UNIVERSITI TEKNOLOGI MARA

PHYSICOCHEMICAL CHARACTERISTICS OF AUTOCHTHONOUSLY-FERMENTED PRAWN SHELL CHITOSAN AND ITS EFFECTS ON DROUGHT-STRESS *SOLANUM MELONGENA* L.

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ABSTRACT

Water deficiency in urban farming negatively impacts crop growth and productivity. Chitosan, a well-known growth stimulant and stress mitigator, can mitigates these deleterious effects. Thus, a convenient household method for producing chitosan from prawn shell waste and the drought-stress mitigating function of the synthesised chitosan on a plant model (*Solanum melongena* L.) were demonstrated in this study. Prawn shell waste was autochthonously fermented for 14 days in sugarcane molasses with varying salt concentrations (2.5%, 5.0%, and 7.5% w/v). Physicochemical characteristics of autochthonously-fermented prawn shell chitosan (AFC) was evaluated by FTIR, XRD and elemental analyser. Microfloral profile in different fermentation conditions i.e. without salt (sample A) and with salt (sample B) was elucidated by New Generation Sequencing (NGS) method. The growth promoting and stress mitigating of AFC were evaluated on *Solanum melongena L*. plants which were subjected to a 10-day drought-stress. The optimum characteristics of AFC was observed in fermentation with 5% (w/v) salt as shown by 73.9% degree of acetylation (DD) by FTIR, 96.81% crystallinity by XRD and a favourable carbon/nitrogen ratio (7.28%) by elemental analyser. Commercial chitosan, for comparison, displayed 78.47 %DD, 6.49% carbon/nitrogen ratio, and 84.54% crystallinity. Microfloral profiling showed initial *Weissella* dominance in fermentation without salt (22.48%), before shifting to *Lactiplantibacillus* after 14 days. Meanwhile, microfloral profile with 5% w/v salt presence showed *Weissella* dominance (19.84%) on day 1, but eventually succeeded by *Lactococcus* (27.03%) after 14 days. AFC improved plant growth and development of drought-stressed *Solanum melongena* L. plant by 8.5% as compared to commercial chitosan. AFC also increased phenolic content by 11.6%, chlorophyll content by 10.6% to 96.5%, and reduced hydrogen peroxide levels by 29.5% as compared to commercial chitosan, indicating its drought stress alleviation. In conclusion, AFC showed comparable physicochemical properties to commercial chitosan and demonstrated comparable functionalities to commercial chitosan in enhancing plant growth and mitigating drought stress effects. This research demonstrated environmental sustainability practice in terms of converting waste (prawn shell) into useful products whilst contributing to food security.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Urban farming is a sustainable approach to reduce country's reliance on food import and achieving the food security goal. It also a viable way for city's inhabitants to achieve self-sufficiency for their food needs. More significantly, it provides income for bottom 40 (B40) who makes up significant (56%) of urban population to improve their livelihood amid the devastating economic impact of COVID19 pandemic. While the idea looks promising, there are technical difficulties for a low cost, convenient implementation of urban farming especially among B40 beginners in restrictive urban setting. Limited water supply and space (for soil regeneration) lead to abiotic stress and stunted growth on plants, respectively which negatively impact crop yield and return on investment. On the other hand, the use chemical fertilizer, pesticide, insecticide is not suitable in urban setting due to their harmful effects on environment and health.

Chitosan is a natural polymer product from deacetylation process of chitin. It is a second abundant biopolymer in nature after cellulose (Tan et al., 2020). Chitosan can be found naturally in crustacean, insect, arthropod exoskeletons, and molluscs (Malerba & Cerana, 2016).Chitin is a natural polysaccharide that can be found at the cell wall of animal of having crustacean and arthropod exoskeleton. The study of chitin characterization began in 1811 by French chemist Henri Brannocot. Later in 1878, Lederhose identified chitosan from chitin structure after treating chitin with heated potassium hydroxide. Only in 1950s that the chemical structure of chitosan was determined (Tan et al., 2020). A lot of interest is dedicated to biomaterial such as chitosan, a derivative of chitin biopolymer with wide range beneficial effects on crops such as abiotic/biotic stress resistant, antipathogen and growth stimulant. Commercial chitosan is produced by strong acid and alkali chemicals to deacetylate chitin into chitosan (Balusamy et al., 2022). The significant drawbacks of chemical synthesis are high energy consumption and relatively low purity chitosan. The need for an eco-friendly and green technique creates significant interest in extraction of chitosan from its precursor by biological route. In addition, biological extraction is advantageous in terms of preserving the chitin integrity, resulting higher conversion and purity as well