UNIVERSITI TEKNOLOGI MARA

MICROWAVE-ASSISTED STERILIZATION AND EXTRACTION OF OIL PALM FRUITS

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Malaysia is the second largest producer and exporter of palm oil after Indonesia. During production of palm oil, a large amount of liquid waste is generated known as Palm Oil Mill Effluent (POME) and it is a major source of water pollutant in Malaysia. Sterilization process is one of the main process that contributed to high amount of POME. In the sterilization process, steams weaken the fruits that are attached to the spikes which are extensions of central woody stalk of the bunch, whereby gums that are water soluble at high temperature can be evaporated when the oil palm fruits are heated. Sterilization also hindered increment of free fatty acids (FFA) which can affect the quality of oil. In this study, microwave-assisted sterilization of oil palm fruits is proposed to loosen the fruits from the bunch and to reduce production of the POME. Microwave was also used to extract the oil from the oil palm fruit. For sterilization process, 200 g of oil palm fruits was subjected to microwave irradiation and effect of using microwave power of 400 W, 600 W, and 800 W, and different ratios of fruit-to-water of 1:0.5, 1:1, and 1:2 on detachment of the fruits from its spikelet were assessed. The optimum condition for the fruit to be completely detached from the spikelet was 6 min, 800 W, and 1:0.5 ratio of fruit-to-water. Good quality of white kernel with 0.39% of FFA was also obtained. Microwave radiation was found to be suitable for rapid detachment of the fruitlet from the spikelet and fruit loosening performed without kernels, which started to turn brown and appear dehydrated. A microwave-assisted extraction technique for sterilizing oil palm fruits, as well as extracting crude palm oil (CPO) and palm fatty acid (PFA) at several microwave powers and extraction times were conducted. Suitable bed thickness that is related to the depth of penetration of oil palm mesocarp in microwave-assisted extraction demonstrated an effective heating distribution and improved the microwave wavelength penetration into the sample, which was obtained at mass of sample and depth of penetration of 100 g and 15.61 mm, respectively. Dielectric properties and depth of penetration are useful in understanding heating patterns, cold spots, and depths of penetration of microwave into oil palm mesocarp. The physical property of CPO is 64.3% yield, while chemical properties are 0.301% of FFA, 3.35 of DOBI, and 1132 ppm of carotene content, were obtained via the microwave-assisted extraction. All the chemical properties during microwave-assisted extraction met the standard requirement of commercial CPO. A caramel-like aroma was also released during the process, and the distillate obtained had high palmitic acid content (C16:0). A Box-Behnken design was applied to evaluate the effects of three independent variables of microwave power level (100–400 W), extraction time (20–30 min), and mass of mesocarp loading (80–120 g) on the responses, such as CPO yield, FFA, and final temperature of the oil palm fruit. The optimal extraction condition was found to be at 300 W, 30 min, and 80 g. Thus, these process condition produced CPO yield, FFA, and final temperature of 57.6%, 0.287%, and 134.3 °C, respectively. From optimum operation, the energy efficiency of microwave-assisted sterilization and extraction was 51% and 95%, respectively. Model based on heat transfer process was used to predict the physical mechanism of extraction, showing a satisfactory approach to the mathematical representation of the extraction of PFA using the microwave-assisted extraction. Based on the kinetics modeling that has been done, it is found that a second-order kinetic model represents the experimental results of PFA extraction by microwave-assisted extraction method with minimum value of RMSE, 2.05×10^{-2} and high value of R^2, 0.92, as compared with a first-order kinetic model.

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TABLE OF CONTENT