

Kod Rujukan: (Diisi oleh PJI)	
RIG	
Bukti Kolaborasi	

(Diisi oleh PJI)

**BORANG PERMOHONAN
GERAN SEMARAK PENYELIDIKAN (GSP) 2024**

**Bahagian Penyelidikan & Jaringan Industri (PJI)
UiTM CAWANGAN PERLIS**

A	TITLE OF PROPOSED RESEARCH: <i>Tajuk penyelidikan yang dicadangkan :</i> MATHEMATICAL MODELLING OF HYBRID NANOFLUID FLOW AND HEAT TRANSFER OF CARBON NANOTUBES IN THE BOUNDARY LAYER REGION	
B	DETAILS OF RESEARCHER / MAKLUMAT PENYELIDIK	
B(i)	Name of Project Leader: <i>Nama Ketua Projek:</i> NURUL HIDAYAH BINTI AB RAJI	IC / Passport Number: <i>No. Kad Pengenalan/ Pasport:</i> 870120-02-5288
B(iii)	Faculty/School/Centre/Unit (Please provide full address): <i>Fakulti/Jabatan /Pusat/Unit</i> KP PENGKOMPUTERAN, INFORMATIK & MATEMATIK UiTM CAWANGAN PERLIS, 02600, ARAU, PERLIS.	
B(iv)	Office Telephone No.: <i>No. Telefon Pejabat:</i> 04-9882688	Handphone No.: <i>No. Telefon Bimbit:</i> 012-4937880
B(v)	E-mail Address: <i>Alamat e-mel:</i> hidayah417@uitm.edu.my	

B(vi)	Date of first appointment with this University: <i>Tarikh mula berkhidmat dengan Universiti ini:</i> 08/07/2010																														
C	RESEARCH INFORMATION / MAKLUMAT PENYELIDIKAN																														
C(i)	Research Domain (Please tick (√)): <i>Domain Penyelidikan (Sila tanda (√)):</i> A. Pure and Applied Sciences (Sains Tulen dan gunaan) <table border="0"> <tr> <td>☐ Chemistry (Kimia)</td> <td>☐ Physic (Fizik)</td> <td>☐ Biology (Biologi)</td> </tr> <tr> <td>☐ Biochemistry (Biokimia)</td> <td>☐ Materials Science (Sains Bahan)</td> <td>☒ Mathematics and Statistics (Matematik dan Statistik)</td> </tr> <tr> <td>☐ Materials Science (Sains Bahan)</td> <td></td> <td></td> </tr> </table> B. Social Sciences (Sains Sosial) <table border="0"> <tr> <td>☐ Anthropology (Antropologi)</td> <td>☐ Psychology (Psikologi)</td> <td>☐ Sociology (Sosiologi)</td> </tr> <tr> <td>☐ Political Science (Sains Politik)</td> <td>☐ Business and Management (Pengurusan dan Perniagaan)</td> <td>☐ Geography (Geografi)</td> </tr> <tr> <td>☐ Economic (Ekonomi)</td> <td>☐ Human Ecology (Ekologi Manusia)</td> <td>☐ Communication (Komunikasi)</td> </tr> </table> C. Arts and Applied Arts (Sastera dan Sastera Ikhtisas) <table border="0"> <tr> <td>☐ Language and Linguistic (Bahasa dan Linguistik)</td> <td>☐ Literature (Kesusasteraan)</td> <td>☐ Religion (Agama)</td> </tr> <tr> <td>☐ Philosophy (Falsafah)</td> <td>☐ Civilization (Tamadun)</td> <td>☐ History (Sejarah)</td> </tr> <tr> <td>☐ Art (Seni)</td> <td>☐ Culture (Budaya)</td> <td>☐ Education (Pendidikan)</td> </tr> <tr> <td>☐ Policies and Law (Dasar dan Undang-undang)</td> <td>☐ Built Environment (Alam Bina-Aspek Kemanusiaan)</td> <td>☐ Environment (Alam Sekitar-Aspek Kemanusiaan)</td> </tr> </table>	☐ Chemistry (Kimia)	☐ Physic (Fizik)	☐ Biology (Biologi)	☐ Biochemistry (Biokimia)	☐ Materials Science (Sains Bahan)	☒ Mathematics and Statistics (Matematik dan Statistik)	☐ Materials Science (Sains Bahan)			☐ Anthropology (Antropologi)	☐ Psychology (Psikologi)	☐ Sociology (Sosiologi)	☐ Political Science (Sains Politik)	☐ Business and Management (Pengurusan dan Perniagaan)	☐ Geography (Geografi)	☐ Economic (Ekonomi)	☐ Human Ecology (Ekologi Manusia)	☐ Communication (Komunikasi)	☐ Language and Linguistic (Bahasa dan Linguistik)	☐ Literature (Kesusasteraan)	☐ Religion (Agama)	☐ Philosophy (Falsafah)	☐ Civilization (Tamadun)	☐ History (Sejarah)	☐ Art (Seni)	☐ Culture (Budaya)	☐ Education (Pendidikan)	☐ Policies and Law (Dasar dan Undang-undang)	☐ Built Environment (Alam Bina-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar-Aspek Kemanusiaan)
☐ Chemistry (Kimia)	☐ Physic (Fizik)	☐ Biology (Biologi)																													
☐ Biochemistry (Biokimia)	☐ Materials Science (Sains Bahan)	☒ Mathematics and Statistics (Matematik dan Statistik)																													
☐ Materials Science (Sains Bahan)																															
☐ Anthropology (Antropologi)	☐ Psychology (Psikologi)	☐ Sociology (Sosiologi)																													
☐ Political Science (Sains Politik)	☐ Business and Management (Pengurusan dan Perniagaan)	☐ Geography (Geografi)																													
☐ Economic (Ekonomi)	☐ Human Ecology (Ekologi Manusia)	☐ Communication (Komunikasi)																													
☐ Language and Linguistic (Bahasa dan Linguistik)	☐ Literature (Kesusasteraan)	☐ Religion (Agama)																													
☐ Philosophy (Falsafah)	☐ Civilization (Tamadun)	☐ History (Sejarah)																													
☐ Art (Seni)	☐ Culture (Budaya)	☐ Education (Pendidikan)																													
☐ Policies and Law (Dasar dan Undang-undang)	☐ Built Environment (Alam Bina-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar-Aspek Kemanusiaan)																													

	D. Natural Sciences and National Heritage (<i>Sains Tabii dan Warisan Negara</i>) ☐ Environment (<i>Alam Sekitar</i>) ☐ Forestry (<i>Perhutanan</i>) ☐ Agriculture (<i>Pertanian</i>) ☐ Marine (<i>Marin</i>) ☐ Archaeology (<i>Arkeologi</i>) ☐ Geoscience (<i>Geosains</i>) ☐ Ethnography (<i>Etnografi</i>) ☐ Built Environment (<i>Heritage Aspect</i>) <i>Alam Bina (Aspek Warisan)</i> ☐ Culture (<i>Budaya</i>) ☐ Biodiversity (<i>Kepelbagaian Biologi</i>) E. Information and Communication Technology (<i>Teknologi Maklumat dan Komunikasi</i>) ☐ Software and Information System (<i>Perisian dan Sistem Maklumat</i>) ☐ Soft Computing (<i>Pengkomputeran Lembut</i>) ☐ Computer Networking (<i>Rangkaian Komputer</i>) ☐ Information Security (<i>Keselamatan Maklumat</i>) ☐ Multimedia (<i>Multimedia</i>) ☐ Computer Engineering (<i>Kejuruteraan Komputer</i>) ☐ Computer Science (<i>Sains Komputer</i>) F. Health Sciences (<i>Sains Kesihatan</i>) ☐ Basic Medical Sciences (<i>Sains Perubatan Asas</i>) ☐ Pharmacy (<i>Farmasi</i>) ☐ Pharmacology (<i>Farmakologi</i>) ☐ Medical Microbiology (<i>Mikrobiologi Perubatan</i>) ☐ Parasitology (<i>Parasitologi</i>) ☐ Pathology (<i>Pathologi</i>) ☐ Community Medical Prevention (<i>Perubatan Pencegahan Masyarakat</i>) ☐ Clinical Surgical (<i>Klinikal Surgikal</i>) ☐ Clinical Medical (<i>Klinikal Medikal</i>) ☐ Associate Health Science (<i>Sains Kesihatan Bersekutu</i>) ☐ Dental (<i>Pergigian</i>) ☐ Nursing Science (<i>Sains Kejururawatan</i>)
C(ii)	Location of Research: <i>Tempat penyelidikan dijalankan:</i> UiTM CAWANGAN PERLIS

C(iii)	Duration of this research (Maximum 24 months): <i>Tempoh masa penyelidikan ini (Maksimum 24 bulan):</i> Duration: 2 year <i>Tempoh :</i> From : 1 Jan 2025 <i>Dari :</i> To : 31 Dec 2026 <i>Hingga :</i>																																	
C(iv)	Other Researchers: <i>Ahli-ahli penyelidik yang lain:</i> <table border="1" data-bbox="199 741 1555 1545"> <thead> <tr> <th data-bbox="199 741 267 930">Bil</th><th data-bbox="267 741 573 930">Name Nama</th><th data-bbox="573 741 865 930">IC / Staff Number: No. Kad Pengenalan/ No. Pekerja:</th><th data-bbox="865 741 1235 930">University / Industry / Agency Fakulti/ P.Pengajian/ Pusat/Unit</th><th data-bbox="1235 741 1555 930">Academic Qualification/ Designation Tahap Kelayakan Akademik/Jawatan</th></tr> </thead> <tbody> <tr> <td data-bbox="199 930 267 1052">1</td><td data-bbox="267 930 573 1052">DR. NUR FATIAH BINTI FAUZI</td><td data-bbox="573 930 865 1052">338510</td><td data-bbox="865 930 1235 1052">FSKM/ UiTM CAWANGAN PERLIS</td><td data-bbox="1235 930 1555 1052">DOKTOR FALSAFAH (PHD) / PENSYARAH KANAN</td></tr> <tr> <td data-bbox="199 1052 267 1173">2</td><td data-bbox="267 1052 573 1173">DR. NURIZATUL SYARFINAS BINTI AHMAD BAKHTIAR</td><td data-bbox="573 1052 865 1173">357999</td><td data-bbox="865 1052 1235 1173">FSKM/ UiTM CAWANGAN PERLIS</td><td data-bbox="1235 1052 1555 1173">DOKTOR FALSAFAH (PHD) / PENSYARAH KANAN</td></tr> <tr> <td data-bbox="199 1173 267 1329">3</td><td data-bbox="267 1173 573 1329">DR. MOHD RIJAL BIN ILIAS</td><td data-bbox="573 1173 865 1329">267982</td><td data-bbox="865 1173 1235 1329">FSKM/ UiTM SHAH ALAM</td><td data-bbox="1235 1173 1555 1329">DOCTOR OF PHILOSOPHY (PHD) / PENSYARAH KANAN</td></tr> <tr> <td data-bbox="199 1329 267 1434">4</td><td data-bbox="267 1329 573 1434">PUAN NURIDAWATI BINTI BAHAROM</td><td data-bbox="573 1329 865 1434">300276</td><td data-bbox="865 1329 1235 1434">FSKM/ UiTM CAWANGAN PERLIS</td><td data-bbox="1235 1329 1555 1434">SARJANA (MASTER) / PENSYARAH KANAN</td></tr> <tr> <td data-bbox="199 1434 267 1545">5</td><td data-bbox="267 1434 573 1545">CIK UMI HANIM BINTI MAZLAN</td><td data-bbox="573 1434 865 1545">279462</td><td data-bbox="865 1434 1235 1545">FSKM/ UiTM CAWANGAN PERLIS</td><td data-bbox="1235 1434 1555 1545">SARJANA (MASTER) / PENSYARAH KANAN</td></tr> </tbody> </table>				Bil	Name Nama	IC / Staff Number: No. Kad Pengenalan/ No. Pekerja:	University / Industry / Agency Fakulti/ P.Pengajian/ Pusat/Unit	Academic Qualification/ Designation Tahap Kelayakan Akademik/Jawatan	1	DR. NUR FATIAH BINTI FAUZI	338510	FSKM/ UiTM CAWANGAN PERLIS	DOKTOR FALSAFAH (PHD) / PENSYARAH KANAN	2	DR. NURIZATUL SYARFINAS BINTI AHMAD BAKHTIAR	357999	FSKM/ UiTM CAWANGAN PERLIS	DOKTOR FALSAFAH (PHD) / PENSYARAH KANAN	3	DR. MOHD RIJAL BIN ILIAS	267982	FSKM/ UiTM SHAH ALAM	DOCTOR OF PHILOSOPHY (PHD) / PENSYARAH KANAN	4	PUAN NURIDAWATI BINTI BAHAROM	300276	FSKM/ UiTM CAWANGAN PERLIS	SARJANA (MASTER) / PENSYARAH KANAN	5	CIK UMI HANIM BINTI MAZLAN	279462	FSKM/ UiTM CAWANGAN PERLIS	SARJANA (MASTER) / PENSYARAH KANAN
Bil	Name Nama	IC / Staff Number: No. Kad Pengenalan/ No. Pekerja:	University / Industry / Agency Fakulti/ P.Pengajian/ Pusat/Unit	Academic Qualification/ Designation Tahap Kelayakan Akademik/Jawatan																														
1	DR. NUR FATIAH BINTI FAUZI	338510	FSKM/ UiTM CAWANGAN PERLIS	DOKTOR FALSAFAH (PHD) / PENSYARAH KANAN																														
2	DR. NURIZATUL SYARFINAS BINTI AHMAD BAKHTIAR	357999	FSKM/ UiTM CAWANGAN PERLIS	DOKTOR FALSAFAH (PHD) / PENSYARAH KANAN																														
3	DR. MOHD RIJAL BIN ILIAS	267982	FSKM/ UiTM SHAH ALAM	DOCTOR OF PHILOSOPHY (PHD) / PENSYARAH KANAN																														
4	PUAN NURIDAWATI BINTI BAHAROM	300276	FSKM/ UiTM CAWANGAN PERLIS	SARJANA (MASTER) / PENSYARAH KANAN																														
5	CIK UMI HANIM BINTI MAZLAN	279462	FSKM/ UiTM CAWANGAN PERLIS	SARJANA (MASTER) / PENSYARAH KANAN																														
C(vi)	Please provide information on academic publications that has been published by the project leader for the last five (5) years. (Example: Journals, Books, Chapters in books, etc) <i>Sila kemukakan maklumat berkaitan penerbitan akademik yang telah diterbitkan oleh ketua penyelidik dalam tempoh lima (5) tahun terakhir. (Contoh: Jurnal, buku, bab dalam buku, dll)</i> <table border="1" data-bbox="199 1711 1555 1990"> <thead> <tr> <th data-bbox="199 1711 878 1833">Title of publication Tajuk penerbitan</th><th data-bbox="878 1711 1312 1833">Name of journals/books Nama jurnal/buku</th><th data-bbox="1312 1711 1555 1833">Year published Tahun diterbitkan</th></tr> </thead> <tbody> <tr> <td data-bbox="199 1833 878 1990">NANOPARTICLE SHAPE EFFECTS OF ALIGNED MAGNETOHYDRODYNAMICS MIXED CONVECTION FLOW OF JEFFREY HYBRID NANOFLUID OVER A STRETCHING VERTICAL PLATE</td><td data-bbox="878 1833 1312 1990">JOURNAL OF ADVANCED RESEARCH IN APPLIED MECHANICS</td><td data-bbox="1312 1833 1555 1990">2023</td></tr> </tbody> </table>				Title of publication Tajuk penerbitan	Name of journals/books Nama jurnal/buku	Year published Tahun diterbitkan	NANOPARTICLE SHAPE EFFECTS OF ALIGNED MAGNETOHYDRODYNAMICS MIXED CONVECTION FLOW OF JEFFREY HYBRID NANOFLUID OVER A STRETCHING VERTICAL PLATE	JOURNAL OF ADVANCED RESEARCH IN APPLIED MECHANICS	2023																								
Title of publication Tajuk penerbitan	Name of journals/books Nama jurnal/buku	Year published Tahun diterbitkan																																
NANOPARTICLE SHAPE EFFECTS OF ALIGNED MAGNETOHYDRODYNAMICS MIXED CONVECTION FLOW OF JEFFREY HYBRID NANOFLUID OVER A STRETCHING VERTICAL PLATE	JOURNAL OF ADVANCED RESEARCH IN APPLIED MECHANICS	2023																																

	ALIGNED MAGNETOHYDRODYNAMIC MIXED CONVECTION FLOW OF CASSON HYBRID NANOFLUID OVER A VERTICAL PLATE WITH NEWTONIAN HEATING	THE DIGITAL COLLECTION OF EXTENDED ABSTRACTS FROM RESEARCH EXHIBITION IN MATHEMATICS AND COMPUTER SCIENCES (REMACS 6.0)	2023
	ALIGNED MAGNETOHYDRODYNAMICS MIXED CONVECTION ON VARIOUS BASE FLUIDS WITH CARBON NANOTUBES OVER AN INCLINED PLATE	CFD LETTERS	2023
	A STUDY OF PREVALENCE OF DEPRESSION, ANXIETY, AND STRESS AMONG MALAYSIAN FEMALE INMATES	HANDBOOK OF RESEARCH ON DISSECTING AND DISMANTLING OCCUPATIONAL STRESS IN MODERN ORGANIZATIONS	2023
	SELF-REVIEW REPORT 2021 UiTM CAWANGAN PERLIS	SELF-REVIEW REPORT 2021 UiTM CAWANGAN PERLIS	2022
	SELF-REVIEW REPORT 2020 UiTM CAWANGAN PERLIS	SELF-REVIEW REPORT 2020 UiTM CAWANGAN PERLIS	2022
	ALIGNED MAGNETOHYDRODYNAMICS FREE CONVECTION FLOW OF MAGNETIC NANOFLUID OVER A MOVING VERTICAL PLATE WITH CONVECTIVE BOUNDARY CONDITION	JOURNAL OF ADVANCED RESEARCH IN FLUID MECHANICS AND THERMAL SCIENCES	2022
	UNSTEADY ALIGNED MHD BOUNDARY LAYER FLOW AND HEAT TRANSFER OF A MAGNETIC NANOFLUIDS PAST AN INCLINED PLATE	INTERNATIONAL JOURNAL OF MECHANICAL ENGINEERING AND ROBOTICS RESEARCH	2020
C(vii)	Executive Summary of Research Proposal (maximum 300 words) (Please include the problem statement, objectives, research methodology, expected output/outcomes/implication, and significance of output from the research project) <i>Ringkasan Cadangan Eksekutif Penyelidikan (maksimum 300 patah perkataan)</i> <i>(Meliputi pernyataan masalah, objektif, kaedah penyelidikan, jangkaan hasil penyelidikan/implikasi dan kepentingan output projek penyelidikan)</i> One of the key engineering strategies for improved energy optimisation and cost control in industrial applications is to enhance cooling or heating systems. It has been suggested that using nanofluids will enable heat transfer liquids to perform better than they do now. Metal nanoparticles (like copper and silver) and carbon nanomaterials (like graphene and carbon nanotubes) have been extensively explored as fillers of nanofluids for heat transfer applications due to their high thermal conductivity and other distinctive properties. Notably, because carbon nanomaterials and metal nanoparticles are not hydrophilic, they cannot match the demands of actual applications and are difficult to spread steadily in the base fluid for an extended period of time. Adding surfactants to a fluid to lower surface tension and help with particle dispersion is a common technique used to increase the nanofluids' stability. Contrarily, carbon nanotubes containing metal nanoparticles have drawn a lot of focus because of their distinctive nanostructures, which interact with the properties of both the host carbon nanotubes and the guest fillers concurrently. The objective of this study is to investigate the effect of carbon nanotubes toward the flow and heat transfer of hybrid nanofluid. The governing partial differential equations corresponding to the momentum and energy equations are transformed into ordinary differential equations by using dimensionless variables. Keller-box method is used to find the numerical solutions of these equations. Numerical results of obtained velocity and temperature profiles with various values of embedded flow parameters are shown graphically and their physical effects will be discussed in detail. Expressions for skin friction and Nusselt number will be obtained. This project is expected to provide the strong mathematical model and its numerical solutions for the problem involved fluid flow embedded with carbon nanotubes. The outputs of this research are very important elements in choosing the good		

	materials in industrial applications. This project absolutely gives a big contribution to the development of knowledge on application of carbon nanotubes and can be serve as reference for future works.
C(viii)	Detailed proposal of research project: <i>Cadangan maklumat penyelidikan secara terperinci:</i> (a) Research background including: / <i>Latarbelakang penyelidikan termasuk:</i> i) Problem Statement / <i>Pernyataan Masalah</i> Heat transfer is a fundamental concept in various fields, including engineering, physics, and environmental sciences. It plays a crucial role in designing and analysing systems such as heat exchangers, refrigeration systems, engines, buildings, and electronics cooling. Understanding heat transfer mechanisms allows engineers and scientists to optimize energy efficiency, control temperature gradients, and ensure the proper functioning of devices and processes. The distribution of nanoparticles in nanofluids has improve the fluid's effective thermal conductivity consequently improves heat transmission, which is an issue for manufacturers and researchers. Recently, heat transfer in carbon nanotubes become fascinating area of research due to the exceptional thermal properties exhibited by these nanostructures. Carbon nanotubes hold great promise for technological advancements since it holds high thermal conductivity, making them excellent candidates for thermal management applications and nanoscale heat transfer studies. Previous researches that have been done conducted on carbon nanotubes also shows that carbon nanotubes have the potential to revolutionize various industries since it also has extraordinary mechanical, electrical, and optical properties. Overall, heat transfer in carbon nanotubes is a complex and active area of research, with potential applications in nanoscale thermal management and advanced materials for various industries. Thus, this study was carried out to investigate heat transfer of carbon nanotube suspensions in hybrid nanofluid flow over a vertical and inclined plate while taking physical parameters into account such as magnetic field inclination angle, magnetic parameter, volume fraction of nanoparticles, and mixed convection parameter. ii) Hypothesis / <i>Hipotesis</i> Carbon Nanotubes will affect the performance of heat and mass transfer in hybrid nanofluid. iii) Research Questions / <i>Persoalan Penyelidikan</i> This study will explore the following questions 1) How the mathematical models of Carbon Nanotubes hybrid nanofluid passing through vertical and inclined plate can be developed? 2) How is the Keller Box Method implemented to solve the mathematical problem? 3) How does the presence of physical parameters affect the profiles of the velocity, temperature, as well as skin friction and Nusselt number? iv) Literature Reviews / <i>Kajian Literatur</i> Thermal management systems are becoming increasingly significant in the modern world. As products mainly electronics devices, become increasingly complicated, more effective thermal management systems become necessary. Due to space and financial constraints, the systems must be made as simple, functional, and small as possible (Apmann et al., 2022). Over the past few decades, nanotechnology has made an excessive progress. Nanotechnology is described as the study and control of matter at scales of 1 to 100 nanometres where the unique phenomena allow for the novel applications. In the beginning of the 21st century, there is an increased interest in the nanoscience and nanotechnology field. Nanotechnology has formed the foundation for a remarkable application in the industry and exponential growth in less than half a century (Hulla et al., 2015). The nanotechnology integrates into a bigger system provided a breakthrough solution to many current environmental, industry and medicinal problems (Bhushan, 2004). For example, nanotechnology has a significant impact on the medical devices such diagnostic biosensors, drug delivery systems and imaging probes.

Any fluid, whether liquid or gas that is employed in a heating or cooling process is referred as heat transfer fluids and are used in a variety of industries including food, chemicals and oil and gas sector. The ability to generate high temperature at low system pressure is the crucial feature of the heat transfer fluids technology. In comparison with traditional technologies such as steam heating or direct fire heating, heat transfer fluid technology provides safety low maintenance and longer operation lifetimes. Thus, it is not surprising that the heat transfer fluids have gotten a lot of attention for in recent years (Czaplicka et al., 2021). In order to make an improvement on the thermal efficiency, Choi (1995) introduced nanometre particles size to be added into the fluids thus known as nanofluid. Nanofluid become innovative concept that has offered solutions to many problems. The main thermophysical properties of nanofluid in terms of flows and heat transmission in thermal systems are density, specific heat capacity, thermal conductivity, viscosity and surface tension (Ganvir et al., 2017).

Many researchers are fascinated with hybrid nanofluid. It is a new generation heat transfer fluid that has been developed to improve the properties of nanofluid, which might exhibit a number of favourable characteristics. Due to the synergistic impact, the primary goal of adopting hybrid nanofluid is to obtain a promising improvement in thermophysical, hydrodynamic and heat transmission properties as compared to mono nanofluid (Sarkar et al., 2015). Among all of the parameters, thermal conductivity is the most important parameter that highly contributed to the improvement of heat transmission. There are many factors, such as selection of base fluid and size of nanoparticles, which play a significant role in the heat transfer enhancement of hybrid nanofluid (Venkata Sastry et al., 2008). The hybridization of appropriate combination of nanoparticles can provide the desired heat transfer effect even the particles concentration is low (Hemmat Esfe, Alirezaie, et al., 2017).

Numerous studies on carbon nanotubes have been conducted in the world of research since the discovery of these materials in 1991 by Iijima because carbon nanotubes are employed in several disciplines, including material science, optics, engineering, chemical synthesis, and microelectronic cooling (Qureshi, et al., 2023). Nanotubes are divided into two types by the wall structure of carbon. Single-wall carbon nanotubes (SWCNTs) are cylinder-shaped materials made of a single layer of graphene particles that holds all of the atoms together. They have a diameter of 0.5–1.5 nm. Multi-wall carbon nanotubes (MWCNTs) consist of tubes joined by graphene layer connections of increasing size. Despite having many traits in common, SWCNTs and MWCNTs also differ significantly in a few crucial aspects. According to studies done on moving flat plate by Aman et al. (2017), Anuar, Bachok & Pop (2018), and Anuar et al. (2019), SWCNTs nanofluid provide greater skin friction and heat transfer than MWCNTs because they have a higher density and thermal conductivity. Ab Raji, et al., (2023) found that MWCNTs transferred heat more efficiently than SWCNTs in the study that conducted on carbon nanotubes with various base fluids flow over an inclined plate.

Recently, a wide range of attentions was given on decoration of carbon nanotubes with metals (Alexeyeva, et al., 2010), metal oxides (Kumar, et al., 2021, Asadikia, et al., 2020 and Ali, et al., 2023) and carbon (Obalalu, et al., 2023 and Balaji, et al., 2021) nanoparticles on various curved geometry due to their extraordinary properties in electrical, magnetic, thermal and optical. The thermal, electrical, and physical characteristics of hybrid nanofluids made of multi-walled carbon nanotubes and Fe₂O₃ nanoparticles in ethylene glycol (EG)/water as the base fluid were investigated by Asadikia et al. (2020). The thermoelectrical property was enhanced by the addition of both nanoparticles to the base fluid, according to the experimental data.

Based on the literature review, it was found that there have been less investigations on the hybrid nanofluid flow and heat transfer of carbon nanotubes over vertical and inclined plate. Nowadays, the most essential topic is the development of nanotechnology and how it might be used for commercial and technological applications. Therefore, we want to numerically scrutinize the boundary layer flow and heat transfer for hybrid nanofluid focusing on the hybridization of metal and carbon nanotubes with base fluid over vertical and inclined plate with various effect, by using Keller-Box method to solve the problem. The mathematical model was solved numerically and impact of some relevant parameters on the physical quantities are plotted in a graphical representation.

v) **Related References / Rujukan berkaitan**

- 1) Apmann, K., Fulmer, R., Scherer, B., Good, S., Wohld, J., & Vafaei, S. (2022). Nanofluid heat transfer: Enhancement of the heat transfer coefficient inside microchannels. *Nanomaterials*, 12(4), 615.

- 2) Bhushan, B. (2004). Introduction to nanotechnology. Springer Handbook of Nanotechnology, 1–6. https://doi.org/10.1007/3-540-29838-x_1
- 3) Hulla, J. E., Sahu, S. C., & Hayes, A. W. (2015). Nanotechnology. Human & Experimental Toxicology, 34(12), 1318–1321. <https://doi.org/10.1177/0960327115603588>
- 4) Czaplicka, N., Grzegórska, A., Wajs, J., Sobczak, J., & Rogala, A. (2021). Promising nanoparticle-based heat transfer fluids—environmental and techno-economic analysis compared to conventional fluids. International Journal of Molecular Sciences, 22(17), 9201. <https://doi.org/10.3390/ijms22179201>
- 5) Choi SUS. (1995). Enhancing thermal conductivity of fluids with nanoparticles, developments and applications of non-newtonian flows. New York: ASME; p.99-105, FED-Vol.231/MD-Vol 66.
- 6) Ganvir, R. B., Walke, P. V., & Kriplani, V. M. (2017). Heat transfer characteristics in nanofluid—a review. Renewable and Sustainable Energy Reviews, 75, 451–460. <https://doi.org/10.1016/j.rser.2016.11.010>
- 7) Sarkar, J., Ghosh, P., & Adil, A. (2015). A review on hybrid nanofluids: Recent research, development and applications. Renewable and Sustainable Energy Reviews, 43,164–177.
- 8) Venkata Sastry, N. N., Bhunia, A., Sundararajan, T., & Das, S. K. (2008). Predicting the effective thermal conductivity of carbon nanotube based nanofluids. Nanotechnology, 19(5), 055704. <https://doi.org/10.1088/0957-4484/19/05/055704>
- 9) Hemmat Esfe, M., Alirezaie, A., & Rejvani, M. (2017). An applicable study on the thermal conductivity of SWCNT-MgO hybrid nanofluid and price-performance analysis for Energy Management. Applied Thermal Engineering, 111, 1202–1210. <https://doi.org/10.1016/j.applthermaleng.2016.09.091>
- 10) Iijima, S. (1991). Helical microtubules of graphitic carbon. nature, 354(6348), 56-58. <https://doi.org/10.1038/354056a0>
- 11) Qureshi, M. Z. A., Raza, Q., Eldin, S. M., Zafar, M., Ali, B., & Siddique, I. (2023). Thermal performance of hybrid magnetized nanofluids flow subject to joint impact of ferro oxides/CNT nanomaterials with radiative and porous factors. Case Studies in Thermal Engineering, 41, 102648.
- 12) Aman, S., Khan, I., Ismail, Z., Salleh, M. Z., & Al-Mdallal, Q. M. (2017). Heat transfer enhancement in free convection flow of CNTs Maxwell nanofluids with four different types of molecular liquids. Scientific reports, 7(1), 2445
- 13) Anuar, N. S., Bachok, N., & Pop, I. (2018). A stability analysis of solutions in boundary layer flow and heat transfer of carbon nanotubes over a moving plate with slip effect. Energies, 11(12), 3243.
- 14) Anuar, N. S., Bachok, N., Arifin, N. M., & Rosali, H. (2019). Dual solutions for stagnation point flow of carbon nanotube over a permeable exponentially shrinking sheet and stability analysis. Journal of Multidisciplinary Engineering Science and Technology, 6, 41-48.
- 15) Ab Raji, N. H., Shahabudin, N. S. M., Awang, N., Ilias, M. R., & Ishak, S. S. (2023). Aligned Magnetohydrodynamics Mixed Convection on Various Base Fluids with Carbon Nanotubes over an Inclined Plate. CFD Letters, 15(6), 12-25.
- 16) Alexeyeva, N., Kozlova, J., Sammelselg, V., Ritslaid, P., Mändar, H., & Tammeveski, K. (2010). Electrochemical and surface characterisation of gold nanoparticle decorated multi-walled carbon nanotubes. Applied Surface Science, 256(10), 3040-3046.
- 17) Kumar, V., Pare, A., Tiwari, A. K., & Ghosh, S. K. (2021). Efficacy evaluation of oxide-MWCNT water hybrid nanofluids: an experimental and artificial neural network approach. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 620, 126562. [9] M. Feng, R. Sun, H. Zhan, Y. Chen, Carbon 48 (2010) 1177.
- 18) Asadikia, A., Mirjalily, S. A. A., Nasirizadeh, N., & Kargarsharifabad, H. (2020). Hybrid nanofluid based on CuO nanoparticles and single-walled Carbon nanotubes: Optimization, thermal, and electrical properties. International Journal of Nano Dimension, 11(3), 277-289.
- 19) Ali, K., Ahmad, S., Tayebi, T., Ashraf, M., Jamshed, W., Abd-Elmonem, A., & El Din, S. M. (2023). Thermal attributes of hybrid (MWCNT-NiZnFe2O4) nanofluid flow having motile microbes and activation energy: A computational approach. Case Studies in Thermal Engineering, 47, 103088.
- 20) Obalalu, A. M., Salawu, S. O., Memon, M. A., Olayemi, O. A., Ali, M. R., Sadat, R., ... & Akindele, A. O. (2023). Computational study of Cattaneo–Christov heat flux on cylindrical surfaces using CNT hybrid nanofluids: A solar-powered ship implementation. Case Studies in Thermal Engineering, 45, 102959.

- 21) Balaji, T., Rajendiran, S., Selvam, C., & Lal, D. M. (2021). Enhanced heat transfer characteristics of water-based hybrid nanofluids with graphene nanoplatelets and multiwalled carbon nanotubes. *Powder Technology*, 394, 1141-1157.
- 22) Asadikia, A., Mirjalily, S. A. A., Nasirizadeh, N., & Kargarsharifabad, H. (2020). Characterization of thermal and electrical properties of hybrid nanofluids prepared with multi-walled carbon nanotubes and Fe₂O₃ nanoparticles. *International Communications in Heat and Mass Transfer*, 117, 104603.

vi) **Relevance to Government Policy, if any / Perkaitan dengan Dasar Kerajaan, jika berkenaan**

This study in line with Education National Key Economic Area (NKEA) under EPP 9: Building an Advanced Engineering, Science and Innovation Discipline Cluster. The new developed model/algorithms in this research are expected to be a generalization in modelling involving carbon nanotubes on boundary layer flow and heat transfer problems at high operating temperature such as gas turbine, nuclear power plant, thermal energy store, etc.

This project also supports the 4.0 Industries revolution in Malaysia under one of the nine drives/pillars which is Simulations. The algorithm developed in this project will help the manufacturing sector to increase the productivity, efficiency, quality and reduced time to market.

(b) Objective (s) of the Research

Objektif Penyelidikan

- 1) To design the mathematical models of carbon nanotubes in hybrid nanofluid passing through vertical and inclined plate with the other pertinent factors.
- 2) To obtain the numerical results of the velocity, temperature as well as skin friction and Nusselt number.
- 3) To assess the performance of the numerical method toward the mathematical model.

(c) Methodology

Kaedah penyelidikan

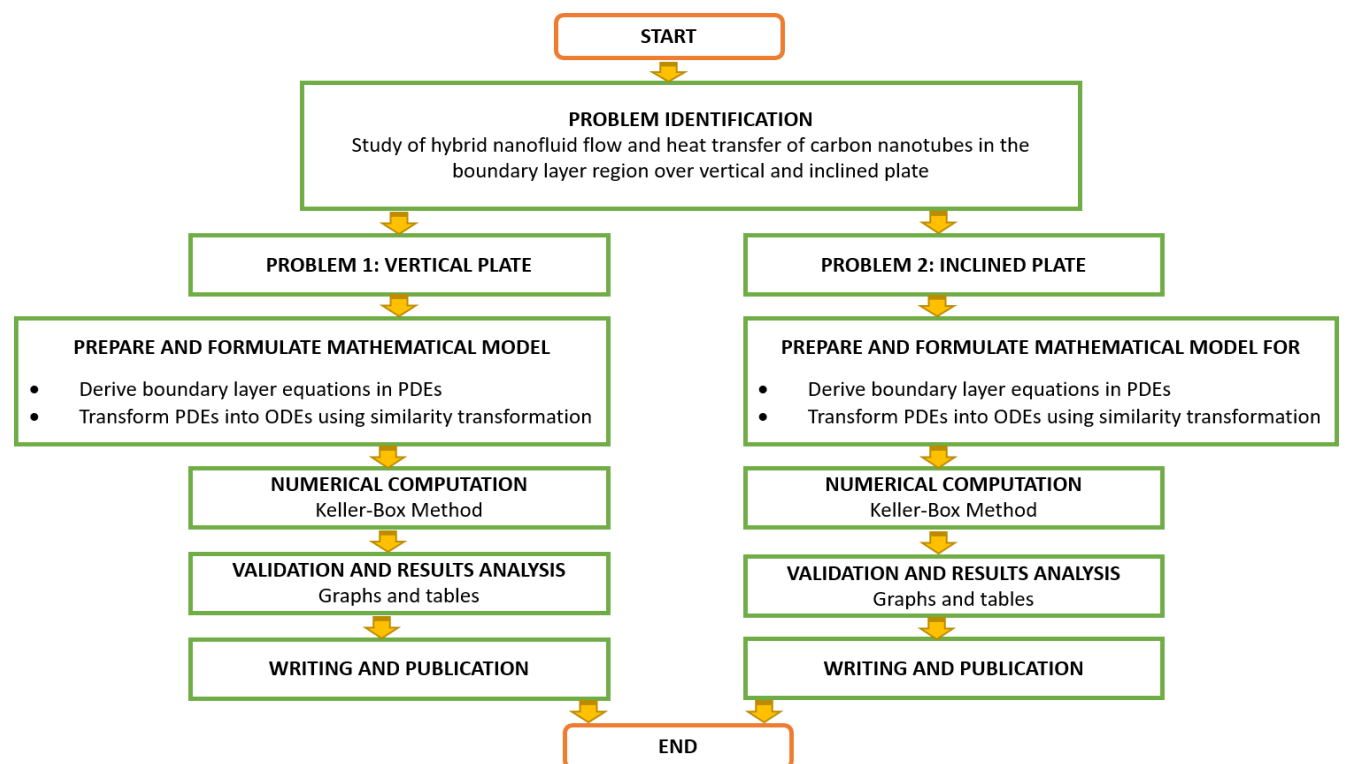


Figure 1 Research Methodology

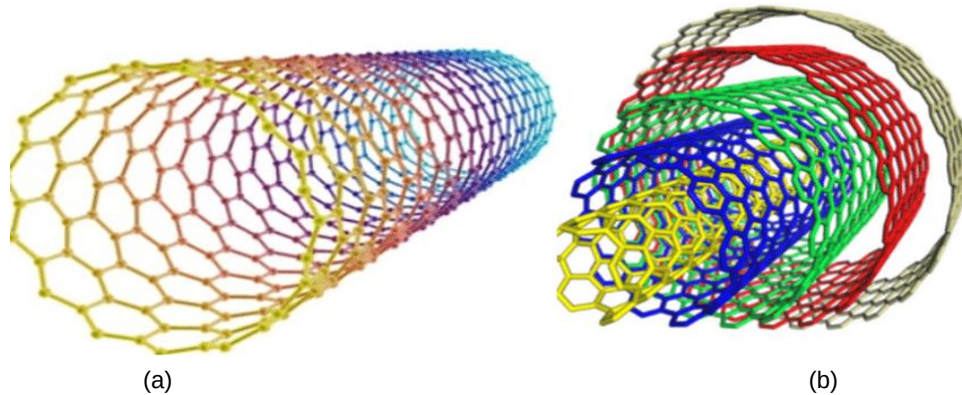


Figure 2 Structure of (a) SWCNT and (b) MWCNT

OBJECTIVE 1: Mathematical Formulation Derivation

Phase (I) Mathematical Modelling – Problem Formulation

The governing boundary layer flow equations will be obtained for the new model based on Tiwari Das nanofluid model as outlined in the objectives under the boundary layer and Boussinesq approximations. These equations are known as continuity equation, momentum equation and energy equation. Considering some assumptions and limitations, the problem formulation will begin from the continuity equation. The continuity equation is based on the law of conservation mass which states that “mass is neither created nor destroyed inside a control volume system”. Another fundamental physical principle namely as Newton’s second law produced the momentum equation by applying to a moving fluid element model of the flow. Specifically, the moving fluid element is using because this model is particularly convenient for the derivation of momentum equation as well as the energy equation. Following the first law of thermodynamics, the energy equation is derived. The principle of conservation of energy (first law of thermodynamics) states that, energy cannot be created or destroyed.

Phase (II) Mathematical Analysis – Similar Transformation

The governing partial differential equations will be transformed into a set of coupled non dimensional nonlinear ordinary differential equations by using an appropriate similarity transformation.

OBJECTIVE 2: Numerical Computation – Keller Box Method

The non-dimensional governing equations will be solved numerically using an implicit difference scheme known as Keller Box method which is described in the book by Bradshaw and Cebeci (1984). This method has been found to be very suitable in dealing with nonlinear parabolic problems. This scheme also enables computing extremely close to the point of separation with no special precautions, while the inclusion of chemically reacting species should offer no difficulties. It had also been extensively tested beforehand on laminar boundary layer flows by Keller and Cebeci (1971). The efficiency of this scheme clearly makes it applicable for steady two dimensional, steady three dimensional, unsteady two dimensional and even applicable on unsteady three-dimensional boundary layer flows.

The basic idea of the Keller box method is to write the governing system of equations in the form of a first order system. Four important steps involved in this method are as follows:

- 1) Reduce the differential equations to a first-order system;
- 2) With the resulting of first order equations, difference equations are written by using central differences;
- 3) Linearize the resulting equations by using the Newtons method and employed on the coefficient of matrix of the finite difference equations;
- 4) The linear system is solved using block elimination method by employing a block-tridiagonal factorization scheme.
- 5) Finally, the numerical algorithms will be developed using FORTRAN 77 for the iterated computational and then continued using MATLAB to plot the associated graph.

OBJECTIVE 3: Results, Discussion and Verification

The governing boundary layer equations are solved numerically by using Keller-box method. It is need to be emphasize that there will be no real experiments conducted to validate the numerical results. The validation will be done by comparing the present result with the previous established output in literature at the limiting cases. In this case if the output obtained is approaching the reference results, therefore the present model and its computation results can be acceptable. Numerical results presented in this research will include the velocity and temperature profiles, as well as skin friction and heat transfer coefficients in term of Nusselt number.

(d) Expected Results/Benefit

Jangkaan Hasil Penyelidikan

1. **Novel theories/New findings/Knowledge**

- i) A new formulation for the mathematical model of carbon nanotubes in hybrid nanofluid.
- ii) A new vision into more developed and structured mathematical models for explaining the behaviour of heat transfer problems in hybrid nanofluid system.
- iii) A new algorithm development or generation of numerical packages for solving similar or related boundary layer flow problem.
- iv) An enhanced understanding and application of the problems in advanced technologies involving processing industries.
- v) Theoretical and numerical solutions were made available for various values of the embedded parameters.

2. **Research Publications**

- i) Journal of Advanced Research in Fluid Mechanics and Thermal Sciences (SCOPUS)
- ii) Ain Shams Engineering Journal (Elsevier, Q1, IF: 4.416, WOS)

3. **Specific or Potential Grant Applications (please specify targeted grant application)**

None.

4. **Number of PhD and Masters (by research) Students (if any)**

None.

5. **Impact on Society, Economy and Nation**

Expected research deliverables on:

- i) Society: The results of this project are beneficial in estimating the suitable amount of volumetric nanoparticle concentrations and the good combination of nanoparticles. Since, nanofluids are widely used as working fluid for solar collectors, refrigeration, cooling, and heating appliances, hence this kind of heat transfer fluid can benefit society in energy and cost savings.
- ii) Economy and nation: The research can fulfil the objectives and policy of the National Nanotechnology Center (NNC) under the auspices of the Ministry of Science, Technology and Innovation (MOSTI). It can help other researchers from both academia and industry (solar energy, electronic cooling, biomedical appliances) in understanding the hybrid nanofluids flow and heat transfer characteristics.

(e) Research activity & Milestone
Aktiviti penyelidikan & Carta perbatuan

Activity	Start Date	End Date
Literature Review and problem identification	01/01/2025	30/04/2025
Mathematical modeling and problem formulations for Problem 1	01/02/2025	30/04/2025
Mathematical analysis and numerical computation for Problem 1. Analysis of the results and discussion for Problem 1.	01/05/2025	30/10/2025
Preparing for national/international conference and journal publication for Problem 1	01/10/2025	30/11/2025
Mathematical modeling and problem formulations for Problem 2	01/11/2025	31/01/2026
Mathematical analysis and numerical computation for Problem 2. Analysis of the results and discussion for Problem 2.	01/02/2026	31/07/2026
Preparing for national/international conference and journal publication for Problem 2	01/08/2026	30/10/2026

Milestone	Date
Mathematical formulation for Problem 1	30/04/2025
Completion of numerical computation and conclusion for Problem 1	30/10/2025
Mathematical formulation for Problem 2	31/01/2026
Completion of numerical computation and conclusion for Problem 2	31/07/2026
Preparing for national/international conference and journal publication	30/10/2026

D

BUDGET /BELANJAWAN

Please indicate your estimated budget for this research and details of expenditure according to the guidelines attached.

Sila nyatakan anggaran bajet bagi cadangan penyelidikan ini dan berikan butir – butir perbelanjaan lengkap dengan berpandukan kepada garis panduan yang dilampirkan.

Budget details <i>Butiran belanjawan</i>	Amount requested by applicant <i>Jumlah yang dipohon oleh pemohon</i>	
	Year 1 (Tahun 1) (RM)	Year 2 (Tahun 2) (RM)

D(i)	Vote 21000 - Travelling and Transportation/ <i>Perjalanan dan Pengangkutan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i> Perjalanan dan penginapan bagi perbincangan bersama – RM1,000	500	500
D(ii)	Vote 24000 - Rental <i>Vot 24000 - Sewaan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>		
D(iii)	Vote 27000 - Research Materials & Supplies <i>Vot 27000 - Bekalan dan Bahan Penyelidikan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>		
D(iv)	Vote 28000 - Maintenance and Minor Repair Services <i>Bvot 28000 - Baik pulih kecil dan ubahsuai</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>		
D(v)	Vote 29000 - Professional Services <i>Vot 29000 - Perkhidmatan Ikhtisas</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i> 1) Journal of Advanced Research in Fluid Mechanics and Thermal Sciences – RM1,500 2) Ain Shams Engineering Journal (Elsevier) - RM2,500	1,500	2,500
D(vi)	Vote 35000 - Accessories and Equipment <i>Vot 35000 - Aksesori dan Peralatan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>		
TOTAL AMOUNT JUMLAH BESAR		5,000	

E	Declaration by applicant / Akuan Pemohon (Please tick (✓)): / (Sila tanda (✓)):
	I hereby declare that: <i>Saya dengan ini mengaku bahawa:</i> ✓ 1. All information stated here are accurate, and PJI has right to reject or to cancel the offer without prior notice if there is any inaccurate information given. <i>Semua maklumat yang diisi adalah benar, PJIM&A berhak menolak permohonan atau membatalkan tawaran pada bila-bila masa sekiranya keterangan yang dikemukakan adalah tidak benar.</i> ✓ 2. Application of this research is presented for the Geran Semarak Penyelidikan <i>Permohonan penyelidikan ini dikemukakan untuk Geran Semarak Penyelidikan.</i> ✓ 3. Application of this research is subject to Ethical Committee approval (if applicable). <i>Permohonan penyelidikan ini dimajukan ke Jawatankuasa Etika (jika berkenaan).</i> Date : <i>Tarikh :</i> 24/11/2024 Applicant's Signature : <i>Tandatangan Pemohon :</i>  Note: APPLICATIONS SUBMITTED WILL BE TREATED IN FULL CONFIDENCE. THE DECISION OF THE INTERNAL RESEARCH ACCULTURATION MAIN COMMITTEE UiTM CAWANGAN PERLIS IS FINAL. Semua permohonan dianggap sulit. Keputusan Jawatankuasa Induk Geran Penyelidikan Pembudayaan Dalam UiTM Cawangan Perlis adalah MUKTAMAD.

Kod Rujukan: (Diisi oleh PJI)	
RIG	
Bukti Kolaborasi	

(Diisi oleh PJI)

BORANG PERMOHONAN GERAN SEMARAK PENYELIDIKAN (GSP) 2024 Bahagian Penyelidikan & Jaringan Industri (PJI) UiTM CAWANGAN PERLIS			
A	TITLE OF PROPOSED RESEARCH: <i>Tajuk penyelidikan yang dicadangkan :</i> Enhancing Water Resistance of Pectin-Chitosan Films Using Hydrophobic Deep Eutectic Solvents (DES) of Thymol with Medium-Chain Fatty Acids (MCFAs)		
B	DETAILS OF RESEARCHER / MAKLUMAT PENYELIDIK		
B(i)	<table><tr><td> Name of Project Leader: <i>Nama Ketua Projek:</i> Dr Rizana Yusof </td><td> IC / Passport Number: <i>No. Kad Pengenalan/ Pasport:</i> 790307-03-5654 </td></tr></table>	Name of Project Leader: <i>Nama Ketua Projek:</i> Dr Rizana Yusof	IC / Passport Number: <i>No. Kad Pengenalan/ Pasport:</i> 790307-03-5654
Name of Project Leader: <i>Nama Ketua Projek:</i> Dr Rizana Yusof	IC / Passport Number: <i>No. Kad Pengenalan/ Pasport:</i> 790307-03-5654		
B(iii)	Faculty/School/Centre/Unit (Please provide full address): <i>Fakulti/Jabatan /Pusat/Unit</i> Fakulti Sains Gunaan, UiTM CAWANGAN PERLIS, 02600, ARAU, PERLIS		
B(iv)	<table><tr><td> Office Telephone No.: 04-9882296 <i>No. Telefon Pejabat:</i> - </td><td> Handphone No.: 012-9665426 <i>No. Telefon Bimbit:</i> </td></tr></table>	Office Telephone No.: 04-9882296 <i>No. Telefon Pejabat:</i> -	Handphone No.: 012-9665426 <i>No. Telefon Bimbit:</i>
Office Telephone No.: 04-9882296 <i>No. Telefon Pejabat:</i> -	Handphone No.: 012-9665426 <i>No. Telefon Bimbit:</i>		
B(v)	E-mail Address: rizana@uitm.edu.my <i>Alamat e-mel:</i>		
B(vi)	Date of first appointment with this University: 4 July 2005 <i>Tarikh mula berkhidmat dengan Universiti ini:</i>		

C	RESEARCH INFORMATION / MAKLUMAT PENYELIDIKAN																																	
C(i)	Research Domain (Please tick (✓)): <i>Domain Penyelidikan (Sila tanda (✓)):</i> A. Pure and Applied Sciences (Sains Tulen dan gunaan) <table border="0"> <tr> <td>☒ Chemistry (Kimia)</td> <td>☐ Physic (Fizik)</td> <td>☐ Biology (Biologi)</td> </tr> <tr> <td>☐ Biochemistry (Biokimia)</td> <td>☐ Materials Science (Sains Bahan)</td> <td>☐ Mathematics and Statistics (Matematik dan Statistik)</td> </tr> <tr> <td colspan="3">☐ Materials Science (Sains Bahan)</td> </tr> </table> B. Social Sciences (Sains Sosial) <table border="0"> <tr> <td>☐ Anthropology (Antropologi)</td> <td>☐ Psychology (Psikologi)</td> <td>☐ Sociology (Sosiologi)</td> </tr> <tr> <td>☐ Political Science (Sains Politik)</td> <td>☐ Business and Management (Pengurusan dan Perniagaan)</td> <td>☐ Geography (Geografi)</td> </tr> <tr> <td>☐ Economic (Ekonomi)</td> <td>☐ Human Ecology (Ekologi Manusia)</td> <td>☐ Communication (Komunikasi)</td> </tr> </table> C. Arts and Applied Arts (Sastera dan Sastera Ikhtisas) <table border="0"> <tr> <td>☐ Language and Linguistic (Bahasa dan Linguistik)</td> <td>☐ Literature (Kesusasteraan)</td> <td>☐ Religion (Agama)</td> </tr> <tr> <td>☐ Philosophy (Falsafah)</td> <td>☐ Civilization (Tamadun)</td> <td>☐ History (Sejarah)</td> </tr> <tr> <td>☐ Art (Seni)</td> <td>☐ Culture (Budaya)</td> <td>☐ Education (Pendidikan)</td> </tr> <tr> <td>☐ Policies and Law (Dasar dan Undang-undang)</td> <td>☐ Built Environment (Alam Bina-Aspek Kemanusiaan)</td> <td>☐ Environment (Alam Sekitar-Aspek Kemanusiaan)</td> </tr> </table> D. Natural Sciences and National Heritage (Sains Tabii dan Warisan Negara) <table border="0"> <tr> <td>☐ Environment (Alam Sekitar)</td> <td>☐ Forestry (Perhutanan)</td> <td>☐ Agriculture (Pertanian)</td> </tr> </table>	☒ Chemistry (Kimia)	☐ Physic (Fizik)	☐ Biology (Biologi)	☐ Biochemistry (Biokimia)	☐ Materials Science (Sains Bahan)	☐ Mathematics and Statistics (Matematik dan Statistik)	☐ Materials Science (Sains Bahan)			☐ Anthropology (Antropologi)	☐ Psychology (Psikologi)	☐ Sociology (Sosiologi)	☐ Political Science (Sains Politik)	☐ Business and Management (Pengurusan dan Perniagaan)	☐ Geography (Geografi)	☐ Economic (Ekonomi)	☐ Human Ecology (Ekologi Manusia)	☐ Communication (Komunikasi)	☐ Language and Linguistic (Bahasa dan Linguistik)	☐ Literature (Kesusasteraan)	☐ Religion (Agama)	☐ Philosophy (Falsafah)	☐ Civilization (Tamadun)	☐ History (Sejarah)	☐ Art (Seni)	☐ Culture (Budaya)	☐ Education (Pendidikan)	☐ Policies and Law (Dasar dan Undang-undang)	☐ Built Environment (Alam Bina-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar)	☐ Forestry (Perhutanan)	☐ Agriculture (Pertanian)
☒ Chemistry (Kimia)	☐ Physic (Fizik)	☐ Biology (Biologi)																																
☐ Biochemistry (Biokimia)	☐ Materials Science (Sains Bahan)	☐ Mathematics and Statistics (Matematik dan Statistik)																																
☐ Materials Science (Sains Bahan)																																		
☐ Anthropology (Antropologi)	☐ Psychology (Psikologi)	☐ Sociology (Sosiologi)																																
☐ Political Science (Sains Politik)	☐ Business and Management (Pengurusan dan Perniagaan)	☐ Geography (Geografi)																																
☐ Economic (Ekonomi)	☐ Human Ecology (Ekologi Manusia)	☐ Communication (Komunikasi)																																
☐ Language and Linguistic (Bahasa dan Linguistik)	☐ Literature (Kesusasteraan)	☐ Religion (Agama)																																
☐ Philosophy (Falsafah)	☐ Civilization (Tamadun)	☐ History (Sejarah)																																
☐ Art (Seni)	☐ Culture (Budaya)	☐ Education (Pendidikan)																																
☐ Policies and Law (Dasar dan Undang-undang)	☐ Built Environment (Alam Bina-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar-Aspek Kemanusiaan)																																
☐ Environment (Alam Sekitar)	☐ Forestry (Perhutanan)	☐ Agriculture (Pertanian)																																

☐ Marine
(Marin)

☐ Archaeology
(Arkeologi)

☐ Geoscience
(Geosains)

☐ Ethnography
(Etnografi)

☐ Built Environment
(Heritage Aspect)
Alam Bina (Aspek Warisan)

☐ Culture
(Budaya)

☐ Biodiversity
(Kepelbagaian Biologi)

E. Information and Communication Technology (Teknologi Maklumat dan Komunikasi)

☐ Software and Information System
(Perisian dan Sistem Maklumat)

☐ Soft Computing
(Pengkomputeran Lembut)

☐ Computer Networking
(Rangkaian Komputer)

☐ Information Security
(Keselamatan Maklumat)

☐ Multimedia
(Multimedia)

☐ Computer Engineering
(Kejuruteraan Komputer)

☐ Computer Science
(Sains Komputer)

F. Health Sciences (Sains Kesihatan)

☐ Basic Medical Sciences
(Sains Perubatan Asas)

☐ Pharmacy
(Farmasi)

☐ Pharmacology
(Farmakologi)

☐ Medical Microbiology
(Mikrobiologi Perubatan)

☐ Parasitology
(Parasitologi)

☐ Pathology
(Pathologi)

☐ Community Medical Prevention
(Perubatan Pencegahan
Masyarakat)

☐ Clinical Surgical
(Klinikal Surgical)

☐ Clinical Medical
(Klinikal Medikal)

☐ Associate Health Science
(Sains Kesihatan Bersekutu)

☐ Dental
(Pergigian)

☐ Nursing Science
(Sains Kejururawatan)

C(ii)

Location of Research:
Tempat penyelidikan dijalankan:

UiTM Perlis Branch
UiTM Shah Alam
UniMAP Perlis

C(iii)	Duration of this research (Maximum 24 months): <i>Tempoh masa penyelidikan ini (Maksimum 24 bulan):</i> Duration: 2 year <i>Tempoh :</i> From : 1 Jan 2025 <i>Dari :</i> To : 31 Dec 2026 <i>Hingga :</i>																																						
C(iv)	Other Researchers: <i>Ahli-ahli penyelidik yang lain:</i> <table border="1" data-bbox="199 743 1555 1608"> <thead> <tr> <th data-bbox="199 743 266 932">Bil</th><th data-bbox="266 743 573 932">Name <i>Nama</i></th><th data-bbox="573 743 862 932">IC / Staff Number: <i>No. Kad Pengenalan/ No. Pekerja:</i></th><th data-bbox="862 743 1230 932">University / Industry / Agency <i>Fakulti/ P.Pengajian/ Pusat/Unit</i></th><th data-bbox="1230 743 1555 932">Academic Qualification/ Designation <i>Tahap Kelayakan Akademik/Jawatan</i></th></tr> </thead> <tbody> <tr> <td data-bbox="199 932 266 1045">1.</td><td data-bbox="266 932 573 1045">Puan Farhana Othman</td><td data-bbox="573 932 862 1045">287658</td><td data-bbox="862 932 1230 1045">Fakulti Sains Gunaan, UiTM Perlis/Kimia</td><td data-bbox="1230 932 1555 1045">Pensyarah Kanan</td></tr> <tr> <td data-bbox="199 1045 266 1161">2.</td><td data-bbox="266 1045 573 1161">Puan Sarina Mohamad</td><td data-bbox="573 1045 862 1161">710202115356/230618</td><td data-bbox="862 1045 1230 1161">Fakulti Sains Gunaan, UiTM Perlis/Biologi</td><td data-bbox="1230 1045 1555 1161">Pensyarah Kanan</td></tr> <tr> <td data-bbox="199 1161 266 1283">3.</td><td data-bbox="266 1161 573 1283">Dr Roziana Mohammed Hanaphi</td><td data-bbox="573 1161 862 1283">830319035452/223188</td><td data-bbox="862 1161 1230 1283">Fakulti Sains Gunaan, UiTM Perlis/Biologi</td><td data-bbox="1230 1161 1555 1283">Pensyarah Kanan</td></tr> <tr> <td data-bbox="199 1283 266 1396">4.</td><td data-bbox="266 1283 573 1396">Prof Madya Dr Ahmad Anas Nagoor Gunny</td><td data-bbox="573 1283 862 1396">830209075111</td><td data-bbox="862 1283 1230 1396">Fakulti kejuruteraan Kimia, UniMAP Perlis/ Kejuruteraan Kimia</td><td data-bbox="1230 1283 1555 1396">Professor Madya</td></tr> <tr> <td data-bbox="199 1396 266 1499"></td><td data-bbox="266 1396 573 1499"></td><td data-bbox="573 1396 862 1499"></td><td data-bbox="862 1396 1230 1499"></td><td data-bbox="1230 1396 1555 1499"></td></tr> <tr> <td data-bbox="199 1499 266 1608"></td><td data-bbox="266 1499 573 1608"></td><td data-bbox="573 1499 862 1608"></td><td data-bbox="862 1499 1230 1608"></td><td data-bbox="1230 1499 1555 1608"></td></tr> </tbody> </table>				Bil	Name <i>Nama</i>	IC / Staff Number: <i>No. Kad Pengenalan/ No. Pekerja:</i>	University / Industry / Agency <i>Fakulti/ P.Pengajian/ Pusat/Unit</i>	Academic Qualification/ Designation <i>Tahap Kelayakan Akademik/Jawatan</i>	1.	Puan Farhana Othman	287658	Fakulti Sains Gunaan, UiTM Perlis/Kimia	Pensyarah Kanan	2.	Puan Sarina Mohamad	710202115356/230618	Fakulti Sains Gunaan, UiTM Perlis/Biologi	Pensyarah Kanan	3.	Dr Roziana Mohammed Hanaphi	830319035452/223188	Fakulti Sains Gunaan, UiTM Perlis/Biologi	Pensyarah Kanan	4.	Prof Madya Dr Ahmad Anas Nagoor Gunny	830209075111	Fakulti kejuruteraan Kimia, UniMAP Perlis/ Kejuruteraan Kimia	Professor Madya										
Bil	Name <i>Nama</i>	IC / Staff Number: <i>No. Kad Pengenalan/ No. Pekerja:</i>	University / Industry / Agency <i>Fakulti/ P.Pengajian/ Pusat/Unit</i>	Academic Qualification/ Designation <i>Tahap Kelayakan Akademik/Jawatan</i>																																			
1.	Puan Farhana Othman	287658	Fakulti Sains Gunaan, UiTM Perlis/Kimia	Pensyarah Kanan																																			
2.	Puan Sarina Mohamad	710202115356/230618	Fakulti Sains Gunaan, UiTM Perlis/Biologi	Pensyarah Kanan																																			
3.	Dr Roziana Mohammed Hanaphi	830319035452/223188	Fakulti Sains Gunaan, UiTM Perlis/Biologi	Pensyarah Kanan																																			
4.	Prof Madya Dr Ahmad Anas Nagoor Gunny	830209075111	Fakulti kejuruteraan Kimia, UniMAP Perlis/ Kejuruteraan Kimia	Professor Madya																																			
C(vi)	Please provide information on academic publications that has been published by the project leader for the last five (5) years. (Example: Journals, Books, Chapters in books, etc) <i>Sila kemukakan maklumat berkaitan penerbitan akademik yang telah diterbitkan oleh ketua penyelidik dalam tempoh lima (5) tahun terakhir. (Contoh: Jurnal, buku, bab dalam buku, dll)</i> <table border="1" data-bbox="199 1772 1555 1898"> <thead> <tr> <th data-bbox="199 1772 617 1898">Title of publication <i>Tajuk penerbitan</i></th><th data-bbox="617 1772 1230 1898">Name of journals/books <i>Nama jurnal/buku</i></th><th data-bbox="1230 1772 1555 1898">Year published <i>Tahun diterbitkan</i></th></tr> </thead> <tbody> <tr> <td data-bbox="199 1898 617 2013">1 The Versatility of Pectin: A Comprehensive Review Unveiling Its Recovery</td><td data-bbox="617 1898 1230 2013">Journal Food Measurement and Characterization. WoS Q2, IF: (Corresponding author).</td><td data-bbox="1230 1898 1555 2013">2024</td></tr> </tbody> </table>				Title of publication <i>Tajuk penerbitan</i>	Name of journals/books <i>Nama jurnal/buku</i>	Year published <i>Tahun diterbitkan</i>	1 The Versatility of Pectin: A Comprehensive Review Unveiling Its Recovery	Journal Food Measurement and Characterization. WoS Q2, IF: (Corresponding author).	2024																													
Title of publication <i>Tajuk penerbitan</i>	Name of journals/books <i>Nama jurnal/buku</i>	Year published <i>Tahun diterbitkan</i>																																					
1 The Versatility of Pectin: A Comprehensive Review Unveiling Its Recovery	Journal Food Measurement and Characterization. WoS Q2, IF: (Corresponding author).	2024																																					

	Techniques and Applications in Innovative Food Products.		
2	Extraction optimization and characterisation of Artocarpus integer peel pectin by malonic acid-based deep eutectic solvents using Response surface methodology.	<i>International Journal of Biological Molecule</i> 280, 135737, WoS Q1, IF: 7.7 (Corresponding author).	2024
3	Enhanced Water Absorption in Pectin-Chitosan Hydrogel via Modification with Deep Eutectic Solvent: Optimization and Characterization.	<i>Journal of Molecular Liquid</i> 413, 125963. WoS Q1, IF: 5.3 (Corresponding author)	2024
4	Unravelling the bioactivity of Acmella paniculata Extract-Mediated Green Deep Eutectic Solvent of Citric Acid Monohydrate and Glycerol	Malaysian Applied Biology- Vol. 53 No. 4 Scopus Q4 (Co-author)	2024
5	Optimization Of Microwave-Assisted Extraction of Artocarpus Integer Peel Pectin with Choline Chloride Based Deep Eutectic Solvent.	<i>Scientific Research Journal</i> , Vol 20, Special Issue 97-111 (Corresponding author)	2023
6	The Bioactivity Potential of Acmella paniculata Plant Extract in Antioxidant Activity by Two Different Extraction Methods.	<i>Scientific Research Journal</i> . Vol 20, Special Issue 1-16 (Co-author)	2023
7	Advances in dispersive solid-phase extraction techniques for analytical quantification of fluoroquinolone antibiotics.	<i>Microchemical Journal</i> . Scopus Q1, (Co-author)	2023
8	<i>Structural And Conductivity Studies Of Choline Chloride-Based Deep Eutectic Solvent For Potential Electrolytes In Lithium-Ion Batteries</i>	<i>Malaysian Journal of Analytical Sciences</i> Scopus (Co-author)	2022
9	Reinforced Pectin-DES Bioplastic with Different Concentration of Citric Acid	<i>Journal of Sustainability Science and Management</i> , Vol 17 No 7 Scopus Q3, (Co-author)	2022
10	Effect of deep eutectic solvent on tensile properties and biodegradation of pectin with eggshell bioplastic	<i>Malaysian Journal of Analytical Sciences</i> , Vol 26 No 1(Corresponding author)	2022
11	An insight into the effects of ratios and temperatures on a tetrabutylammonium bromide and ethylene glycol deep eutectic solvent.	<i>Journal of Molecular Liquid</i> , 339, (106779): 1-12 WOS Q1, IF: 6.165, (Main Author)	2021
12	Binding of Tetrabutylammonium Bromide based Deep Eutectic Solvent to DNA by Spectroscopic Analysis.	<i>Spectrochimica Acta A: Molecular and Biomolecular Spectroscopy</i> , 253 (119543): 1-8, WOS- Q1, IF: 3.232, (Main Author)	2021
13	Averrhoa bilimbi pectin-based edible films:Effects of the linearity and branching of the pectin on the	<i>International Journal of Biological Macromolecules</i> . 163: 1276-1282. WOS -Q1, IF: 5.162, (co- Author)	2020

	physicochemical, mechanical and barrier properties of the films.		
14	Effect of several commercial rubbers as substrates for zinc oxide in the photocatalytic degradation of methylene blue under visible irradiation.	<i>eXPRESS Polymer Letters</i> , Vol.14, No.9: 838–847, WOS – Q2, IF: 3.083, (co- Author)	2020
C(vii)	Executive Summary of Research Proposal (maximum 300 words) (Please include the problem statement, objectives, research methodology, expected output/outcomes/implication, and significance of output from the research project) <i>Ringkasan Cadangan Eksekutif Penyelidikan (maksimum 300 patah perkataan)</i> <i>(Meliputi pernyataan masalah, objektif, kaedah penyelidikan, jangkaan hasil penyelidikan/implikasi dan kepentingan output projek penyelidikan)</i> The limitations of pectin-chitosan films in plastic packaging, including poor water resistance and brittleness, which could trap moisture, promote mold growth within the packaging can reduce the film quality. Modifications using DES could overcome the brittleness issue, but the incompatibility between the hydrophobic DES and hydrophilic pectin-chitosan has become a new challenge. Hence, this study aims to improve water resistance and mechanical strength by modifying pectin-chitosan film with a hydrophobic deep eutectic solvent (DES) based on thymol and medium-chain fatty acids (MCFA). To overcome the incompatibility, lecithin will be used as an emulsifier and stabilizer to improve dispersion and blend stability. Molecular interaction and structural changes will be observed through analysis using FTIR, OM, SEM, DSC, tensile testing. The water barrier properties will be assessed by measuring water vapor transmission rates and water sorption while the antimicrobial effects of MCFAs in DES will be compared to a control. The impact of different fatty acid chain lengths on water resistance and antibacterial activity in film will also be explored. It is hypothesized that combining pectin-chitosan with thymol-based hydrophobic DES will enhance the water resistance and antibacterial properties of films. A novel biodegradable, water-resistant, and mechanically flexible film with improved antibacterial properties will be developed as an alternative to petroleum-based plastic, potentially preserving the environment. The project is expected to advance knowledge in the field, support the training of a Master's student, and generate potential intellectual property.		
C(viii)	Detailed proposal of research project: <i>Cadangan maklumat penyelidikan secara terperinci:</i> (a) Research background including: / <i>Latarbelakang penyelidikan termasuk:</i> i) Problem Statement / <i>Pernyataan Masalah</i> Polysaccharide-based films have become popular as environmentally benign and biodegradable alternatives to traditional plastic packaging materials. Despite being sustainable, pectin-chitosan-based films exhibit inherent limitations such as poor mechanical properties (brittle and rigid) and high permeability to water, which limit their use in moisture-sensitive applications like food packaging, where water resistance is critical. The hydrophilic groups of the pectin-chitosan chain resulted in water affinity, which traps moisture, leading to bacterial and mold growth inside the wrapping and destroying food quality. Existing techniques to increase the hydrophobicity of pectin-based films frequently include harmful and costly chemicals such as fluoroalkyl compounds, which require energy-intensive procedures and could produce highly persistent pollutants. Additionally, these techniques encounter difficulties in obtaining consistent hydrophobicity, leading to inconsistent performance and reduced practicality. Hydrophobic deep eutectic solvents (DESs) have emerged as a promising, green, low-cost alternative for modifying biopolymers and a practical approach to enhancing material properties. Previously, DES was commonly known for its wide range of solubility and its effectiveness as a plasticizer to enhance film's		

elongation. However, there has been a lack of research on using hydrophobic DESs to improve the water-resistance of hydrophilic biopolymer films due to the formation of phase separation during processes, which leads to poor film uniformity. Hence, this study will modify the pectin-chitosan film with thymol-based hydrophobic DES using medium-chain fatty acids (MCFAs), common fat from animals and plants. The medium chain of fatty acids from DES is expected to increase the water-resistant ability because of its hydrophobicity. Additionally, lecithin as an organic emulsifier will be added as it is expected to bridge the hydrophilic and hydrophobic components in the pectin-chitosan film.

Additionally, the antimicrobial properties of MCFAs and antioxidant properties of lecithin could benefit the film to be used as food packaging. It is hypothesized that the film's material properties will have a synergistic effect, ensuring that food remains fresh and nutritious while preventing decomposition and contamination. This could pave the way for the development of more effective food packaging. The influence and interaction of MCFAs-DES with pectin-chitosan on film mechanical properties are unclear. Understanding material interactions could be utilized to anticipate plasticization behaviors. Addressing these issues could unlock the potential of new water-resist pectin-chitosan films as a biodegradable and high-performance alternative to typical plastic packaging, thereby reducing environmental pollution and promoting circular economy practices.

ii) **Hypothesis / Hipotesis**

- The incorporation of hydrophobic deep eutectic solvent (DES) based on thymol and medium-chain fatty acids (MCFA) will structurally modify pectin-chitosan and change the water barrier, mechanical properties and antimicrobial properties of pectin-chitosan films.
- The improved pectin-chitosan film making the material more suitable for applications where water resistance is essential, such as in food packaging.

iii) **Research Questions / Persoalan Penyelidikan**

- a) How does the thymol with different medium-chain fatty acids (MCFAs) hydrophobic DES affecting or modify the structure of the pectin-chitosan film?
- b) How does the modification (structural changes) improve the water retention of the pectin-chitosan film?
- c) How much (percent) hydrophobic DES is required to improves the pectin-chitosan film's water retention, mechanical properties, and antimicrobial properties?

iv) **Literature Reviews / Kajian Literatur**

Polysaccharide-based packaging materials represent a sustainable and eco-friendly packaging solution. There has been a growing interest in producing polysaccharide-based packaging because polysaccharides such as cellulose, starch, chitin, chitosan, and pectin are abundant, biodegradable, and can be derived from renewable sources, which makes them an excellent alternative to replace synthetic petroleum-based plastic, which causes environmental pollution. Pectin, a natural and biodegradable anionic biopolymer, is made up of α -(1,4) linked D-galacturonic acid (GalA) and is partly methyl esterified. They are complex polysaccharides and frequently utilized in the food industry and pharmaceutical industries as a thickener, agent for gelling, texturizer, and stabilizer. Nowadays, pectin is recognized as a potential material for edible film and coating to protect and extend the shelf life of food products to replace synthetic packaging materials to prevent environmental pollution. However, pectin films tend to show poor mechanical properties. Pure pectin films tend to be brittle, fragile, and have high solubility in water (Younis et al., 2022) due to their hydrophilic OH and carboxylic COOH, which limits their usefulness for food wrapping (Machado et al., 2020). Meanwhile, chitosan is a cationic, linear polysaccharide composed of β -linked D-glucosamine and N-acetyl-D-glucosamine attached via β (1-4) linkages. The presence of active groups in the chitosan structure can provide an active site for many modifications and thus alter its behavior and properties. Chitosan is a commonly used in preparing film due to its low cost and interesting properties such as bio-adhesion, biodegradability, biocompatibility, non-toxicity, antimicrobial, antifungal, and chelating metal properties (Dziadek et al., 2022, Flórez et al. 2022).

To overcome the disadvantages of biopolymers, researchers commonly composite the polymers together or add the additives to the polysaccharide system. In the case of pectin-chitosan, the mechanical properties of the composites are better compared to the film made from their individual components (Merino et al., 2023). **Figure 1** shows the interaction of pectin and chitosan. The interaction of anionic pectin and polycationic chitosan occurs through electrostatic interaction and hydrogen bonding, which occur at low pH values (Tripathi et al., 2010). Among the additives added to overcome the poor water barrier properties are lipids, crosslinkers (Sun et al., 2018), synthetic polymers (Abdillah and Charles, 2021), and hydrophobic materials (Wen et al., 2023). Previous research by Guzman-Puyola (2022) stated that cellulose treated with hydrophobic tridecafluorononanoic acid (TFNA) showed excellent performance in terms of grease-proofness and water barrier. However, these high-cost fluoroalkyl compounds are toxic, which limits their use in the application (Krafft and Riess et al., 2015).

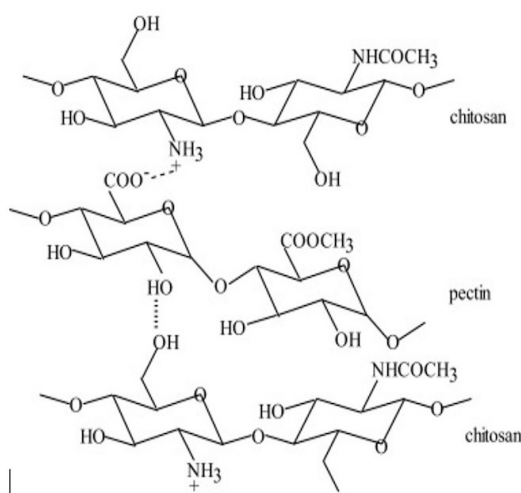


Figure 1: Interaction between pectin and chitosan

Deep eutectic solvents (DES) are the new generation of ionic liquids (ILs) as they are cheaper, non-toxic, and easy to prepare. DES is typically formed by mixing two or more components that can form hydrogen bonds, resulting in a liquid with a lower melting point than the individual components. This property makes DES a viable and eco-friendly alternative to traditional solvents, which can harm the environment and human health. In the past ten years, hydrophilic DES has been reported to be an effective plasticizer and crosslinker in polysaccharide films due to its compatibility with polymers (Shafie et al., 2019). The film modified with DES showed enhanced mechanical properties by improved morphology, conductivity, thermal, elongation at break, chemical properties, and high elongation at break. However, there are limit of studies reported on ability of hydrophilic DES to increase water barrier properties in food packaging (Tomé et al., 2018). Hydrophobic DES are commonly reported as a promising solvent for extracting metals, pesticides, and natural compounds like flavonoids from aqueous solutions. According to Kivela et al. (2022), hydrophobic DES can be readily obtained by combining quaternary ammonium salts or small organic molecules (menthol, thymol, ibuprofen, organic acids) with medium or long-chain fatty acids. Figure 2 shows the most common free fatty acids with medium or long carbon chains used in previous studies. Kongpol et al. (2022), reported on the hydrophobic deep eutectic solvents (HDESs), containing menthol and fatty acids (capric, caprylic, and oleic acids) can enhance the anti-inflammatory effects of therapeutic of curcuminoids and curcumin.

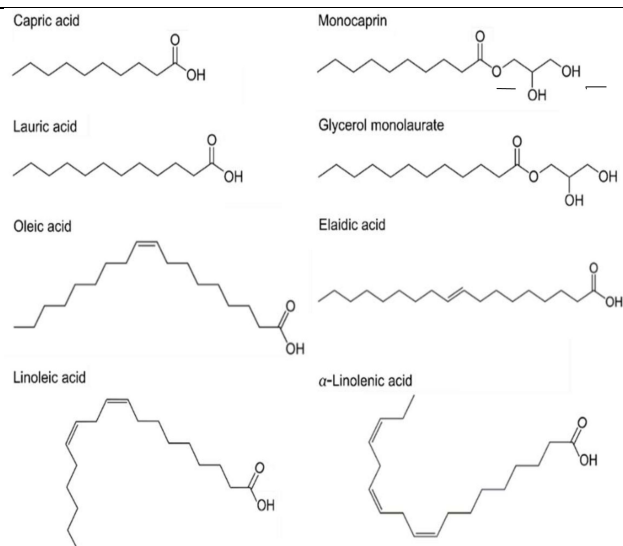


Figure 2. Free fatty acids with medium/long carbon chains

Recently, Wen et al. (2023) reported on hydrophobic deep eutectic solvent (DES), containing thymol and octanoic acid to increase the water barrier on chitosan/gelatin film. According to them, the composite has successfully improved water resistance and displayed good antibacterial activity against *Staphylococcus aureus* and *Escherichia coli* due to chitosan, gelatin, and DES's properties. The hydrophobic DES is reported to have antibacterial activities, which could benefit food packaging applications. According to Szlek et al. (2022), when the hydrophobic material is inserted into the polysaccharide system, it can disrupt the hydrogen bonding between polysaccharides, thus creating a less resistant path for the diffusion of non-polar molecules. **Figure 3** illustrates hydrogen bonding disruption with hydrophobic material within the polysaccharides system.

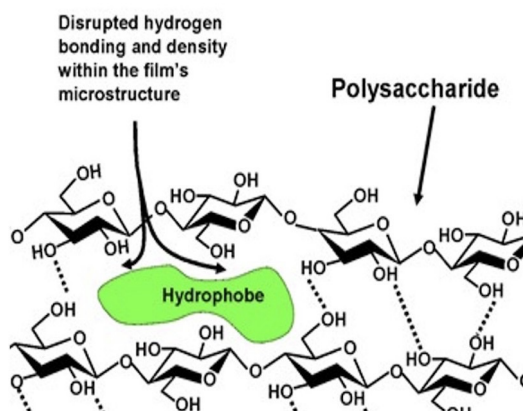


Figure 3. Disruption of hydrogen bonding between pectin and chitosan
Due to insertion of hydrophobic material

Creating a hydrophobic region in this system could increase the water barrier properties of the film and reduce water sorption. Fatty acids have a polar end (the carboxylic acid group) that could participate in hydrogen-bonding reactions with water and a non-polar hydrocarbon chain that does not form hydrogen bonds and consequently “repels” water. These fatty acids are nearly insoluble in water because of their hydrophobicity. As the chain length increases, the water solubility decreases. Emulsification is frequently employed to enhance the dispersion of hydrophobic compounds in films. Emulsifiers such as tween 80 and lecithin can improve the characteristics of starch films (Wang et al., 2021; Yang et al., 2024).

High humidity is the main factor causing food spoilage and loss of commercial value. The high moisture provides a conducive environment for bacterial growth, as they need water for their metabolic processes and to absorb nutrients. The low water barrier film could trap water from the natural environment and promote bacteria and mold on food stored in the food wrappers, which could change its taste, texture, and appearance (Gaikwad et al., 2019). The efficiency of the film is governed by the capacity of the chitosan, pectin, and hydrophobic fatty acid DES to inhibit bacterial growth as an antibacterial agent. Antibacterial agents are a group of materials that selectively fight against pathogenic bacteria by killing or reducing the metabolic activity of bacteria. According to Joana et al. (2019), hydrophobic DES that contains the free fatty acids capric acid, lauric acid, myristic acid, and stearic acid are reported to have antibacterial and antifungal properties. The antibacterial properties of these fatty acids are dependent on a few factors, including chain size, hydrophobicity, and the number and position of double bonds and functional groups. According to Wen et al. (2023), the antimicrobial activity of chitosan and hydrophobic fatty acid DES (thymol and fatty acid) has been successfully reported to extend the shelf-life of food in food wrapping. The research development of food packaging films combining hydrophilic and hydrophobic components, is a new challenge as it includes phase separation, inconsistent properties, and processing difficulties. Still, it is in line with market demands for packaging that is both safe and biodegradable.

v) **Related References / Rujukan berkaitan**

Abdillah, A. A., & Charles, A. L. (2021). Characterization of a natural biodegradable edible film obtained from arrowroot starch and iota-carrageenan and application in food packaging. *International Journal of Biological Macromolecules*, 191, 618–626. <https://doi.org/10.1016/j.ijbiomac.2021.09.141>

Dziadek, M., Dziadek, K., Salagierski, S., Drozdowska, M., Serafim, A., Stancu, I. C., Szatkowski, P., Kopec, A., Rajzer, I., Douglas, T. E. L., & Cholewa-Kowalska, K. (2022). Newly crosslinked chitosan- and chitosan-pectin-based hydrogels with high antioxidant and potential anticancer activity. *Carbohydrate Polymers*, 290.

Flórez, M., Guerra-Rodríguez, E., Cazón, P. and Vázquez, M. (2022). Chitosan for food packaging: Recent advances in active and intelligent films, *Food Hydrocolloids*, Volume 124, Part B, 107328.

Guzman-Puyola, S., Tedeschia, G., Goldonic, L., José J. Benítez, Ceseracciu, L., Koschella, A., Heinze, T., Athanassiou, A., José A. Heredia-Guerrero (2022). Greaseproof, hydrophobic, and biodegradable food packaging bioplastics from C6-fluorinated cellulose esters. *Food hydrocolloid* 128, 107562

Joana M. Silva, Eduardo Silva, Rui L. Reis, Ana Rita C. Duarte (2019). A closer look in the antimicrobial properties of deep eutectic solvents based on fatty acids, *Sustainable Chemistry and Pharmacy*, Volume 14, 100192

Kantapich Kongpol, Preenapan Chaihao, Parichat Shuapan, Ploypailin Kongduk, Warangkana Chunglok and Gorawit Yusakul (2022). Therapeutic hydrophobic deep eutectic solvents of menthol and fatty acid for enhancing anti-inflammation effects of curcuminoids and curcumin on RAW264.7 murine macrophage cells, *RSC Adv.*, 2022,12, 17443-17453

Kivelä, H., Salomäki, M., Vainikka, P., Mäkilä, E., Poletti, F., Ruggeri, S., Terzi, F. and Lukkari, J. (2022) Effect of Water on a Hydrophobic Deep Eutectic Solvent. *The Journal of Physical Chemistry B*, 126 (2), 513-527

Machado, B. R., Facchi, S. P., de Oliveira, A.C., Nunes, C.S., Souza, P. R., Vilsinski, B.H., Popat, K.C., Kipper, M.J., Muniz, E.C. and Martins, A.F. (2020). Bactericidal Pectin/Chitosan/Glycerol Films for Food Pack Coatings: A Critical Viewpoint. *International Journal of Molecular Science*, 21, 8663

Marie-Pierre Krafft and Jean G. Riess (2015). Per- and polyfluorinated substances (PFASs): Environmental challenges, *Current Opinion in Colloid & Interface Science*, Volume 20, Issue 3, Pages 192-212

Merino, D., Bellasi, P., Paul, U.C., Morelli, L., and Athanassiou, A. (2023). Assessment of chitosan/pectin-rich vegetable waste composites for the active packaging of dry foods, *Food hydrocolloids* 139, 108580

Shafie, M.H, Yusof, R. and Gan, C-Y (2019). Synthesis of citric acid monohydrate-choline chloride based deep eutectic solvents (DES) and characterization of their physicochemical properties, *Journal of Molecular Liquids*, Volume 288, 111081

Sun, S., Liu, P., Ji, N., Hou, H., & Dong, H. (2018). Effects of various cross-linking agents on the physicochemical properties of starch/PHA composite films produced by extrusion blowing. *Food Hydrocolloids*, 77, 964–975.

Szlek, D. B., Reynolds, A. M., and Hubbe, M. A. (2022). Hydrophobic molecular treatments of cellulose-based or other polysaccharide barrier layers for sustainable food packaging: A Review, *BioResources* 17(2), 3551-3673.

Tomé, L.I.N, Baião, V., da Silva, W., and Brett, C.M.A. (2018). Deep eutectic solvents for the production and application of new materials, *Applied Materials Today*, Volume 10, Pages 30-50.

Tripathi, G.K., Mehrotra and P.K. Dutt. (2010). Preparation and physicochemical evaluation of chitosan/poly(vinyl alcohol)/pectin ternary film for food-packaging applications. *Carbohydrate polymer* 79. 711-716.

Bin Wang, Jie Sui, Bin Yu, Chao Yuan, Li Guo, A.M. Abd El-Aty, Bo Cui (2024). Physicochemical properties and antibacterial activity of corn starch-based films incorporated with *Zanthoxylum bungeanum* essential oil. *Carbohydrate Polymers*, Volume 254, 117314

Wen, H., Tang, D., Lin, Y., Zou, J., Liu, Z., Zhou, P. and Wang, X. (2023). Enhancement of water barrier and antimicrobial properties of chitosan/gelatin films by hydrophobic deep eutectic solvent. *Carbohydrate Polymers* 303, 120435

Qianwen Yang, Furun Zheng, Qingqing Chai, Zhao Li, Haibo Zhao, Jiantao Zhang, Katsuyoshi Nishinari, Meng Zhao, Bo Cui (2024). Effect of emulsifiers on the properties of corn starch films incorporated with *Zanthoxylum bungeanum* essential oil. *International Journal of Biological Macromolecules*, Volume 256, Part 1, 128382,

Younis, H., Zhao, G., & Abdellatif, H. (2022). Pectin and Its Applicability in Food Packaging: A Glance at Food Processing Applications. *IntechOpen*. doi: 10.5772/intechopen.101614

vi) **Relevance to Government Policy, if any / Perkaitan dengan Dasar Kerajaan, jika berkenaan**

This study supports the Twelfth Malaysian Plan and Key Economic Growth Activities “KEGA 14” that emphasize advanced and modern services policies that ensure progressive technology growth, especially in the biofilm industries.

(b) Objective (s) of the Research

Objektif Penyelidikan

- 1) To investigate the effect of hydrophobic DES consist of thymol with different lengths of medium-chain fatty acids (MCFAs) toward molecular interaction and mechanical properties of modified pectin-chitosan.
- 2) To measure the water retention and antimicrobial characteristics of the modified pectin-chitosan with varied concentrations of thymol with medium-chain fatty acids (MCFAs)

(c) Methodology

Kaedah penyelidikan

The methodology Flowchart was attached on the last page of proposal.

PHASE 1: STRUCTURAL CHARACTERIZATION OF MODIFIED PECTIN-CHITOSAN WITH HYDROPHOBIC DES OF THYMOL WITH DIFFERENT MCFAs

i. Preparation of hydrophobic DES of Thymol with medium-chain fatty acids (MCFAs)

Location: Makmal Penyelidikan Kimia UiTM Perlis

Duration: 01/01/2025 - 31/03/2025

Researcher-in-charge: Dr. Rizana Yusof and PM Dr Ahmad Anas

The hydrophobic DES will be made by mixing hydrogen bond acceptors with various hydrogen bond donors at different chain lengths. Thymol will be mixed with octanoic acid (8 carbon chains) at a mole ratio of 1:1. The mixture will be stirred and heated at 80 °C for 30 minutes until a clear solution is produced. The same procedures will be repeated for other DESs of thymol-nonaic acid and thymol-decanoic acid.

i. Modification of pectin-chitosan film with different hydrophobic DES of Thymol with medium-chain fatty acids (MCFAs) via casting technique

Location: Makmal Penyelidikan Kimia UiTM Perlis

Duration: 01/04/2025 – 30/09/2025

Researcher-in-charge: Dr Rizana Yusof and PM Dr Ahmad Anas

The pectin-chitosan blends then will be prepared using the casting technique based on Shafie et al. (2018). The commercialized pectin and chitosan solution (1% wt/v) will be prepared separately in aqueous HCl solution (0.1M) at 60 for 10 min. The pectin and chitosan solutions will be mixed at a 66/34 weight ratio by stirring at 60 ± 1 °C for 5.0 minutes with a magnetic stirrer. The blend solution (30 mL) will be stirred with different percents of hydrophobic DES at 60 ± 1 °C for 5 minutes. Then the viscous solution will be taken in a 10 mL syringe, transferred onto a petri dish, and placed in a vacuum desiccator for 24 hours at 35°C. The films will be peeled off from the petri dish and stored at room temperature before analysis. Pectin-chitosan without DES will be prepared as a control.

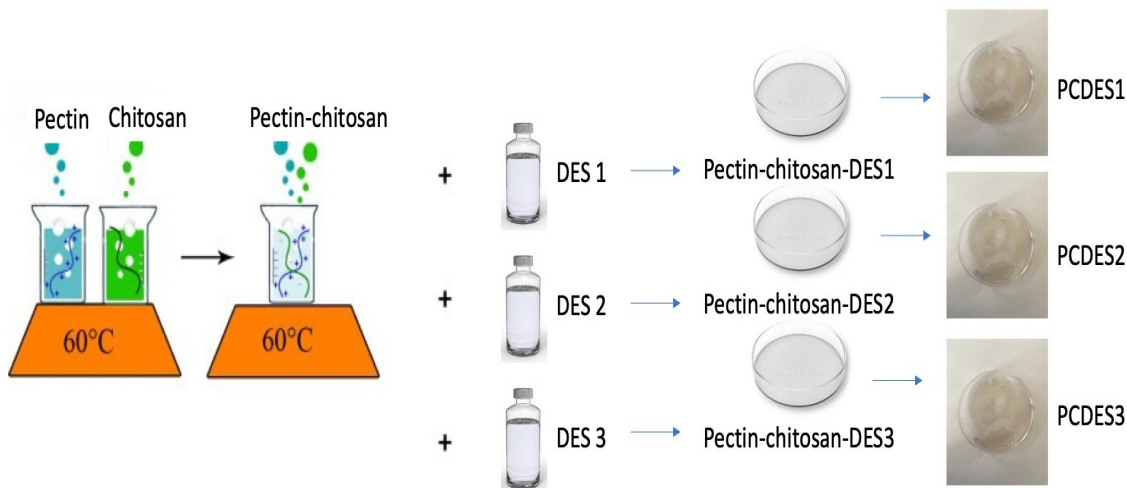


Figure 2. Preparation of pectin-chitosan blend film with different hydrophobic DES via casting technique

Table 1: Type of Films will be prepared

Films	Abbreviation	Percentage HDES (%)
Pectin-chitosan (control)	PC	0
Pectin-chitosan-Thymol: Octanoic acid (PCTOA)	PCTOA10	10
	PCTOA20	20
	PCTOA30	30
	PCTOA40	40
Pectin-chitosan-Thymol: nonanoic acid (PCTNA)	PCTNA10	10
	PCTNA20	20
	PCTNA30	30
	PCTNA40	40
Pectin-chitosan-Thymol: Decanoic acid (PCTDA)	PCTDA10	10
	PCTDA20	20
	PCTDA30	30
	PCTDA40	40

iii. **Characterizations of molecular interaction, structural changes and mechanical properties on modified pectin-chitosan films (FTIR, OM, SEM, DSC, tensile and thickness)**

Location: Instrumentation Lab 1, UiTM Perlis (FTIR), Biology Lab, UiTM Perlis (OM), Instrumentation Lab, UNIMAP (SEM), UiTM Perlis (DSC), Polymer Lab, UiTM Perlis (Tensile properties)

Duration: 01/10/2025 - 31/01/2026

Researcher-in-charge: Dr Rizana and PM Dr Ahmad Anas

The functionality, structure, and thermal stability of the pectin-chitosan-hydrophobic DES will be determined using the following instrumental analyses:

- Fourier Transform Infrared (FTIR) spectral analysis will be conducted to identify the functional groups of the samples. Each sample will be scanned for 16 times in the range of 4000 to 600 cm^{-1} .
- Optical Microscopy (OM) will be conducted to observe the morphology of the samples.
- Scanning electron microscope (SEM) will be conducted to examine the surface morphology and chemical elemental composition of the samples. The sample will be imaged using the scanning electron microscope (SEM) with an accelerating voltage of 10 kV and working distances of 12.5 mm at a magnification of 250x and 2500x for surface and cross-section, respectively.
- Differential scanning calorimetry (DSC) will be conducted to determine the thermal stability of the samples. All the bioplastics will be sealed firmly in aluminium pans and the analysis will be performed at temperatures ranging from 30 to 280 $^{\circ}\text{C}$ at a heating rate of 5 $^{\circ}\text{C}/\text{min}$.
- Mechanical properties (tensile properties) will be conducted measure the tensile strength, stress and elongation at break of samples. The mechanical properties of samples will be measured according to the method described by Du et al. (2019). The bioplastics will be cut into rectangular shapes of 75- and 10-mm length and width, respectively. The first grid separation will be 50 mm, with a crosshead speed of 5 mm/min. The mechanical properties of the bioplastics will be measured by a tensile testing machine (Instron 5865, USA) equipped with a 500 N load cell. The elongation ratio, fracture energy (defined as the area below the tensile strength (stress)–strain curve), and tensile strength of the eutectogel will be obtained from tensile curves. Each sample will be tested three times. A digital thickness gauge will be used to measure the thickness of samples (Model 547-301, Mitutoyo, Japan).

Phase 1 will be used to achieve Objective 1

(To investigate the effect of hydrophobic DES consist of thymol with different lengths of medium-chain fatty acids (MCFAs) toward molecular interaction and mechanical properties of modified pectin-chitosan)

PHASE 2: EVALUATION ON HYDROPHOBICITY/ WATER BARRIER OF MODIFIED PECTIN-CHITOSAN FILMS

The increase the water barrier of pectin-chitosan-HDES, a formulation of hydrophobic DES will be varied at different percentages (0, 10, 20, 30, and 40%) to obtain the highest water-resistant film. The samples will be prepared as shown in Table 1. The ability of each film to repel water will be observed via testing of:

i. Water Vapor Transmission Rate (WVTR) determination

Location: Makmal Penyelidikan Kimia UiTM Perlis

Duration: 01/02/2026 - 31/08/2026

Researcher-in-charge: Dr Rizana Yusof and Puan Farhana Othman

WVTR of films will be determined according to a modified ASTM standard Method E96- 80 (ASTM, 1981). The films will be dried at 50 $^{\circ}\text{C}$ for 24 hours using drying oven before WVTR analysis. The dried films will be cut and glued on the mouth of the test tube containing silica gels. The test tube with dried films will be preweighed and left in a desiccator with saturated salt solutions at room temperature. The salt solutions included MgCl_2 , $\text{Mg}(\text{NO}_3)_2$, NaCl and KNO_3 with known relative humidity of 32.4, 51.4, 75.7 and 92.5% respectively. The test tube will be reweighed every 24 hours for 5 days and the WVTR will be calculated according to the equation :

$$\text{WVTR} = \Delta W / \Delta t \times A$$

Where;

$\Delta W/\Delta t$ was the amount of water gain per unit time transfer,

A was the area exposed to water transfer.

ii. Water Sorption (Humidity, Swelling and Solubility in Water

Location: Makmal Penyelidikan Kimia UiTM Perlis

Duration: 01/02/2026 - 31/08/2026

Researcher-in-charge: Puan Farhana Othman and Puan Sarina

Water sorption will be conducted via humidity, swelling rate and Solubility. Humidity tests will be carried out by drying the sample (2 cm x 2 cm) at 105 °C for 24 h with samples being weighed on an analytical scale as M1. The samples will be conditioned in a natural convection oven at 70 °C for 24 h and then re-weighed (M2). For the determination of swelling and solubility in water, the dried films with mass will be placed in a Petri dish containing 30 mL of Milli-Q water and stored at room temperature. After 24 hours, water was removed and the samples were gently dried using tissue paper and weighed on an analytical scale (M3). These films were then re-dried in a natural convection oven at 70 °C for 24 h before being re-weighed (M4).

$$\begin{aligned}\% \text{Humidity} &= ((M1 - M2)/(M1)) \times 100 \\ \% \text{Swelling degree (SD)} &= ((M3 - M2)/(M2)) \times 100 \\ \% \text{Solubility} &= ((M4 - M2)/(M2)) \times 100\end{aligned}$$

PHASE 3: MEASUREMENT OF ANTIMICROBIAL PROPERTIES OF MODIFIED PECTIN-CHITOSAN FILMS

i. Antimicrobial activity Location: UiTM Perlis

Duration: 01/09/2026 - 31/12/2026

Researcher-in-charge: Dr Roziana Mohamed Hanaphi and Puan Sarina Muhammad

The biofilm antimicrobial index will be determined on the highest water resistant of each hydrophobic DES selected from phase 2. The nutrient agar solution will be prepared by boiling 10.2 g of nutrient agar into 300 mL of distilled water. The nutrient agar solution will be autoclaved at 121 °C for 15 minutes, follow by cooling down to 50 °C using a water bath. The 15 mL of nutrient agar will be poured into a petri dish for solidification. The stock cultures from different bacteria (*Escherichia coli* and *Staphylococcus aureus*) will be grown in nutrient broth at 37 °C for 24 hours before analysis. To measure the antimicrobial activity, about 100 µL of the culture will be spread in a petri dish containing nutrient agar, with the sample will be aseptically placed in the center of the petri dish. The plates will be incubated at 37 °C for 24 hours before the inhibition zones are analysed. A calliper will be used to measure the diameter of the inhibition. The antimicrobial index will be calculated according to the equation:

$$\text{Antimicrobial index} = 2 - 1/1$$

where 1 is an area of the disc
and 2 is the area of the inhibition zone

Phase 2 and 3 will be used to achieve Objective 2

(To measure the water retention and antimicrobial characteristics of the modified pectin-chitosan with varied concentrations of thymol with medium-chain fatty acids (MCFAs))

PHASE 4: DATA ANALYSIS AND INTERPRETATION

An average of three replicates values of the analyses will be taken for each sample and used in a one-way analysis of variance (ANOVA) in each experimental phase. The statistical analysis of the data will be performed using SPSS statistical 24.0 software. A significant difference among the treatment at a 95% confidence interval will be analyzed using Duncan's multiple range test.

(d) Expected Results/Benefit

Jangkaan Hasil Penyelidikan

1. Novel theories/New findings/Knowledge

- a. The findings obtained will provide knowledge on the effect of modifying pectin-chitosan films using different chain lengths of hydrophobic DES on the water resistance and antibacterial activity of the pectin-chitosan film system.
- b. The study broadens the capabilities of hydrophobic deep eutectic solvents (DES) as water repellents in bioplastics, surpassing the conventional confines associated with solvent extraction.

- c. The findings from this study are expected to provide valuable insights into the formulation of hydrophilic-hydrophobic films, contributing to advancements in sustainable food packaging technologies.

2. **Research Publications**

1 Scopus : Malaysian Journal of Chemistry

Water retention behavior of modified pectin-chitosan film with free fatty acid hydrophobic deep eutectic solvents

3. **Specific or Potential Grant Applications (please specify targeted grant application)**

FRGS Grant

4. **Number of PhD and Masters (by research) Students (if any)**

1 Master student

5. **Impact on Society, Economy and Nation**

Society: Replacing non-biodegradable packaging with sustainable alternatives to reduce plastic pollution and debris will promoting cleaner ecosystems and enhancing public health and biodiversity.

Economy: The green packaging industry is increasing due to customer demand for environmentally friendly products. Municipal waste management and recycling costs decrease over time.

Nation: The national targets for lowering carbon footprints and addressing climate change would be accomplished.

(e) Research activity & Milestone

Aktiviti penyelidikan & Carta perbatuan

Research activity

Activity	Start Date	End Date
Preparation of hydrophobic DES of Thymol with medium-chain fatty acids (MCFAs)	01/01/2025	31/03/2025
Modification of pectin-chitosan film with different hydrophobic DES of Thymol with medium-chain fatty acids (MCFAs)	01/04/2025	31/09/2025
Characterizations of molecular interaction, structural changes and mechanical properties on modified pectin-chitosan films (FTIR, OM, SEM, DSC, tensile and thickness)	01/10/2025	31/01/2026
Evaluation hydrophobicity of modified pectin-chitosan films (WVTR, water sorption)	01/02/2026	31/08/2026
Measurement antimicrobial properties of modified pectin-chitosan films	01/09/2026	31/12/2026

Milestone

Activity	Date	Cumulative completion
Completion of preparation of hydrophobic DES	1/04/2025	3 months
Completion of pectin-chitosan modification with DES	31/09/2025	6 months
Completion of characterizations of molecular interaction, structural changes and mechanical on modified pectin-chitosan	31/01/2026	4 months
Completion of hydrophobicity evaluation	31/08/2026	7 months
Completion of antimicrobial activity measurement	31/12/2026	4 months

D	BUDGET /BELANJAWAN																													
	Please indicate your estimated budget for this research and details of expenditure according to the guidelines attached. <i>Sila nyatakan anggaran bajet bagi cadangan penyelidikan ini dan berikan butir – butir perbelanjaan lengkap dengan berpandukan kepada garis panduan yang dilampirkan.</i> <table border="1" data-bbox="199 451 1555 745"> <thead> <tr> <th data-bbox="199 451 1117 611" rowspan="2">Budget details <i>Butiran belanjawan</i></th> <th colspan="2" data-bbox="1117 451 1555 611">Amount requested by applicant <i>Jumlah yang dipohon oleh pemohon</i></th> </tr> <tr> <th data-bbox="1117 611 1333 745">Year 1 (Tahun 1) (RM)</th> <th data-bbox="1333 611 1555 745">Year 2 (Tahun 2) (RM)</th> </tr> </thead> </table>			Budget details <i>Butiran belanjawan</i>	Amount requested by applicant <i>Jumlah yang dipohon oleh pemohon</i>		Year 1 (Tahun 1) (RM)	Year 2 (Tahun 2) (RM)																						
Budget details <i>Butiran belanjawan</i>	Amount requested by applicant <i>Jumlah yang dipohon oleh pemohon</i>																													
	Year 1 (Tahun 1) (RM)	Year 2 (Tahun 2) (RM)																												
D(i)	Vote 21000 - Travelling and Transportation/ <i>Perjalanan dan Pengangkutan</i> Perjalanan ke Shah Alam untuk analisis sampel UiTM Perlis – UiTM Shah Alam - UiTM Perlis : RM 100 x 2 kali = RM 200		RM 200																											
D(ii)	Vote 24000 - Rental <i>Vot 24000 - Sewaan</i>		-																											
D(iii)	Vote 27000 - Research Materials & Supplies <i>Vot 27000 - Bekalan dan Bahan Penyelidikan</i> <table border="1" data-bbox="215 1255 1068 1549"> <thead> <tr> <th>Raw material</th> <th>Unit</th> <th>Price/unit</th> </tr> </thead> <tbody> <tr> <td>chitosan</td> <td>1</td> <td>RM1300/100g</td> </tr> <tr> <td>pectin</td> <td>2</td> <td>RM404 x 2 /400g = RM808</td> </tr> <tr> <td>Thymol</td> <td>1</td> <td>RM 870 / 500 g</td> </tr> <tr> <td>octanoic acid</td> <td>1</td> <td>RM 205/ 500 mL</td> </tr> <tr> <td>nonanoic acid</td> <td>1</td> <td>RM327/ 500 mL</td> </tr> <tr> <td>decanoic acid</td> <td>1</td> <td>RM278 /100g</td> </tr> </tbody> </table> <table border="1" data-bbox="215 1575 1068 1654"> <thead> <tr> <th>Glassware</th> <th>Unit</th> <th>Price/unit</th> </tr> </thead> <tbody> <tr> <td>Magnetic stir bar 5 mm</td> <td>10</td> <td>RM 100/10 unit</td> </tr> </tbody> </table>		Raw material	Unit	Price/unit	chitosan	1	RM1300/100g	pectin	2	RM404 x 2 /400g = RM808	Thymol	1	RM 870 / 500 g	octanoic acid	1	RM 205/ 500 mL	nonanoic acid	1	RM327/ 500 mL	decanoic acid	1	RM278 /100g	Glassware	Unit	Price/unit	Magnetic stir bar 5 mm	10	RM 100/10 unit	RM 3000
Raw material	Unit	Price/unit																												
chitosan	1	RM1300/100g																												
pectin	2	RM404 x 2 /400g = RM808																												
Thymol	1	RM 870 / 500 g																												
octanoic acid	1	RM 205/ 500 mL																												
nonanoic acid	1	RM327/ 500 mL																												
decanoic acid	1	RM278 /100g																												
Glassware	Unit	Price/unit																												
Magnetic stir bar 5 mm	10	RM 100/10 unit																												
D(iv)	Vote 28000 - Maintenance and Minor Repair Services <i>Bvot 28000 - Baik pulih kecil dan ubahsuai</i>																													

D(v)	Vote 29000 - Professional Services <i>Vot 29000 - Perkhidmatan Ikhtisas</i> SEM Measurement (10 samples x RM100 = RM1000)	RM1000	
D(vi)	Vote 35000 - Accessories and Equipment <i>Vot 35000 - Aksesori dan Peralatan</i>		
TOTAL AMOUNT <i>JUMLAH BESAR</i>		RM5000	
E	Declaration by applicant / Akuan Pemohon (Please tick (✓)): / (Sila tanda (✓)):		

I hereby declare that:

Saya dengan ini mengaku bahawa:



- 1. All information stated here are accurate, and PJI has right to reject or to cancel the offer without prior notice if there is any inaccurate information given.**

Semua maklumat yang diisi adalah benar, PJIM&A berhak menolak permohonan atau membatalkan tawaran pada bila-bila masa sekiranya keterangan yang dikemukakan adalah tidak benar.



- 2. Application of this research is presented for the Geran Semarak Penyelidikan**

Permohonan penyelidikan ini dikemukakan untuk Geran Semarak Penyelidikan.



- 3. Application of this research is subject to Ethical Committee approval (if applicable).**

Permohonan penyelidikan ini dimajukan ke Jawatankuasa Etika (jika berkenaan).

Date :

Tarikh :

24 November 2024

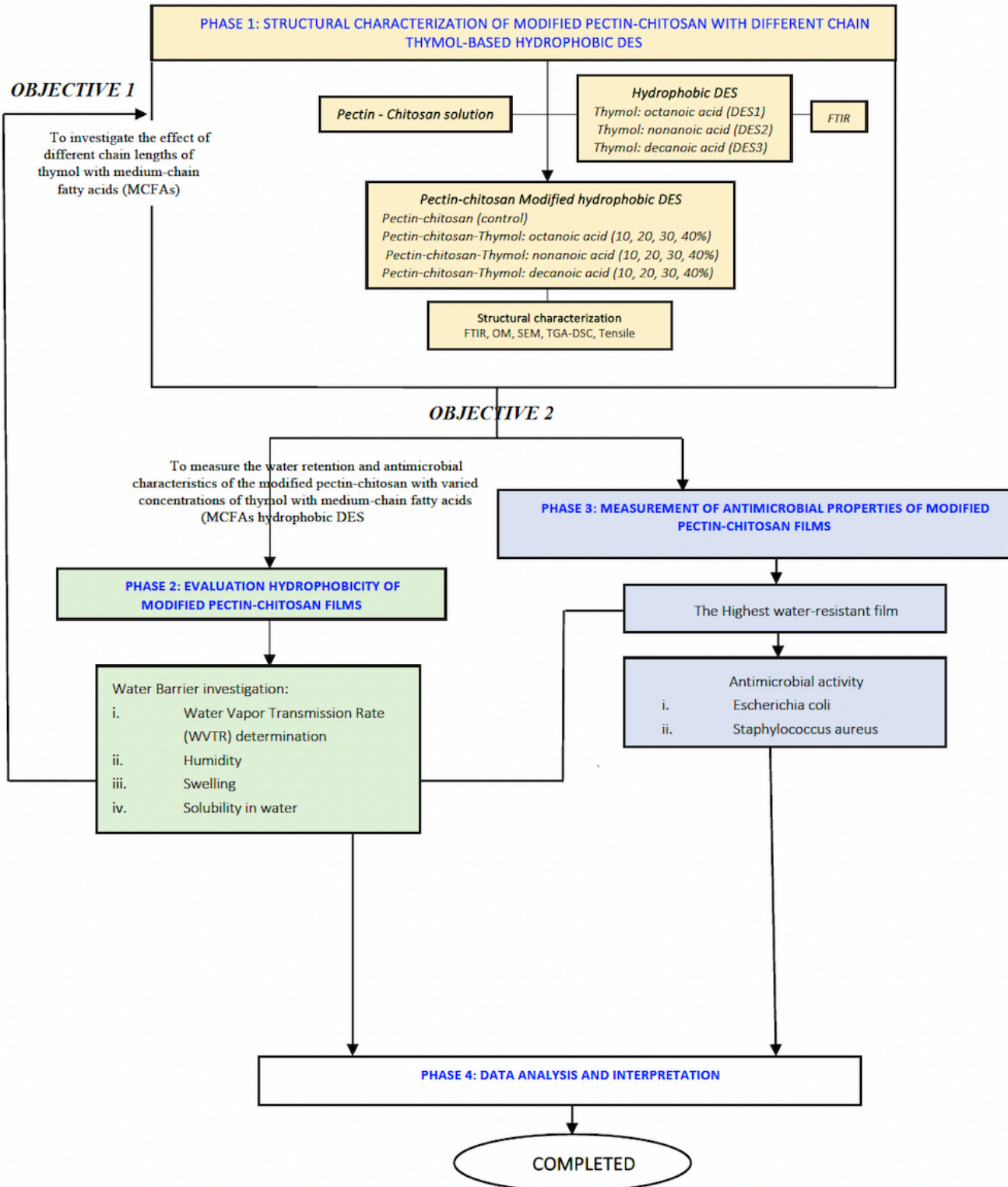
Applicant's Signature :

Tandatangan Pemohon :



Note: APPLICATIONS SUBMITTED WILL BE TREATED IN FULL CONFIDENCE. THE DECISION OF THE INTERNAL RESEARCH ACCULTURATION MAIN COMMITTEE UiTM CAWANGAN PERLIS IS FINAL. Semua permohonan dianggap sulit. Keputusan Jawatankuasa Induk Geran Penyelidikan Pembudayaan Dalam UiTM Cawangan Perlis adalah MUKTAMAD.

METHODOLOGY FLOWCHART



PEJABAT TIMBALAN REKTOR
Penyelidikan, Jaringan Industri, Masyarakat & Alumni
(PJIM&A)
UNIVERSITI TEKNOLOGI MARA
Cawangan Perlis, Malaysia
Tel: (+604) 9882027/2028/2029/2301/2302
Faks: (+604) 9882304

Universiti Teknologi MARA Cawangan Perlis
Kampus Arau
02600 Arau, Perlis, MALAYSIA
Tel: (+604) 988 2000 / 2999 / 3000 Faks: (+604) 988 2019
Laman Web: <http://perlis.uitm.edu.my>



Rujukan : 100 UiTMPs(PJIM&A/PPP.15/1)
Tarikh : 27 Oktober 2020

Dr Rizana Yusof
Pensyarah Kanan
Fakulti Sains Gunaan
Universiti Teknologi MARA Cawangan Perlis
Kampus Arau

Puan,

PENDAFTARAN RESEARCH INTEREST GROUP (RIG)

Tajuk Projek : Sustainable and Eco-Friendly Research Group (SERG)
Kod Pendaftaran : RIG028/2020
Ketua Projek : Dr. Rizana Yusof
Ahli Projek : Dr. Roziana Mohammed Hanaphi
: Dr. Dalina Samsudin
: Pn. Farhana Othman
: Dr. Nurul Zawani Alias
: Pn. Shafinas Abdullah
: Pn. Sarina Mohamad
: Pn. Nor Atikah Husna Ahmad Nasir

Dengan hormatnya perkara di atas adalah dirujuk.

2. Untuk makluman 'Research Interest Group – Sustainable and Eco-Friendly Research Group (SERG) puan telah didaftarkan di bawah PJIM&A UiTM Cawangan Perlis dengan Kod Pendaftaran RIG028/2020.

3. Sehubungan dengan itu, kumpulan RIG ini adalah digalakkan untuk mengatur sebarang aktiviti atau program yang bermanfaat untuk perkembangan kumpulan RIG tersebut. Di samping itu, kumpulan RIG ini hendaklah menghantar sesalinan laporan aktiviti yang dilaksanakan untuk direkodkan oleh pihak PJIM&A.

4. Segala sumbangan dan sokongan daripada pihak puan didahului dengan ucapan ribuan terima kasih.

Sekian.

Yang benar,

PROF. DR. HJ. KHUDZIR B. HJ. ISMAIL
Rektor

BORANG GSP 2024

Kod Rujukan: (Diisi oleh PJI)	
RIG	
Bukti Kolaborasi	

(Diisi oleh PJI)

**BORANG PERMOHONAN
GERAN SEMARAK PENYELIDIKAN (GSP) 2024**
Bahagian Penyelidikan & Jaringan Industri (PJI)
UiTM CAWANGAN PERLIS

A	TITLE OF PROPOSED RESEARCH: <i>Tajuk penyelidikan yang dicadangkan :</i> DIGITAL DINING: EXPLORING SENIOR PATRONS ACCEPTANCE OF QR CODE ORDERING SYSTEMS IN NORTHERN MALAYSIA		
B	DETAILS OF RESEARCHER / MAKLUMAT PENYELIDIK		
B(i)	<table><tr><td>Name of Project Leader: <i>Nama Ketua Projek:</i> IMA ILYANI BINTI DATO' HJ. IBRAHIM</td><td>IC / Passport Number: <i>No. Kad Pengenalan/ Pasport:</i> 830604-14-5650</td></tr></table>	Name of Project Leader: <i>Nama Ketua Projek:</i> IMA ILYANI BINTI DATO' HJ. IBRAHIM	IC / Passport Number: <i>No. Kad Pengenalan/ Pasport:</i> 830604-14-5650
Name of Project Leader: <i>Nama Ketua Projek:</i> IMA ILYANI BINTI DATO' HJ. IBRAHIM	IC / Passport Number: <i>No. Kad Pengenalan/ Pasport:</i> 830604-14-5650		
B(iii)	Faculty/School/Centre/Unit (Please provide full address): <i>Fakulti/Jabatan /Pusat/Unit (Sila nyatakan alamat penuh):</i> FAKULTI PENGURUSAN DAN PERNIAGAAN, UiTM CAWANGAN PERLIS		
B(iv)	<table><tr><td>Office Telephone No.: <i>No. Telefon Pejabat:</i> 04-9882845</td><td>Handphone No.: <i>No. Telefon Bimbit:</i> 018-2111904</td></tr></table>	Office Telephone No.: <i>No. Telefon Pejabat:</i> 04-9882845	Handphone No.: <i>No. Telefon Bimbit:</i> 018-2111904
Office Telephone No.: <i>No. Telefon Pejabat:</i> 04-9882845	Handphone No.: <i>No. Telefon Bimbit:</i> 018-2111904		
B(v)	E-mail Address: <i>Alamat e-mel:</i> ilyani686@uitm.edu.my		
B(vi)	Date of first appointment with this University: <i>Tarikh mula berkhidmat dengan Universiti ini:</i> 3 Julai 2009		

C	RESEARCH INFORMATION / MAKLUMAT PENYELIDIKAN																																	
C(i)	Research Domain (Please tick (✓)): <i>Domain Penyelidikan (Sila tanda (✓)):</i> A. Pure and Applied Sciences (Sains Tulen dan gunaan) <table border="0"> <tr> <td>☐ Chemistry (Kimia)</td> <td>☐ Physic (Fizik)</td> <td>☐ Biology (Biologi)</td> </tr> <tr> <td>☐ Biochemistry (Biokimia)</td> <td>☐ Materials Science (Sains Bahan)</td> <td>☐ Mathematics and Statistics (Matematik dan Statistik)</td> </tr> <tr> <td colspan="3">☐ Materials Science (Sains Bahan)</td> </tr> </table> B. Social Sciences (Sains Sosial) <table border="0"> <tr> <td>☐ Anthropology (Antropologi)</td> <td>☐ Psychology (Psikologi)</td> <td>☐ Sociology (Sosiologi)</td> </tr> <tr> <td>☐ Political Science (Sains Politik)</td> <td>☒ Business and Management (Pengurusan dan Perniagaan)</td> <td>☐ Geography (Geografi)</td> </tr> <tr> <td>☐ Economic (Ekonomi)</td> <td>☐ Human Ecology (Ekologi Manusia)</td> <td>☐ Communication (Komunikasi)</td> </tr> </table> C. Arts and Applied Arts (Sastera dan Sastera Ikhtisas) <table border="0"> <tr> <td>☐ Language and Linguistic (Bahasa dan Linguistik)</td> <td>☐ Literature (Kesusasteraan)</td> <td>☐ Religion (Agama)</td> </tr> <tr> <td>☐ Philosophy (Falsafah)</td> <td>☐ Civilization (Tamadun)</td> <td>☐ History (Sejarah)</td> </tr> <tr> <td>☐ Art (Seni)</td> <td>☐ Culture (Budaya)</td> <td>☐ Education (Pendidikan)</td> </tr> <tr> <td>☐ Policies and Law (Dasar dan Undang-undang)</td> <td>☐ Built Environment (Alam Bina-Aspek Kemanusiaan)</td> <td>☐ Environment (Alam Sekitar-Aspek Kemanusiaan)</td> </tr> </table> D. Natural Sciences and National Heritage (Sains Tabii dan Warisan Negara) <table border="0"> <tr> <td>☐ Environment (Alam Sekitar)</td> <td>☐ Forestry (Perhutanan)</td> <td>☐ Agriculture (Pertanian)</td> </tr> </table>	☐ Chemistry (Kimia)	☐ Physic (Fizik)	☐ Biology (Biologi)	☐ Biochemistry (Biokimia)	☐ Materials Science (Sains Bahan)	☐ Mathematics and Statistics (Matematik dan Statistik)	☐ Materials Science (Sains Bahan)			☐ Anthropology (Antropologi)	☐ Psychology (Psikologi)	☐ Sociology (Sosiologi)	☐ Political Science (Sains Politik)	☒ Business and Management (Pengurusan dan Perniagaan)	☐ Geography (Geografi)	☐ Economic (Ekonomi)	☐ Human Ecology (Ekologi Manusia)	☐ Communication (Komunikasi)	☐ Language and Linguistic (Bahasa dan Linguistik)	☐ Literature (Kesusasteraan)	☐ Religion (Agama)	☐ Philosophy (Falsafah)	☐ Civilization (Tamadun)	☐ History (Sejarah)	☐ Art (Seni)	☐ Culture (Budaya)	☐ Education (Pendidikan)	☐ Policies and Law (Dasar dan Undang-undang)	☐ Built Environment (Alam Bina-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar)	☐ Forestry (Perhutanan)	☐ Agriculture (Pertanian)
☐ Chemistry (Kimia)	☐ Physic (Fizik)	☐ Biology (Biologi)																																
☐ Biochemistry (Biokimia)	☐ Materials Science (Sains Bahan)	☐ Mathematics and Statistics (Matematik dan Statistik)																																
☐ Materials Science (Sains Bahan)																																		
☐ Anthropology (Antropologi)	☐ Psychology (Psikologi)	☐ Sociology (Sosiologi)																																
☐ Political Science (Sains Politik)	☒ Business and Management (Pengurusan dan Perniagaan)	☐ Geography (Geografi)																																
☐ Economic (Ekonomi)	☐ Human Ecology (Ekologi Manusia)	☐ Communication (Komunikasi)																																
☐ Language and Linguistic (Bahasa dan Linguistik)	☐ Literature (Kesusasteraan)	☐ Religion (Agama)																																
☐ Philosophy (Falsafah)	☐ Civilization (Tamadun)	☐ History (Sejarah)																																
☐ Art (Seni)	☐ Culture (Budaya)	☐ Education (Pendidikan)																																
☐ Policies and Law (Dasar dan Undang-undang)	☐ Built Environment (Alam Bina-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar-Aspek Kemanusiaan)																																
☐ Environment (Alam Sekitar)	☐ Forestry (Perhutanan)	☐ Agriculture (Pertanian)																																

	☐ Marine (Marin) ☐ Archaeology (Arkeologi) ☐ Geoscience (Geosains) ☐ Ethnography (Etnografi) ☐ Built Environment (Heritage Aspect) Alam Bina (Aspek Warisan) ☐ Culture (Budaya) ☐ Biodiversity (Kepelbagaian Biologi) E. Information and Communication Technology (Teknologi Maklumat dan Komunikasi) ☐ Software and Information System (Perisian dan Sistem Maklumat) ☐ Soft Computing (Pengkomputeran Lembut) ☐ Computer Networking (Rangkaian Komputer) ☐ Information Security (Keselamatan Maklumat) ☐ Multimedia (Multimedia) ☐ Computer Engineering (Kejuruteraan Komputer) ☐ Computer Science (Sains Komputer) F. Health Sciences (Sains Kesihatan) ☐ Basic Medical Sciences (Sains Perubatan Asas) ☐ Pharmacy (Farmasi) ☐ Pharmacology (Farmakologi) ☐ Medical Microbiology (Mikrobiologi Perubatan) ☐ Parasitology (Parasitologi) ☐ Pathology (Pathologi) ☐ Community Medical Prevention (Perubatan Pencegahan Masyarakat) ☐ Clinical Surgical (Klinikal Surgikal) ☐ Clinical Medical (Klinikal Medikal) ☐ Associate Health Science (Sains Kesihatan Bersekutu) ☐ Dental (Pergigian) ☐ Nursing Science (Sains Kejururawatan)
C(ii)	Location of Research: Tempat penyelidikan dijalankan: Sekitar restoran di Utara Malaysia (Perlis, Kedah, Penang)

C(iii)	Duration of this research (Maximum 24 months): <i>Tempoh masa penyelidikan ini (Maksimum 24 bulan):</i> Duration: 24 months <i>Tempoh :</i> From : 1 Jan 2025 <i>Dari :</i> To : 31 Dec 2026 <i>Hingga :</i>				
C(iv)	Other Researchers: <i>Ahli-ahli penyelidik yang lain:</i>				
	Bil	Name <i>Nama</i>	IC / Staff Number: <i>No. Kad Pengenalan/ No. Pekerja:</i>	University / Industry / Agency <i>Fakulti/ P.Pengajian/ Pusat/Unit</i>	Academic Qualification/ Designation <i>Tahap Kelayakan Akademik/Jawatan</i>
	1	NURUL FARIHIN BINTI MHD NASIR	840519025610 / 302850	FAKULTI PENGURUSAN DAN PERNIAGAAN, UiTM CAWANGAN PERLIS	MASTER / PENSYARAH KANAN
	2	NIK AZLINA BINTI NIK ABDULLAH	801020035594 / 220848	FAKULTI PENGURUSAN DAN PERNIAGAAN, UiTM CAWANGAN PERLIS	MASTER / PENSYARAH KANAN
	3	SYAZWANI BINTI YA	851022035702 / 279446	FAKULTI PENGURUSAN DAN PERNIAGAAN, UiTM CAWANGAN PERLIS	MASTER / PENSYARAH KANAN
	4	NURWAHIDA BINTI FUAD	810111075086 / 250397	FAKULTI PENGURUSAN DAN PERNIAGAAN, UiTM CAWANGAN PERLIS	PhD / PENSYARAH KANAN
	5	SITI FARHANA BINTI HASANUDIN	850326-14-5076 / 02/011	FAKULTI PERNIAGAAN DAN SAINS PENGURUSAN, UniSIRAJ	MASTER / PENSYARAH
C(vi)	Please provide information on academic publications that has been published by the project leader for the last five (5) years. (Example: Journals, Books, Chapters in books, etc) <i>Sila kemukakan maklumat berkaitan penerbitan akademik yang telah diterbitkan oleh ketua penyelidik dalam tempoh lima (5) tahun terakhir. (Contoh: Jurnal, buku, bab dalam buku, dll)</i>				
	Title of publication <i>Tajuk penerbitan</i>		Name of journals/books <i>Nama jurnal/buku</i>		Year published <i>Tahun diterbitkan</i>
	Word-of-Mouth: The Key Driver Behind Gen Y's Buying Trends		Advanced International Journal Of Business, Entrepreneurship And SMEs (AIJBES)		2024
	The Conceptualisation of Halal Certification Adoption Model Among Small and Medium-Sized Enterprises (SMEs) in Malaysia		Advanced International Journal of Business, Entrepreneurship and SME's (AIJBES)		2023

	Examining The Awareness of Muslim Consumers Towards Halal Food	International Journal of Entrepreneurship and Management Practises (IJEMP)	2023
	Muslim Consumer's Inclinations Towards Non-Certified Halal Food Outlets	Journal of Islamic, Social, Economics and Development (JISED)	2023
	The Essential of Entrepreneurship Inclination in Higher Learning Institution (HLI)	International Journal of Academic Research in Business and Social Sciences	2021
	The Association between the Impacts of Telecommuting Work Arrangement and Employee Performance during Covid19 Pandemic: A Case Study in Private Sector	International Journal of Academic Research In Business And Social Sciences	2021
	The Purchase Intention's Driver Of Private Label Brands From The Hypermarket Standpoint	Advanced International Journal of Business, Entrepreneurship and SME's (AIJBES)	2020
	Human Resources Management and Employees' Practices at the Workplace: Enhancing Organizational Citizenship Behavior for Environment	International Journal of Academic Research in Business And Social Sciences	2020
	Transfer of Training Among Workforce in Property Industry	International Journal of Accounting, Finance And Business (IJAFB)	2019
C(vii)	Executive Summary of Research Proposal (maximum 300 words) (Please include the problem statement, objectives, research methodology, expected output/outcomes/implication, and significance of output from the research project) <i>Ringkasan Cadangan Eksekutif Penyelidikan (maksimum 300 patah perkataan)</i> <i>(Meliputi pernyataan masalah, objektif, kaedah penyelidikan, jangkaan hasil penyelidikan/implikasi dan kepentingan output projek penyelidikan)</i> As digital technology reshapes dining, QR code menus have become a staple in many restaurants, providing a contactless and efficient ordering solution. However, for many older diners, using these digital menus can be challenging due to varying comfort levels with technology and occasional usability issues. This study seeks to uncover the factors that impact QR code menu acceptance among senior diners, addressing the obstacles they face and exploring ways to improve their experience. The main goals are to identify key factors influencing seniors' acceptance of QR menus and to offer actionable recommendations for restaurant operators to make QR menus more senior-friendly. Using a quantitative approach, the study will gather diverse perspectives from senior diners (aged 60+) at different restaurants that utilize QR menus. Structured surveys will assess variables such as perceived ease of use (PEOU), perceived usefulness (PU), perceive trust (PT), and perceived risk (PR). By analysing responses from approximately 384 participants, the research aims to capture a well-rounded view of factors affecting QR menu acceptance. Statistical methods, including regression and factor analysis, will be applied to pinpoint the most influential variables. The findings from this study will offer valuable insights for fostering the adoption of QR menus in an age-inclusive manner, helping to create a more accessible dining experience for senior customers while supporting digital progress in the hospitality industry.		
C(viii)	Detailed proposal of research project: <i>Cadangan maklumat penyelidikan secara terperinci:</i> (a) Research background including: / Latarbelakang penyelidikan termasuk:		

- i) **Problem Statement** / *Pernyataan Masalah*
- ii) **Hypothesis** / *Hipotesis*
- iii) **Research Questions** / *Persoalan Penyelidikan*
- iv) **Literature Reviews** / *Kajian Literatur*
- v) **Related References** / Rujukan berkaitan
- vi) **Relevance to Government Policy, if any** / *Perkaitan dengan Dasar Kerajaan, jika berkenaan*

i) Problem Statement

As digital menus, particularly QR code menus, become increasingly popular in the dining industry, senior diners often encounter distinct challenges with adapting to this technology. Many restaurants are turning to QR codes to streamline service and minimize contact, yet older patrons may face hurdles related to ease of use, perceived usefulness, perceive trust, and even perceived risk. This study explores the essential factors shaping seniors' acceptance of QR code menus and seeks strategies to enhance their experience, aiming to balance digital innovation with inclusivity for older adults.

ii) Hypothesis

1. **H1:** There is a significant relationship between perceived ease of use and senior patrons' acceptance of QR code ordering system
2. **H2:** There is a significant relationship between perceived usefulness and senior patrons' acceptance of QR code ordering system.
3. **H3:** There is a significant relationship between perceived trust and senior patrons' acceptance of QR code ordering system.
4. **H4:** There is a significant relationship between perceived risk and senior patrons' acceptance of QR code ordering system.

iii) Research Questions

1. Is there a relationship between perceived ease of use and senior patrons' acceptance of QR code ordering system?
2. Is there a relationship between perceived usefulness and senior patrons' acceptance of QR code ordering system?
3. Is there a relationship between perceived trust and senior patrons' acceptance of QR code ordering system?
4. Is there a relationship between perceived risk and senior patrons' acceptance of QR code ordering system?

iv) Literature Review

Consumer Acceptance of QR Code Ordering System

The adoption of QR code ordering systems has gained attention in recent years, with research highlighting factors influencing consumer acceptance. The Unified Theory of Acceptance and Use of Technology (UTAUT) and its extensions provide a strong foundation for understanding adoption. Key determinants include performance expectancy (efficiency and convenience), effort expectancy (ease of use), social influence (peer or societal encouragement), and facilitating conditions (availability of resources) (Suo et al., 2022; Rashid et al., 2023). Trust, particularly in data security and payment processes, plays a critical role in shaping consumer behavior (Ru & Anshul, 2023). Additionally, hedonic motivation, or the enjoyment derived from using QR-based systems, influences adoption in casual dining contexts, where self-service technologies enhance customer experience and operational efficiency (Phillips, 2023). However, challenges such as user preference for traditional menus, especially in high-end dining, and the perceived complexity of digital interfaces for less tech-savvy customers, remain barriers (Technomic, 2023). Further exploration into integrating user-friendly designs and hybrid approaches could improve acceptance and satisfaction.

Perceived Ease of Use

The rise of modern technologies has dramatically reshaped how today's businesses function (Koiri et al., 2019). For instance, consumer purchasing choices are now swayed by the perceived ease of use, making marketing outcomes both convenient and impactful (Loketkrawee & Bhatiasavi, 2018). This shift is especially notable in the hospitality industry, where innovations like the E-Menu offer restaurant owners the flexibility to update menus remotely, anytime, and without assistance, from anywhere in the world (Sahin, 2020). Many consumers now prefer using mobile apps for ordering at restaurants due to the speed, simplicity, and convenience they offer (Alawan, 2020). Tablet menus, with their interactive digital displays, also bring unique advantages over

traditional menus, allowing customers to quickly browse food options with ease (Yim & Yoo, 2020). Recent studies explore how Perceived Ease of Use (PEoU) impacts senior citizens' adoption of QR code menu ordering systems. One study highlights that simple and user-friendly designs enhance seniors' confidence and willingness to use digital systems, reducing cognitive strain (Kılıç et al., 2023). Additionally, incorporating the Technology Acceptance Model (TAM), researchers found PEoU directly boosts perceived usefulness and intention to use QR menus, reinforcing adoption rates (Davis et al., 2023). When users perceive these digital tools as easy to navigate, their attitudes toward adopting such technologies become overwhelmingly positive (Kang & Namkung, 2019). Effort expectancy, linked to minimal learning time and ease of interaction, further influences satisfaction, especially for seniors unfamiliar with technology (Purohit et al., 2022). Facilitating conditions like technical support and smartphone accessibility significantly impact older adults' usage behavior (Liaw et al., 2022). Moreover, social endorsement from family or peers promotes confidence in navigating QR menus (Iskender et al., 2022).

Perceived Usefulness

Perceived usefulness reflects how effectively an information system can boost user performance. Davis (1989) introduced a model for technology adoption that includes this concept, while Tee (2018) further defined perceived usefulness as a user's belief that a particular system will enhance job performance. Five indicators are commonly used to measure this perception: access to needed information, expanded details, improved efficiency, ease of work, and overall benefit (Ellitan et al., 2022). Tamilvizhi et al. (2021) support this by showing how perceived usefulness saves time, enabling consumers to make, modify, and submit orders, as well as process payments without waiting in line. E-Menus, for instance, allow restaurants to transition from expensive printed menus to customizable digital formats for various occasions (Al Amin et al., 2021). They streamline operations, reduce service costs, and are especially popular in fast-food establishments (Altan, 2018). Recent literature emphasizes the role of perceived usefulness (PU) in influencing senior citizens' adoption of QR code menu systems. Studies grounded in the Technology Acceptance Model (TAM) highlight that PU significantly affects behavioral intentions to adopt these systems, as users value efficiency and utility (Davis, 1989; Kalyoncuoğlu, 2018). Perceived ease of use (PEoU) also impacts PU, as simpler interfaces encourage adoption among older demographics by reducing technological anxiety (Kılıç et al., 2023). Facilitating conditions, such as user support and access to resources, further enhance senior diners' confidence and willingness to engage with QR codes, aligning with findings from broader studies on digital tools (Tandon et al., 2022). Additionally, the hedonic motivation tied to QR menus, where enjoyment in use boosts adoption, is gaining attention (Rauschnabel et al., 2015). Social influences, including peer recommendations, also positively impact older users' acceptance, bridging generational gaps in technology use (Iskender et al., 2022). These insights reveal that a multifaceted approach is key to enhancing PU among senior diners.

Perceived Trust

Perceived trust refers to a consumer's confidence in automated tools—like an E-Menu—believing these systems can fulfill responsibilities reliably and honestly, often as well as or better than a human (Tussyadiah et al., 2020). This trust grows when consumers see the E-Menu as consistently dependable in managing issues during transactions, free from fraud, and assuring smooth, satisfactory interactions (Suleman et al., 2019). Thus, perceived trust plays a crucial role in shaping consumers' intention to make purchases (Suleman et al., 2019). Supporting this, Ray & Bala (2019) found that trust significantly boosts consumers' willingness to engage with such systems. Elements of human trust are essential in fostering confidence in modern technologies like the E-Menu, especially given the perceived risks and uncertainties consumers may face (Chun, 2019). Recent studies have explored the perceived trust of QR code menu systems among senior citizens. Trust often hinges on ease of use, perceived usefulness, and technology familiarity. Research has shown that senior users are more likely to trust systems with straightforward interfaces, promoting confidence and reducing technological anxiety. Studies also emphasize the role of security and privacy assurances in fostering trust. Age-related factors like cognitive decline or limited tech exposure influence trust levels, necessitating adaptive designs tailored to seniors' needs. Furthermore, perceived performance, a core factor in the Technology Acceptance Model (TAM), highlights the importance of convenience and task efficiency in boosting trust.

Perceived Risk

Consumers' concerns about sharing personal data with E-menu systems are heightened due to potential security risks, including the threat of data breaches (Susmitha, 2021). The E-menu operates autonomously, handling food orders without any human oversight, so users should be mindful of the risks associated with an entirely automated decision-making system (Tzavlopoulos et al., 2019). Given that data privacy is now a widely recognized public issue, a stronger policy framework is essential to minimize risks associated with disclosing personal data on E-commerce platforms like the E-menu (Muneer, 2018). Recent studies shed light on perceived risks associated with QR code menu systems among senior diners. Research highlights that older

adults often face challenges such as technological unfamiliarity and concerns about data privacy, which can deter their acceptance of QR code menus. For instance, the Technology Acceptance Model (TAM) underscores that perceived ease of use and usefulness significantly influence seniors' willingness to adopt such systems, yet these perceptions are often dampened by fears of complexity or misuse of personal data (Koay, K.Y. and Ang, K. (2024). Additionally, while QR menus enhance efficiency and hygiene—key benefits post-pandemic—seniors may still find the lack of human interaction a drawback. This perceived loss of personalized service further complicates their willingness to embrace digital ordering (Koay, K.Y. and Ang, K. (2024).

v) Related References

Some useful references to start with may include:

1. Aurangzeb, W., Kashan, S., & Rehman, Z. U. (2024). Investigating technology perceptions among secondary school teachers: A systematic literature review on perceived usefulness and ease of use. *Academy of Education and Social Sciences Review*, 4(2), 160–173. <https://doi.org/10.48112/aessr.v4i2.746>
2. Majdalawieh, M. (2023). Building trust in supply chains: The blockchain-QR code advantage. In *2023 20th ACS/IEEE International Conference on Computer Systems and Applications (AICCSA)* (pp. 1–7). IEEE. <https://doi.org/10.1109/AICCSA59173.2023.10479331>
3. Djanir, U., Sukriyadi, Munizu, M., Tomadehe, S., & Ady Bakri, A. (2024). Analysis of the influence of perceived usefulness factors and subjective norm on intention to use QR code of digital wallet users. *Jurnal Informasi Dan Teknologi*, 6(1), 240–244. <https://doi.org/10.60083/jidt.v6i1.506>
4. Iskender, A., Sirakaya-Turk, E., Cardenas, D., & Hikmet, N. (2022). Restaurant patrons' intentions toward QR code menus in the U.S. during COVID-19: Acceptance of technology adoption model (ATAM). *Journal of Foodservice Business Research*. <https://doi.org/10.1080/15378020.2022.2133518>
5. Shahril, Z., Den, N. S. A. R., Bahari, N. A. S. S., & Asnawi, N. I. M. (2024). Customer satisfaction in using digital QR code menu ordering in restaurants. *Journal of Tourism, Hospitality & Culinary Arts*, 16(1), 820–831.
6. Koay, K. Y., & Ang, K. (2024). Understanding consumers' intentions to use QR code menus in the post-COVID-19 pandemic. *British Food Journal*, 126(5), 2172–2186. <https://doi.org/10.1108/BFJ-10-2023-0880>

vi) Relevance to Government Policy

Government policies are increasingly focused on **digital inclusion** and **accessibility** for seniors, as older populations are often left behind in the push for digital transformation. This study aligns with policies focused on:

1. **Digital Accessibility Standards:** Governments, particularly in countries with aging populations, have set standards for digital accessibility to ensure that seniors are not excluded from using new technologies. Findings from this study could support guidelines for designing QR code menus to comply with accessibility standards for older users.
2. **Senior Empowerment and Inclusion Initiatives:** Many countries have policies aimed at increasing digital literacy among seniors. Insights from this research could guide government-backed digital literacy programs by highlighting specific areas where seniors need support when interacting with QR code systems.

(b) Objective (s) of the Research

Objektif Penyelidikan

1. To identify factors that promote or impede the acceptance of QR menu systems among senior patrons.
2. To suggest strategies for restaurants to enhance the QR menu experience for senior customers.

(c) Methodology

Kaedah penyelidikan

Please state in the form / Sila nyatakan di borang ini

This study utilized a quantitative approach to explore hypotheses related to the Perceived Ease of Use, Perceived Usefulness, Perceived Trust and Perceived Risk of senior patrons' acceptance towards QR code ordering system. Participants will be selected from senior citizens in Northern Malaysia, a region with a

notably high concentration of older adults. According to 2023 data from the Department of Statistics Malaysia (DOSM), five Malaysian states with the highest proportions of individuals aged 60-64 are Perak (14.6%), Kedah (13.08%), Sarawak (12.7%), Penang (12.3%), and Perlis (12.1%). For those aged 65 and above, Perak (9.7%), Kedah (8.8%), Sarawak (8.3%), Perlis (8.1%), and Penang (7.7%) lead in population percentages. This demographic concentration makes Northern Malaysia a particularly pertinent area for studying older adults' responses to QR code menu ordering.

(d) Expected Results/Benefit

Jangkaan Hasil Penyelidikan

1. **Novel theories/New findings/Knowledge**

Technology Acceptance Model (TAM) for Seniors: Developing an adaptation of the Technology Acceptance Model (TAM) specific to senior diners could provide new theoretical insights. This "Senior Technology Acceptance Model (S-TAM)" could incorporate factors like cognitive load, physical accessibility, and social influence, which play unique roles in senior acceptance towards technology.

2. **Research Publications**

One SCOPUS atau Web of Science (WoS)

3. **Specific or Potential Grant Applications (please specify targeted grant application)**

FRGS

4. **Number of PhD and Masters (by research) Students (if any)**

None

5. **Impact on Society, Economy and Nation**

Setting Standards for Inclusive Technology: This research could encourage policymakers to set industry standards on digital inclusivity, benefiting seniors across other sectors, like healthcare and retail.

(e) Research activity & Milestone

Aktiviti penyelidikan & Carta perbatuan

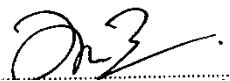
Research activity

Stage	Activity	Start date	End date
Research design and planning	Finalize research problem/questions	1.1.2025	28.2.2025
	Develop research design		
	Prepare research proposal		
Literature review	Search, capture and synthesize relevant literature	1.3.2025	31.5.2025
	Prepare draft literature review		
Data collection	Finalize sampling plan	1.6.2025	30.5.2026
	Develop data collection instrument		
	Pre-test/pilot data collection instrument		
	Carry out data collection		
	Write up data collection		
Data analysis	Prepare data for analysis	1.6.2026	31.8.2026
	Analyze data		
	Draw conclusions/ recommendations		
Writing up	Final draft of application	1.9.2026	31.12.2026
	Review draft		
	Final editing		
	Submit to extramural funder		

Milestone		
Stage	Activity	Cumulative Project Completion Percentage (%)
Research design and planning	Finalize research problem/questions	20%
	Develop research design	
	Prepare research proposal	
Literature review	Search, capture and synthesize relevant literature	35%
	Prepare draft literature review	
Data collection	Finalize sampling plan	50%
	Develop data collection instrument	
	Pre-test/pilot data collection instrument	
	Carry out data collection	
	Write up data collection	
Data analysis	Prepare data for analysis	70%
	Analyze data	
	Draw conclusions/ recommendations	
Writing up	Final draft of application	100%
	Review draft	
	Final editing	
	Submit to extramural funder	

D	BUDGET /BELANJAWAN		
	Please indicate your estimated budget for this research and details of expenditure according to the guidelines attached. <i>Sila nyatakan anggaran bajet bagi cadangan penyelidikan ini dan berikan butir – butir perbelanjaan lengkap dengan berpandukan kepada garis panduan yang dilampirkan.</i>		
	Budget details <i>Butiran belanjawan</i>	Amount requested by applicant <i>Jumlah yang dipohon oleh pemohon</i>	
		Year 1 (Tahun 1) (RM)	Year 2 (Tahun 2) (RM)
D(i)	Vote 21000 - Traveling and Transportation/ <i>Perjalanan dan Pengangkutan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>	2000	
D(ii)	Vote 24000 - Rental <i>Vot 24000 - Sewaan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>		

D(iii)	Vote 27000 - Research Materials & Supplies <i>Vot 27000 - Bekalan dan Bahan Penyelidikan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>		
D(iv)	Vote 28000 - Maintenance and Minor Repair Services <i>Bvot 28000 - Baik pulih kecil dan ubahsuai</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>		
D(v)	Vote 29000 - Professional Services <i>Vot 29000 - Perkhidmatan Ikhtisas</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i> • 1 x SCOPUS atau Web of Science (WoS) - RM 1500 • Harta Intelek - RM 200 • Proof Reading - RM 500 • Bahan percetakan - RM 500 • Pemprosesan data - RM 300	500	1500 200 500 300
D(vi)	Vote 35000 - Accessories and Equipment <i>Vot 35000 - Aksesori dan Peralatan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>		
TOTAL AMOUNT JUMLAH BESAR		5000	

E	Declaration by applicant / Akuan Pemohon (Please tick (✓)): / (Sila tanda (✓)):
	I hereby declare that: <i>Saya dengan ini mengaku bahawa:</i> ☒ 1. All information stated here are accurate, and PJIM&A has right to reject or to cancel the offer without prior notice if there is any inaccurate information given. <i>Semua maklumat yang diisi adalah benar, PJIM&A berhak menolak permohonan atau membatalkan tawaran pada bila-bila masa sekiranya keterangan yang dikemukakan adalah tidak benar.</i> ☒ 2. Application of this research is presented for the Geran Semarak Penyelidikan <i>Permohonan penyelidikan ini dikemukakan untuk Geran Semarak Penyelidikan.</i> ☒ 3. Application of this research is subject to Ethical Committee approval (if applicable). <i>Permohonan penyelidikan ini dimajukan ke Jawatankuasa Etika (jika berkenaan).</i> Date : <i>Tarikh : 22 November 2024</i> Applicant's Signature: <i>Tandatangan Pemohon:</i>  Note: APPLICATIONS SUBMITTED WILL BE TREATED IN FULL CONFIDENCE. THE DECISION OF THE INTERNAL RESEARCH ACCULTURATION MAIN COMMITTEE UiTM CAWANGAN PERLIS IS FINAL. Semua permohonan dianggap sulit. Keputusan Jawatankuasa Induk Geran Penyelidikan Pembudayaan Dalam UiTM Cawangan Perlis adalah MUKTAMAD.



Rujukan : 100 UiTMPs(PJIM&A/PPP.15/1)
Tarikh : 9 November 2020

Dr. Ahmad Nizan Mat Noor
Timbalan Rektor
Bahagian Hal Ehwal Pelajar
Universiti Teknologi MARA Cawangan Perlis
Kampus Arau

Tuan,

PENDAFTARAN RESEARCH INTEREST GROUP (RIG)

Tajuk Projek : Halal Industry, Entrepreneurship, Marketing and Management Studies
Kod Pendaftaran : RIG030/2020
Ketua Projek : Dr. Ahmad Nizan Mat Noor
Ahli Projek : Dr. Ismailaili Ismail
: Pn. Nik Azlina Nik Abdullah
: Pn. Nurul Farihin Mhd. Nasir
: Pn. Syazwani Ya
: Pn. Zulaiha Ahmad
: Pn. Ima Ilyani Ibrahim

Dengan hormatnya perkara di atas adalah dirujuk.

2. Untuk makluman '**Research Interest Group – Halal Industry, Entrepreneurship, Marketing and Management Studies**' tuan telah didaftarkan di bawah PJIM&A UiTM Cawangan Perlis dengan Kod Pendaftaran **RIG030/2020**.

3. Sehubungan dengan itu, kumpulan RIG ini adalah digalakkan untuk mengatur sebarang aktiviti atau program yang bermanfaat untuk perkembangan kumpulan RIG tersebut. Di samping itu, kumpulan RIG ini hendaklah menghantar sesalinan laporan aktiviti yang dilaksanakan untuk direkodkan oleh pihak PJIM&A.

4. Segala sumbangan dan sokongan daripada pihak tuan didahului dengan ucapan ribuan terima kasih.

Sekian.

Yang benar,

PROF. DR. HJ. KHUDZIR B. HJ. ISMAIL
Rektor

BORANG GSP 2024

Kod Rujukan: (Diisi oleh PJI)	
RIG	
Bukti Kolaborasi	
(Diisi oleh PJI)	

**BORANG PERMOHONAN
GERAN SEMARAK PENYELIDIKAN (GSP) 2024**
Bahagian Penyelidikan & Jaringan Industri (PJI)
UiTM CAWANGAN PERLIS

A	TITLE OF PROPOSED RESEARCH: <i>Tajuk penyelidikan yang dicadangkan :</i> Specifications and quality of chicken feather vermicompost to be used as a microbial fertilizer product	
B	DETAILS OF RESEARCHER / MAKLUMAT PENYELIDIK	
B(i)	Name of Project Leader: <i>Nama Ketua Projek:</i> NORHANANI BINTI AHMAD	IC / Passport Number: <i>No. Kad Pengenalan/ Pasport:</i> 771209-14-5506
B(iii)	Faculty/School/Centre/Unit (Please provide full address): <i>Fakulti/Jabatan /Pusat/Unit (Sila nyatakan</i> FAKULTI PERLADANGAN DAN AGROTEKNOLOGI	
B(iv)	Office Telephone No.: 04-9882712 <i>No. Telefon Pejabat:</i> -	Handphone No.: 019 2965766 <i>No. Telefon Bimbit:</i>
B(v)	E-mail Address: norhanani615@uitm.edu.my <i>Alamat e-mel:</i>	
B(vi)	Date of first appointment with this University: 1 FEBRUARY 2011 <i>Tarikh mula berkhidmat dengan Universiti ini:</i>	

C	RESEARCH INFORMATION / MAKLUMAT PENYELIDIKAN																																	
C(i)	Research Domain (Please tick (✓)): <i>Domain Penyelidikan (Sila tanda (✓)):</i> A. Pure and Applied Sciences (Sains Tulen dan gunaan) <table border="0"> <tr> <td>☐ Chemistry (Kimia)</td> <td>☐ Physic (Fizik)</td> <td>☐ Biology (Biologi)</td> </tr> <tr> <td>☐ Biochemistry (Biokimia)</td> <td>☐ Materials Science (Sains Bahan)</td> <td>☐ Mathematics and Statistics (Matematik dan Statistik)</td> </tr> <tr> <td colspan="3">☐ Materials Science (Sains Bahan)</td> </tr> </table> B. Social Sciences (Sains Sosial) <table border="0"> <tr> <td>☐ Anthropology (Antropologi)</td> <td>☐ Psychology (Psikologi)</td> <td>☐ Sociology (Sosiologi)</td> </tr> <tr> <td>☐ Political Science (Sains Politik)</td> <td>☐ Business and Management (Pengurusan dan Perniagaan)</td> <td>☐ Geography (Geografi)</td> </tr> <tr> <td>☐ Economic (Ekonomi)</td> <td>☐ Human Ecology (Ekologi Manusia)</td> <td>☐ Communication (Komunikasi)</td> </tr> </table> C. Arts and Applied Arts (Sastera dan Sastera Ikhtisas) <table border="0"> <tr> <td>☐ Language and Linguistic (Bahasa dan Linguistik)</td> <td>☐ Literature (Kesusasteraan)</td> <td>☐ Religion (Agama)</td> </tr> <tr> <td>☐ Philosophy (Falsafah)</td> <td>☐ Civilization (Tamadun)</td> <td>☐ History (Sejarah)</td> </tr> <tr> <td>☐ Art (Seni)</td> <td>☐ Culture (Budaya)</td> <td>☐ Education (Pendidikan)</td> </tr> <tr> <td>☐ Policies and Law (Dasar dan Undang-undang)</td> <td>☐ Built Environment (Alam Bina-Aspek Kemanusiaan)</td> <td>☐ Environment (Alam Sekitar-Aspek Kemanusiaan)</td> </tr> </table> D. Natural Sciences and National Heritage (Sains Tabii dan Warisan Negara) <table border="0"> <tr> <td>☐ Environment (Alam Sekitar)</td> <td>☐ Forestry (Perhutanan)</td> <td>☒ Agriculture (Pertanian)</td> </tr> </table>	☐ Chemistry (Kimia)	☐ Physic (Fizik)	☐ Biology (Biologi)	☐ Biochemistry (Biokimia)	☐ Materials Science (Sains Bahan)	☐ Mathematics and Statistics (Matematik dan Statistik)	☐ Materials Science (Sains Bahan)			☐ Anthropology (Antropologi)	☐ Psychology (Psikologi)	☐ Sociology (Sosiologi)	☐ Political Science (Sains Politik)	☐ Business and Management (Pengurusan dan Perniagaan)	☐ Geography (Geografi)	☐ Economic (Ekonomi)	☐ Human Ecology (Ekologi Manusia)	☐ Communication (Komunikasi)	☐ Language and Linguistic (Bahasa dan Linguistik)	☐ Literature (Kesusasteraan)	☐ Religion (Agama)	☐ Philosophy (Falsafah)	☐ Civilization (Tamadun)	☐ History (Sejarah)	☐ Art (Seni)	☐ Culture (Budaya)	☐ Education (Pendidikan)	☐ Policies and Law (Dasar dan Undang-undang)	☐ Built Environment (Alam Bina-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar)	☐ Forestry (Perhutanan)	☒ Agriculture (Pertanian)
☐ Chemistry (Kimia)	☐ Physic (Fizik)	☐ Biology (Biologi)																																
☐ Biochemistry (Biokimia)	☐ Materials Science (Sains Bahan)	☐ Mathematics and Statistics (Matematik dan Statistik)																																
☐ Materials Science (Sains Bahan)																																		
☐ Anthropology (Antropologi)	☐ Psychology (Psikologi)	☐ Sociology (Sosiologi)																																
☐ Political Science (Sains Politik)	☐ Business and Management (Pengurusan dan Perniagaan)	☐ Geography (Geografi)																																
☐ Economic (Ekonomi)	☐ Human Ecology (Ekologi Manusia)	☐ Communication (Komunikasi)																																
☐ Language and Linguistic (Bahasa dan Linguistik)	☐ Literature (Kesusasteraan)	☐ Religion (Agama)																																
☐ Philosophy (Falsafah)	☐ Civilization (Tamadun)	☐ History (Sejarah)																																
☐ Art (Seni)	☐ Culture (Budaya)	☐ Education (Pendidikan)																																
☐ Policies and Law (Dasar dan Undang-undang)	☐ Built Environment (Alam Bina-Aspek Kemanusiaan)	☐ Environment (Alam Sekitar-Aspek Kemanusiaan)																																
☐ Environment (Alam Sekitar)	☐ Forestry (Perhutanan)	☒ Agriculture (Pertanian)																																

☐ Marine
(Marin)

☐ Archaeology
(Arkeologi)

☐ Geoscience
(Geosains)

☐ Ethnography
(Etnografi)

☐ Built Environment
(Heritage Aspect)
Alam Bina (Aspek Warisan)

☐ Culture
(Budaya)

☐ Biodiversity
(Kepelbagaian Biologi)

E. Information and Communication Technology (Teknologi Maklumat dan Komunikasi)

☐ Software and Information System
(Perisian dan Sistem Maklumat)

☐ Soft Computing
(Pengkomputeran Lembut)

☐ Computer Networking
(Rangkaian Komputer)

☐ Information Security
(Keselamatan Maklumat)

☐ Multimedia
(Multimedia)

☐ Computer Engineering
(Kejuruteraan Komputer)

☐ Computer Science
(Sains Komputer)

F. Health Sciences (Sains Kesihatan)

☐ Basic Medical Sciences
(Sains Perubatan Asas)

☐ Pharmacy
(Farmasi)

☐ Pharmacology
(Farmakologi)

☐ Medical Microbiology
(Mikrobiologi Perubatan)

☐ Parasitology
(Parasitologi)

☐ Pathology
(Pathologi)

☐ Community Medical Prevention
(Perubatan Pencegahan
Masyarakat)

☐ Clinical Surgical
(Klinikal Surgical)

☐ Clinical Medical
(Klinikal Medikal)

☐ Associate Health Science
(Sains Kesihatan Bersekutu)

☐ Dental
(Pergigian)

☐ Nursing Science
(Sains Kejururawatan)

C(ii)

Location of Research:
Tempat penyelidikan dijalankan:

UiTM Perlis Branch, Arau Campus

C(iii)	Duration of this research (Maximum 12 months): <i>Tempoh masa penyelidikan ini (Maksimum 12 bulan):</i> Duration: 1 year <i>Tempoh :</i> From : 1 Jan 2025 <i>Dari :</i> To : 31 Dec 2025 <i>Hingga :</i>																																	
C(iv)	Other Researchers: <i>Ahli-ahli penyelidik yang lain:</i> <table border="1"> <thead> <tr> <th>Bil</th> <th>Name Nama</th> <th>IC / Staff Number: No. Kad Pengenalan/ No. Pekerja:</th> <th>University / Industry / Agency Fakulti/ P.Pengajian/ Pusat/Unit</th> <th>Academic Qualification/ Designation Tahap Kelayakan Akademik/Jawatan</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Dr. Najihah Farhan Sabri</td> <td>257785</td> <td>Faculty of Plantation and Agrotechnology, UiTM Perlis</td> <td>PhD (Plant Pathology, USM)</td> </tr> <tr> <td>2</td> <td>Noor Zuhairah Samsuddin</td> <td>304489</td> <td>Faculty of Plantation and Agrotechnology, UiTM Perlis</td> <td>MSc. (Plant Biotechnology, UKM)</td> </tr> <tr> <td>3</td> <td>Nur Faezah Binti Omar</td> <td>342360</td> <td>Faculty of Plantation and Agrotechnology, UiTM Perlis</td> <td>PhD (Crop production, UPM)</td> </tr> <tr> <td>4.</td> <td>Nazalyyussma Binti Yusop</td> <td>208873</td> <td>Faculty of Plantation and Agrotechnology, UiTM Perlis</td> <td>MSc. (Agronomy, UiTM)</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>				Bil	Name Nama	IC / Staff Number: No. Kad Pengenalan/ No. Pekerja:	University / Industry / Agency Fakulti/ P.Pengajian/ Pusat/Unit	Academic Qualification/ Designation Tahap Kelayakan Akademik/Jawatan	1	Dr. Najihah Farhan Sabri	257785	Faculty of Plantation and Agrotechnology, UiTM Perlis	PhD (Plant Pathology, USM)	2	Noor Zuhairah Samsuddin	304489	Faculty of Plantation and Agrotechnology, UiTM Perlis	MSc. (Plant Biotechnology, UKM)	3	Nur Faezah Binti Omar	342360	Faculty of Plantation and Agrotechnology, UiTM Perlis	PhD (Crop production, UPM)	4.	Nazalyyussma Binti Yusop	208873	Faculty of Plantation and Agrotechnology, UiTM Perlis	MSc. (Agronomy, UiTM)					
Bil	Name Nama	IC / Staff Number: No. Kad Pengenalan/ No. Pekerja:	University / Industry / Agency Fakulti/ P.Pengajian/ Pusat/Unit	Academic Qualification/ Designation Tahap Kelayakan Akademik/Jawatan																														
1	Dr. Najihah Farhan Sabri	257785	Faculty of Plantation and Agrotechnology, UiTM Perlis	PhD (Plant Pathology, USM)																														
2	Noor Zuhairah Samsuddin	304489	Faculty of Plantation and Agrotechnology, UiTM Perlis	MSc. (Plant Biotechnology, UKM)																														
3	Nur Faezah Binti Omar	342360	Faculty of Plantation and Agrotechnology, UiTM Perlis	PhD (Crop production, UPM)																														
4.	Nazalyyussma Binti Yusop	208873	Faculty of Plantation and Agrotechnology, UiTM Perlis	MSc. (Agronomy, UiTM)																														
C(vi)	Please provide information on academic publications that has been published by the project leader for the last five (5) years. (Example: Journals, Books, Chapters in books, etc) <i>Sila kemukakan maklumat berkaitan penerbitan akademik yang telah diterbitkan oleh ketua penyelidik dalam tempoh lima (5) tahun terakhir. (Contoh: Jurnal, buku, bab dalam buku, dll)</i> <table border="1"> <thead> <tr> <th>Title of publication Tajuk penerbitan</th> <th>Name of journals/books Nama jurnal/buku</th> <th>Year published Tahun diterbitkan</th> </tr> </thead> <tbody> <tr> <td colspan="3"> </td> </tr> </tbody> </table>				Title of publication Tajuk penerbitan	Name of journals/books Nama jurnal/buku	Year published Tahun diterbitkan																											
Title of publication Tajuk penerbitan	Name of journals/books Nama jurnal/buku	Year published Tahun diterbitkan																																

1	The Effect of Different Animal Dung in Vermicompost Production Using <i>Eudrilus eugeniae</i> Worm and Spent Mushroom Substrate as Vermicomposting Medium	. In Charting the Sustainable Future of ASEAN in Science and Technology: Proceedings from the 3rd International Conference on the Future of ASEAN (ICoFA) 2019-Volume 2 (pp. 137-145). Springer Singapore	2020
2	The Impacts of Different Types of Slopes on Soil Fertility Movement of Harumanis Mango.	In <i>Charting the Sustainable Future of ASEAN in Science and Technology: Proceedings from the 3rd International Conference on the Future of ASEAN (ICoFA) 2019-Volume 2</i> (pp. 23-35). Springer Singapore	2020
C(vii)	Executive Summary of Research Proposal (maximum 300 words) (Please include the problem statement, objectives, research methodology, expected output/outcomes/implication, and significance of output from the research project) <i>Ringkasan Cadangan Eksekutif Penyelidikan (maksimum 300 patah perkataan)</i> <i>(Meliputi pernyataan masalah, objektif, kaedah penyelidikan, jangkaan hasil penyelidikan/implikasi dan kepentingan output projek penyelidikan)</i> The quality of microbial fertilizer is one of the most important factors resulting in acceptance or rejection by the end-user, the farmers and specifications vary from country to country and depend on the number of selected microorganisms in the active form per gramme or millilitre of biofertilizer. Therefore, this study will be carried out to formulate chicken feather vermicompost substance containing microorganisms and fulfil specifications and quality requirements as a microbial fertilizer product. Hence, parameters such as microbial density at the time of manufacture and the time of expiration, permissible contamination, presence of microbial strain, and the organic acid will be determined. The physical and chemical composition of the microbial fertilizer will be determined to indicate the quality and maturity of the chicken feathers vermicompost. Meanwhile, the effects of vermicompost on the crops growth also require measuring the activities of the biofertilizer. In this study, the results of this research will be compared with Malaysian Standard specifications for organic fertilizers. This research is significant in transforming chicken feather waste into a useful biofertilizer product based on the purpose or objective of the specification output biofertilizer data.		

C(viii)	Detailed proposal of research project: <i>Cadangan maklumat penyelidikan secara terperinci:</i> (a) Research background including: / <i>Latarbelakang penyelidikan termasuk:</i> i) Problem Statement / <i>Pernyataan Masalah</i> ii) Hypothesis / <i>Hipotesis</i> iii) Research Questions / <i>Persoalan Penyelidikan</i> iv) Literature Reviews / <i>Kajian Literatur</i> v) Related References / <i>Rujukan berkaitan</i> vi) Relevance to Government Policy, if any / <i>Perkaitan dengan Dasar Kerajaan, jika berkenaan</i> <u>Problem statement</u> Fertilizer producers have demonstrated that microbial products can promote plant growth, reduce pest incidence, encourage decomposition, and improve soil quality. The primary effect of the microbial present in biofertilizer could affect the target crop. Nevertheless, there are instances in which approximately 40% of the declared microbes' presence either naturally occurs or is installed and has multiple effects. Therefore, understanding the representatives of microbial products must be considered or controlled in the use of microbial products, especially for a growers to choose the best for their crop requirement and soil condition. <u>Hypothesis</u> Formulation of chicken feather vermicompost substance containing microorganisms could be used as microbial biofertilizer products. <u>Research Question</u> 1. What are the strains of bacteria present in chicken feather vermicompost to become biofertilizer microbial products? 2. What is the number of microbes (density) and specifications to become biofertilizer microbial products? 3. What is the effect of microbial fertilizer on the growth and quality of the targeted crops? <u>Literature review</u> Microbial fertilizers, also known as biofertilizers, are substances containing living microorganisms. These fertilizers were found to encourage plant growth by increasing the supply or availability of primary nutrients (N, P, and K) to the host plant (Daniel et al.,2022). Nitrogen-fixing bacteria such as <i>Rhizobium</i> and <i>Azotobacter</i>, phosphorus-solubilising such as <i>Pseudomonas</i> and <i>Bacillus</i>, and potassium-solubilising such as <i>Pseudomonas</i>, <i>Azzobcter</i>, <i>Paenibacillus</i>, and <i>Acietobacter</i>, and plant growth-promoting rhizobacteria (PGPR) such as <i>Agrobacterium</i>, <i>Pseudomonas fluorescens</i>, <i>Arthrobacter</i>, <i>Erwinia</i>, <i>Bacillus</i>, and <i>Rhizobium</i> are among the examples of biofertilizers that enhance plant growth and yield (Nawaz et al., 2023). In agriculture, the application of biofertilizers is necessary to provide nutrition, promote plant growth and productivity, and improve soil health. Biofertilizers offer a long-term solution for soil health. Once introduced, they create a self-perpetuating cycle of nutrient enrichment, reducing the need for continuous applications (Bumandalalet al., 2019). Biofertilizers are a sustainable and eco-friendly alternative to chemical fertilisers, offering a multitude of benefits, from nutrient enrichment and enhancement of organic matter to growth promotion and environmental protection (Gaur, 2010). Vermicomposting is a sustainable waste management technique that involves the use of earthworms such as <i>African nightcrawlers</i>, <i>red wigglers</i>, blue worms, and <i>European nightcrawlers</i> to decompose organic waste materials (Emamjomeh et al., 2018). It is an efficient and eco-friendly process that transforms organic

waste from plants and animals into a nutrient-rich fertiliser called vermicompost. The quality of vermicompost is significantly influenced by the type of organic materials used as feedstock. Different materials contribute varying levels of nutrients, carbon-to-nitrogen ratios, and other properties, which affect the final product (Dey Chowdhury et al., 2023). Through careful selection and combination of organic feedstocks with balanced nutrient ratios, it is possible to produce superior vermicompost enriched with essential nutrients and a diverse microbial community (Sharma et al., 2024).

Chicken feather is an organic waste from the poultry industry, mainly consisting of feathers that are removed during the processing of chickens for meat consumption. These feathers are a significant waste product, often discarded or incinerated. It contains 80–90% keratin, a fibrous structural protein that is insoluble and resistant to chemical and enzymatic degradation (Maurya and Singh, 2024). However, when it is processed and composted properly, chicken feathers can be used as an organic fertilizer (Hadas et al., 1994; Nayaka and Vidyasagar, 2013; Bhari et al., 2021). Keratin in chicken feathers represents a promising resource of carbon, sulfur, and nitrogen, enabling its transformation into diverse products such as biofertilizers (Bhari et al., 2021).

The lack of standardized specifications and quality control measures for chicken feather vermicompost poses several challenges and limitations to its widespread adoption and utilization as a sustainable biofertilizer. The nutrient content of chicken feather vermicompost can vary significantly depending on factors such as the quality of the feathers, the composting process, and the type of microorganisms used. While there is growing interest in the use of chicken feather vermicompost, research on its production and application is still limited. More research is needed to develop standardized protocols and guidelines for its production and use. Therefore, conducting further research to optimise the production process is hoped able to improve the quality of chicken feather vermicompost as biofertilizers.

References

- Daniel, A. I., Fadaka, A. O., Gokul, A., Bakare, O. O., Aina, O., Fisher, S., ... & Klein, A. (2022). Biofertilizer: the future of food security and food safety. *Microorganisms*, 10(6), 1220.
- Nawaz, A., Qamar, Z. U., Marghoob, M. U., Imtiaz, M., Imran, A., & Mubeen, F. (2023). Contribution of potassium solubilizing bacteria in improved potassium assimilation and cytosolic K⁺/Na⁺ ratio in rice (*Oryza sativa* L.) under saline-sodic conditions. *Frontiers in Microbiology*, 14, 1196024.
- Bumandalai, O., & Tserennadmid, R. (2019). Effect of *Chlorella vulgaris* as a biofertilizer on germination of tomato and cucumber seeds. *International Journal of Aquatic Biology*, 7(2), 95-99.
- Gaur, V. (2010). Biofertilizer–necessity for sustainability. *J. Adv. Dev*, 1(8).
- Emamjomeh, M. M., Tahergorabi, M., Farzadkia, M., & Bazrafshan, E. (2018). A review of the use of earthworms and aquatic worms for reducing sludge produced: an innovative ecotechnology. *Waste and biomass valorization*, 9, 1543-1557.
- Dey Chowdhury, S., Suhaib, K. H., Bhunia, P., & Surampalli, R. Y. (2023). A critical review on the vermicomposting of organic wastes as a strategy in circular bioeconomy: mechanism, performance, and future perspectives. *Environmental Technology*, 1-38.
- Sharma, A., Mittal, R., Bohat, N., Malik, K., & Dahiya, B. (2024). Sustainable agriculture and soil enrichment through diverse organic vermicompost synthesized from different organic waste. *International Journal of Environmental Science and Technology*, 1-14.
- Maurya, S. D., & Singh, A. (2024). Application and future perspectives of keratin protein extracted from waste chicken feather: A review. *Sustainable Chemical Engineering*, 31-45.
- Bhari, R., Kaur, M., and Sarup Singh, R. (2021). Chicken feather waste hydrolysate as a superior biofertilizer in agroindustry. *Curr. Microbiol.* 78, 2212–2230. doi: 10.1007/s00284-021-02491-z
- Hadas, A., & Kautsky, L. (1994). Feather meal, a semi-slow-release nitrogen fertilizer for organic farming. *Fertilizer research*, 38, 165-170.
- Nayaka, S., & Vidyasagar, G. M. (2013). Development of eco-friendly bio-fertilizer using feather compost. *Ann. Plant Sci*, 2(7), 238-244.
- Bhari, R., Kaur, M., & Sarup Singh, R. (2021). Chicken feather waste hydrolysate as a superior biofertilizer in agroindustry. *Current Microbiology*, 78(6), 2212-2230.

Relevance to government policy

This research is a current scenario on the methods management of chicken poultry waste, and transformation of this waste into biofertilizer product could enhance our government focuses on utilizing agricultural waste, and

also an alternative tools to promote and improve organic farming, agro-ecosystem, environment, human health, and soil biological activities.

(b) Objective (s) of the Research

Objektif Penyelidikan

1. To formulate chicken feather vermicompost as microbial fertilizer product.
2. To determine the specification and quality chicken feather vermicompost as microbial fertilizer product.

(c) Methodology

Kaedah penyelidikan

Please state in the form / Sila nyatakan di borang ini

A. Procedures for Quality Control of Microbial Biofertilizer

1. Determination of Rhizobium in chicken feather vermicompost using broth test and gram staining/(Gram stain or Fuchsin stain)
2. Determination of Non-symbiotic N₂-fixer- use cell count method directly by microscopy-Count of Colony Forming Units
3. Determination of, phosphate solubilizers (PS) bacteria and P mobilization bacteria
4. Plant Growth promoting microbes

B. Test Of Physical And Chemical Quality Certificated

1. Assessment of physiochemical parameter of biofertilizer-Water content (%), Size (l mm),Organic matter (%C), pH

C. Analysis of Organic Acid

1. Cultivation of isolate on solution medium contained insoluble phosphate
2. Check the solubility on medium
3. Dissolving of calcium phosphate
4. Analysis of the organic acids in solution by the HPLC

D. Test of plant growth rate and nutrient absorption of crops

1. Control test with sterilized biofertilizer

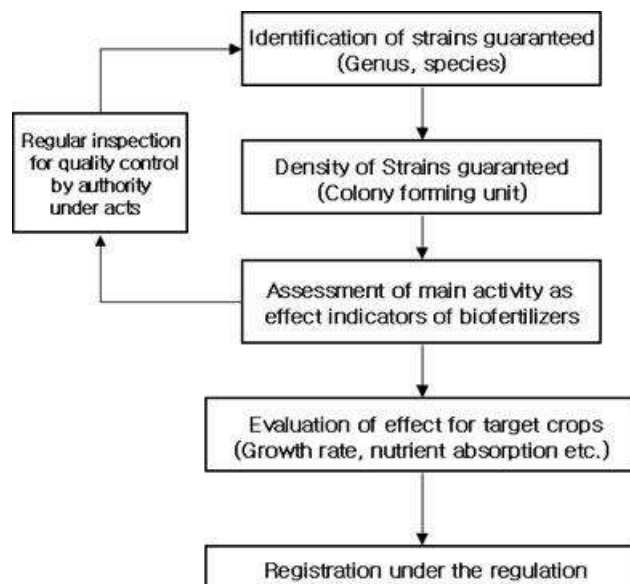


Fig. 1: General procedure for quality control of biofertilizers.

(d) Expected Results/Benefit

Jangkaan Hasil Penyelidikan

1. ***Novel theories/New findings/Knowledge***

Application of new combinations of several microbes, such as rhizobium, non-symbiotic fixer, phosphate solubilizing bacteria etc could contribute to the optimum quality of microbial biofertilizer for plant growth.

2. Research Publications

Journal index Scopus

3. Specific or Potential Grant Applications (please specify targeted grant application)

4. **Number of PhD and Masters (by research) Students (if any)**

5. *Impact on Society, Economy and Nation*

The utilization of chicken feathers as vermicompost biofertilizer offers numerous benefits for Malaysian society, economy, and nation. It promotes environmental sustainability through sustainable waste management practices. In terms of economic growth, vermicompost biofertilizers can create new market opportunities for entrepreneurs and businesses.

(e) Research activity & Milestone

Aktiviti penyelidikan & Carta perbatuan

[illegible]

	<table border="1"> <thead> <tr> <th>No</th><th>Project activity description</th><th>Date</th><th>Completion project progress</th></tr> </thead> <tbody> <tr> <td>1</td><td>Determination of <i>Rhizobium</i> in chicken feather vermicompost</td><td>1/1/2025</td><td>20%</td></tr> <tr> <td>2</td><td>Assessment of physiochemical parameters</td><td>1/5/2025</td><td>40%</td></tr> <tr> <td>3</td><td>Analysis of organic acid</td><td>1/7/2025</td><td>60%</td></tr> <tr> <td>4</td><td>Field test on evaluation of the biofertilizer and nutrient absorption on various crops</td><td>1/8/2025</td><td>80%</td></tr> <tr> <td>5</td><td>Statistical analysis, report writing and submission</td><td>1/12/2025</td><td>100%</td></tr> </tbody> </table>	No	Project activity description	Date	Completion project progress	1	Determination of <i>Rhizobium</i> in chicken feather vermicompost	1/1/2025	20%	2	Assessment of physiochemical parameters	1/5/2025	40%	3	Analysis of organic acid	1/7/2025	60%	4	Field test on evaluation of the biofertilizer and nutrient absorption on various crops	1/8/2025	80%	5	Statistical analysis, report writing and submission	1/12/2025	100%
No	Project activity description	Date	Completion project progress																						
1	Determination of <i>Rhizobium</i> in chicken feather vermicompost	1/1/2025	20%																						
2	Assessment of physiochemical parameters	1/5/2025	40%																						
3	Analysis of organic acid	1/7/2025	60%																						
4	Field test on evaluation of the biofertilizer and nutrient absorption on various crops	1/8/2025	80%																						
5	Statistical analysis, report writing and submission	1/12/2025	100%																						
D	BUDGET /BELANJAWAN																								
	Please indicate your estimated budget for this research and details of expenditure according to the guidelines attached. <i>Sila nyatakan anggaran bajet bagi cadangan penyelidikan ini dan berikan butir – butir perbelanjaan lengkap dengan berpandukan kepada garis panduan yang dilampirkan.</i> <table border="1"> <thead> <tr> <th rowspan="2">Budget details <i>Butiran belanjawan</i></th><th>Amount requested by applicant <i>Jumlah yang dipohon oleh pemohon</i></th></tr> <tr> <th>Year 1 Tahun 1 (RM)</th></tr> </thead> <tbody> <tr> <td> D(i) Vote 21000 - Travelling and Transportation/ Perjalanan dan Pengangkutan Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i> </td><td>RM 500</td></tr> </tbody> </table>	Budget details <i>Butiran belanjawan</i>	Amount requested by applicant <i>Jumlah yang dipohon oleh pemohon</i>	Year 1 Tahun 1 (RM)	D(i) Vote 21000 - Travelling and Transportation/ Perjalanan dan Pengangkutan Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>	RM 500																			
Budget details <i>Butiran belanjawan</i>	Amount requested by applicant <i>Jumlah yang dipohon oleh pemohon</i>																								
	Year 1 Tahun 1 (RM)																								
D(i) Vote 21000 - Travelling and Transportation/ Perjalanan dan Pengangkutan Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>	RM 500																								

D(ii)	Vote 24000 - Rental <i>Vot 24000 - Sewaan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>	
D(iii)	Vote 27000 - Research Materials & Supplies <i>Vot 27000 - Bekalan dan Bahan Penyelidikan</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>	RM 4000
D(iv)	Vote 28000 - Maintenance and Minor Repair Services <i>Bvot 28000 - Baik pulih kecil dan ubahsuai</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>	
D(v)	Vote 29000 - Professional Services <i>Vot 29000 - Perkhidmatan Ikhtisas</i> Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>	RM500
D(vi)	Vote 35000 - Accessories and Equipment <i>Vot 35000 - Aksesori dan Peralatan</i>	

	Please specify <i>Sila nyatakan secara lengkap dengan pecahannya sekali.</i>	
TOTAL AMOUNT <i>JUMLAH BESAR</i>		RM5000
E	Declaration by applicant / Akuan Pemohon (Please tick (✓)): / (Sila tanda (✓)):	

I hereby declare that:

Saya dengan ini mengaku bahawa:



All information stated here are accurate, and PJI has right to reject or to cancel the offer without prior notice if there is any inaccurate information given.

Semua maklumat yang diisi adalah benar, PJIM&A berhak menolak permohonan atau membatalkan tawaran pada bila-bila masa sekiranya keterangan yang dikemukakan adalah tidak benar.



Application of this research is presented for the Geran Semarak Penyelidikan

Permohonan penyelidikan ini dikemukakan untuk Geran Semarak Penyelidikan.



Application of this research is subject to Ethical Committee approval (if applicable).

Permohonan penyelidikan ini dimajukan ke Jawatankuasa Etika (jika berkenaan).

Date : 27/11/2024

Tarikh :

Applicant's Signature :

Tandatangan Pemohon : _____



Note: APPLICATIONS SUBMITTED WILL BE TREATED IN FULL CONFIDENCE. THE DECISION OF THE INTERNAL RESEARCH ACCULTURATION MAIN COMMITTEE UiTM CAWANGAN PERLIS IS FINAL.
Semua permohonan dianggap sulit. Keputusan Jawatankuasa Induk Geran Penyelidikan Pembudayaan Dalam UiTM Cawangan Perlis adalah MUKTAMAD.