HEAT AND MICROWAVE REFLUX EXTRACTION, OPTIMIZATION, AND PHYSICOCHEMICAL CHARACTERIZATION OF OLEORESINS FROM MALAYSIAN PEPPER (*Piper nigrum*)

OLALERE, OLUSEGUN ABAYOMI

Doctor of Philosophy

UNIVERSITI MALAYSIA PAHANG
SUPervisor’s declaration

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 Doctor of Philosophy.

(Supervisor’s Signature)
Full Name: PROF. DR ABDURAHMAN HAMID NOUR
Position: PROFESSOR
Date: 1st August 2018

(Co-supervisor’s Signature)
Full Name: PROF. DATO’ DR ROSLI BIN MOHD YUNUS
Position: PROFESSOR
Date: 1st August 2018
STUDENT’S DECLARATION

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.

_______________________________
(Student’s Signature)

Full Name: OLALERE, OLUSEGUN ABAYOMI
ID Number: PKC15013
Date: 1st August 2018
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LIST OF SYMBOLS

\( h_1 \)  Extraction time in heat reflux extraction
\( h_2 \)  Feed particle size in heat reflux extraction
\( h_3 \)  Feed-solvent ratio in heat reflux extraction
\( x_1 \)  Irradiation time in microwave refluxation
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\( y'_b(\text{av}) \)  Average extraction yield from heat refluxed black pepper
\( y_{w(\text{av})} \)  Average extraction yield from white pepper refluxation
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\( Q_{t,b(\text{av})} \)  Average absorbed microwave energy by black pepper sample
\( a \)  Values are means ±SD of triplicate runs
LIST OF ABBREVIATIONS

ANOM    Analysis of Mean
ARP     Antiradical Power
BPOE    Black Pepper Oleoresin Extracts
HRE     Heat Reflux Extraction
MRE     Microwave Reflux Extraction
PI      Performance Index
REI     Relative Extraction Index
SFE     Single Factor Experiment
SNR     Signal to noise ratio
TODOE   Taguchi orthogonal design of experiment
WPOE    White Pepper Oleoresin Extracts