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We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science in Chemical Engineering



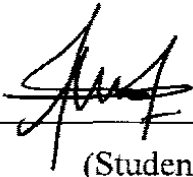
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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.



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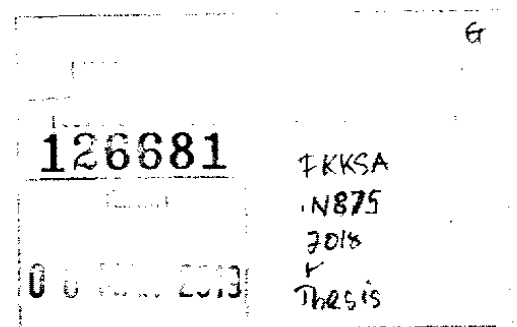
OPTIMIZATION OF GALLIC ACID YIELD FROM *LABISIA PUMILA* IN 25-L  
MOBILE PILOT SCALE EXTRACTOR VIA ULTRASOUND-ASSISTED  
EXTRACTION

NURI 'ADILAH NASHRULMILLAH BINTI IDRIS

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## ABSTRAK

*Labisia pumila* adalah salah satu herba yang digunakan secara meluas dalam kalangan wanita Malaysia. Tujuan kajian ini adalah untuk menilai prestasi pengekstrakan terbantu ultrabunyi (*ultrasound-assisted extraction*, UAE) dalam pengekstrakan mudah alih 25 L untuk mengekstrak asid galik dari daun *Labisia pumila*. Bagi pengekstrakan asid galik, pengekstrakan konvensional (kawalan) dan UAE pada 25 kHz dijalankan, dan air digunakan sebagai pelarut. Pada mulanya, kajian skala makmal dijalankan menggunakan pendekatan satu-faktor-pada-satu-masa (*one-factor-at-a-time*, OFAT) untuk menentukan julat parameter tidak bersandar yang mempengaruhi pengekstrakan asid galik. Ekstrak dianalisis untuk menentukan asid galik menggunakan kromatografi cecair prestasi tinggi–pengesanan tatasusunan diod (*high performance liquid chromatography–diode-array detector*, HPLC–DAD). Hasil asid galik dan faktor-faktor dimodel dan disahkan menggunakan pendekatan reka bentuk faktorial dan metodologi permukaan sambutan (*response surface methodology*, RSM). Faktor-faktor yang dikaji ialah nisbah bahan kepada pelarut, suhu, kitar tugas, dan masa pengekstrakan. Kajian penyaringan menunjukkan bahawa kitar tugas ialah faktor yang paling berpengaruh diikuti oleh masa pengekstrakan, dan untuk itu kedua-dua faktor ini seterusnya dioptimumkan. Model ramalan dihasilkan dari keputusan eksperimen dan keadaan optimum ramalan disahkan. Nilai-nilai eksperimen pada keadaan optimum adalah tekal dengan nilai-nilai ramalan dengan nilai ralat yang kurang daripada 10%. Hasil optimum ramalan asid galik ialah  $139.44 \pm 0.712$  mg asid galik setara (*gallic acid equivalent*, GAE)/g berat kering pada 60 °C dan kitar tugas 50% untuk 8 jam. Kajian ini mengesahkan bahawa penggunaan pengekstrakan mudah alih 25 L adalah lebih berkesan berbanding pengekstrakan konvensional kerana ia memberikan hasil yang lebih tinggi dalam tempoh yang lebih pendek pada suhu yang lebih rendah.

## ABSTRACT

*Labisia pumila* is one of the herbs that has been widely utilized among Malay women in Malaysia. The aim of this study was to evaluate the performance of the ultrasound-assisted extraction (UAE) in 25 L mobile extractor to extract gallic acid from *Labisia pumila* leaves. For gallic acid extraction both conventional extraction (control) and UAE at 250 kHz were employed, and water was used as the extraction solvent. Initially a preliminary laboratory scale study was conducted using one-factor-at-a-time (OFAT) approach to finalize the ranges of the independent parameters that affect the extraction of gallic acid. Design Expert version 7.0.0 was employed to screen and optimize the gallic acid yield. The extracts were analyzed for gallic acid using high performance liquid chromatography–diode-array detector (HPLC–DAD). The gallic acid yield and the factors were modeled and validated using factorial design and response surface methodology (RSM) approaches. The factors studied were material-to-solvent ratio, temperature, duty cycle, and extraction time. The screening study revealed that the duty cycle was the most influential factor followed by the extraction time, and therefore these two variables were further optimized. Predictive models were generated using the experimental results and the optimal condition predicted was validated. The experimental values under optimal conditions were consistent with the predicted values with the error value of less than 10 %. The predicted optimal yield of gallic acid was  $139.44 \pm 0.712$  mg GAE/g dry weight at 60 °C and 50% of duty cycle for 8 h. This study confirmed that the use of UAE in 25 L mobile extractor was more effective than the conventional method as it provided more yield in shorter time at lower temperature

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