to ~155 g/L).
- SEM/TEM showed 6–18 nm spherical particles.
- Antimicrobial testing revealed substantial inhibition zones against drug-resistant bacteria and pathogens (e.g., Salmonella paratyphi inhibition zone ~53 mm).

**References**

Scaling-up strategies for controllable biosynthetic ZnO NPs using cell-free extract of endophytic Streptomyces albus: characterization, statistical optimization, and biomedical activities evaluation

https://www.nature.com/articles/s41598-023-29757-9