PROCESS DESIGN AND MICROBIAL GROWTH MODELLING OF SELF-INDUCED ANAEROBIC FERMENTATION FOR MIXED-MATURITY ARABICA COFFEE PROCESSING

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BOGOR
2026

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Bogor, August 2026

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ABSTRACT

ADZKIA ZAVIER MUHAMMAD. Process Design and Microbial Growth Modelling of Self-Induced Anaerobic Fermentation for Mixed-Maturity Arabica Coffee Processing. Supervised by ENDANG WARSIKI and TITI CANDRA SUNDARTI.

Mixed-maturity Arabica coffee cherries constitute a heterogeneous raw material requiring postharvest processing capable of improving process consistency and product quality. This study aimed to develop a self-induced anaerobic fermentation (SIAF) process and model microbial population development during spontaneous and *L. plantarum*-inoculated solid-state fermentation. Process development followed an iterative approach comprising natural processing, submerged SIAF, and solid-state SIAF. Microbial growth modelling of solid-state SIAF used observations at 0, 12, 24, 36, and 48 h for total plate count (TPC), lactic acid bacteria (LAB), and mold and yeast, supported by pH, titratable acidity, and temperature measurements. Microbial populations were fitted using modified Gompertz and Logistic models. Inoculation was associated with earlier and greater LAB development, reaching 9.00 log CFU/g at 48 h compared with 7.65 log CFU/g under spontaneous fermentation. The modified Gompertz model provided an equal or lower prediction error across all microbial trajectories than the Logistic model. However, sparse sampling, unobserved stationary phases, and population fluctuations limited the reliability of several model parameters. The resulting models provide exploratory reference profiles for fermentation monitoring and future scale-up validation.

Keywords: coffee fermentation, *L. plantarum*, microbial growth modelling, mixed-maturity coffee, self-induced anaerobic fermentation

ABSTRAK

ADZKIA ZAVIER MUHAMMAD. *Process Design and Microbial Growth Modelling of Self-Induced Anaerobic Fermentation for Mixed-Maturity Arabica Coffee Processing*. Dibimbing oleh ENDANG WARSIKI dan TITI CANDRA SUNARTI.

Kopi Arabika dengan tingkat kematangan buah yang beragam merupakan bahan baku heterogen yang memerlukan proses pascapanen untuk meningkatkan konsistensi proses dan mutu produk. Penelitian ini bertujuan mengembangkan proses self-induced anaerobic fermentation (SIAF) dan memodelkan perkembangan populasi mikroba pada fermentasi solid-state spontan dan yang diinokulasi Lactiplantibacillus plantarum. Pengembangan proses dilakukan secara iteratif melalui proses natural, SIAF submerged, dan SIAF solid-state. Pemodelan pertumbuhan mikroba pada SIAF solid-state menggunakan pengamatan pada jam ke-0, 12, 24, 36, dan 48 terhadap total plate count (TPC), bakteri asam laktat (BAL), serta kapang dan khamir, didukung pengukuran pH, total asam tertitrasi, dan suhu. Populasi mikroba dimodelkan menggunakan model Gompertz dan Logistic termodifikasi. Inokulasi berkaitan dengan perkembangan BAL yang lebih awal dan lebih besar, mencapai 9,00 log CFU/g pada 48 jam dibandingkan 7,65 log CFU/g pada fermentasi spontan. Model Gompertz termodifikasi memberikan galat prediksi yang sama atau lebih rendah pada seluruh trajektori mikroba dibandingkan model Logistic. Namun, keterbatasan titik pengamatan, belum teramatinya fase stasioner, dan fluktuasi populasi membatasi keandalan beberapa parameter model. Model yang dihasilkan dapat digunakan sebagai profil acuan eksploratif untuk pemantauan fermentasi dan validasi skala lebih besar.

Kata kunci: fermentasi kopi, kopi kematangan campuran, L. plantarum, pemodelan pertumbuhan mikroba, self-induced anaerobic fermentation

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Undergraduate Final Project
as one of the requirements to obtain
a Bachelor's degree in 2026
Agroindustrial Engineering Study Program

AGROINDUSTRIAL ENGINEERING STUDY PROGRAM
FACULTY OF ENGINEERING AND TECHNOLOGY
IPB UNIVERSITY
BOGOR
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PREFACE

Praise and gratitude are sincerely offered to Allah subhanaahu wa ta'ala for His blessings, guidance, and mercy, which enabled the author to complete this undergraduate final project entitled "Process Design and Microbial Growth Modelling of Self-Induced Anaerobic Fermentation for Mixed-Maturity Arabica Coffee Processing." This study was conducted from March to July 2026 as part of the requirements for obtaining a Bachelor's degree in the Agroindustrial Engineering Study Program, Faculty of Engineering and Technology, IPB University. The author would like to express sincere gratitude and appreciation to all individuals who provided guidance, assistance, encouragement, and support throughout the author's studies and the completion of this final project, particularly to:

1. Prof. Dr. Endang Warsiki, S.TP., M.Si. and Prof. Dr. Ir. Titi Candra Sunarti, M.Si., as academic supervisors, for their continuous guidance, knowledge, constructive feedback, patience, and invaluable support throughout the research process and preparation of this final project.
2. All lecturers, laboratory staff, administrative staff, and other staff of the Department of Agroindustrial Technology, IPB University, for the knowledge, assistance, facilities, and support provided throughout the author's academic journey and research activities.
3. The author's parents, sister, and family, for their unconditional love, prayers, patience, encouragement, and continuous support throughout the author's education and the completion of this final project.
4. Kayla Andhita Azzahra, for her unwavering support, companionship, and for sharing countless experiences and important milestones throughout the author's university journey, from PL and PI to achieving third place in the Packstar competition, participating in FIAC 2026, and finally completing Produta together.
5. Zidan, Dzaky, and other parties who supported the completion of Produta, for their valuable insights, discussions, suggestions, assistance, and encouragement throughout the development and completion of the project.
6. K3 TIN 59, INT 59, and all other friends, for the friendship, laughter, adventures, meaningful experiences, and countless memories that accompanied the author throughout his time studying at IPB University.

The author realizes that this final project still has limitations and therefore welcomes constructive suggestions for its improvement. It is sincerely hoped that this work may provide useful information for the development of controlled coffee fermentation, particularly self-induced anaerobic fermentation, and contribute to future research and practical applications in coffee postharvest processing.

Bogor, August 2026

Adzkia Zavier Muhammad

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