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Model Optimization Using Artificial Intelligence Algorithms for Biological Food Waste Degradation

Norazwina Zainol, Abdul Sahli Fakharudin, and Nor Ilyya Syahira Zulaidi

Abstract Food waste is categorized as the largest degradable component in the waste stream. Degradation of food waste that involved aerobic bacteria is the most suitable approach to dispose of this waste. The main objective of this research is to evaluate the optimum condition of aerobic bacteria growth for food waste degradation by comparing the implementation of response surface method (RSM) and genetic algorithm. Preliminary experiment is conducted to determine the best time for aerobic bacteria growth. Then, evaluation of five factors such as temperature, time, type of nutrient, agitation rate and inoculum size is done by conducting experiments according to the experimental table that is constructed by using design expert software. Growth of aerobic bacteria can be determined by measuring the optical density (OD) of the bacteria. Aerobic bacteria at the best growth condition are mixed with the food waste for degradation process. The ability of aerobic bacteria to degrade food waste is determined by monitoring the pH, moisture content and ratio of volatile solid to total solid (VS/TS) of food waste on the first and twentieth days of degradation. The result analysis using RSM showed that the optimum condition for aerobic bacteria growth is at 37 °C and 200 rpm in commercial nutritional supplement (CNS) medium with 10% (v/v) of inoculum size for 20 h. At this optimum condition, the OD value was 2.264 while optimization using genetic algorithm generated the OD value at 2.643 where this is 14% improvement from the RSM.

Keywords Genetic algorithm · Response surface method · Optimization · Food waste degradation

N. Zainol
CARIFF, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia

A. S. Fakharudin (✉)
Faculty of Computing, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia
e-mail: sahli@ump.edu.my

N. I. S. Zulaidi
College of Engineering, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia

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1 Introduction

In recent years in Malaysia, environmental issues keep rising due to the increasing amount of food waste. Statistics from the Solid Waste Corporation of Malaysia (SWCorp) showed that in 2015, the food waste in Malaysia reached 15,000 tonnes daily (Komandai 2017). Degradation of food waste by using aerobic bacteria is one of the most promising approaches to manage food waste as this waste contains high organic matters which are easily biodegradable. Food waste can also be degraded under anaerobic condition but the process is slow and less efficient compared to the aerobic condition (Gill et al. 2014).

Tortora et al. (2016) stated that aerobic bacteria grow at its best at pH near neutral which is between 6.5 and 7.5. According to Haug (2018), aerobic bacteria required adequate amounts of oxygen to grow and degrade food waste. Oxygen should be well supplied during the degradation process to reduce the reaction time between food waste and aerobic bacteria. Other than that, moisture content is one of the factors that must be considered for food waste degradation. Excess amount of moisture in food waste is not good for degradation process because it can slow the process (Hamid et al. 2019). On the other hand, carbon-to-nitrogen ratio is also important in degradation process because it shows the quality of biofertilizer. Lin et al. (2019) stated that the degradation may be more effective when C/N ratio is between 30 and 40%. Other factors such as temperature, time, type of nutrients, agitation rate and inoculum size are also crucial for bacteria growth. Most of the previous studies did not focus on those five factors. Therefore, this study focused on those five affecting factors to aerobic bacteria growth for food waste degradation. Hence, the main objective of this research is to optimize the growth of aerobic bacteria for food waste degradation.

The modelling and optimization process done by (Dhanarajan et al. 2014) for production of marine bacterial lipopeptide from food waste had used artificial neural network (ANN) to model the production process, and particle swarm had been used to optimize the production output. The selected feedforward network architecture was 4-17-1 and the model training error of 0.000124 mean square error (MSE). The optimization of production output had used the particle swarm optimization produced a significant enhancement of lipopeptide production from waste by about 46% (w/v).

The modelling and optimization of anaerobic codigestion of potato waste and aquatic weed by response surface methodology and genetic algorithm by Jacob and Banerjee (2016) had produced higher methane yield around 6% improvement by the ANN-GA method when compared with the CCD-RSM method. The ANN topology for modelling had used 3-12-1 architecture and used Levenberg–Marquardt training algorithm to train the network. The MSE for ANN modelling with architecture of 3-12-1 was 0.14 while other ANN architectures produced higher modelling MSE compared to the 3-12-1 architecture. Genetic algorithm (GA) was also being used to determine the maximum biogas yield output from several ANN models which used back-propagation training, particle swarm optimization and evolutionary neural networks (Fakharudin et al. 2013).