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No. Rujukan	

PEJABAT TIMBALAN NAIB CANSELOR
(PENYELIDIKAN DAN INOVASI)

KERTAS KONSEP

LRGS

Disediakan untuk/*Prepared for*:
Jabatan Pengajian Tinggi, Kementerian Pengajian Tinggi, Malaysia
Department of Higher Education, Ministry of Higher Education, Malaysia

LRGS CONCEPT

PUSAT PENGURUSAN PENYELIDIKAN
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SEMUA MAKLUMAT YANG DIKEMUKAKAN DI DALAM PERMOHONAN INI DIANGGAP SULIT

TARIKH PERMOHONAN: __/__/____

MAKLUMAT PENYELIDIKAN / KAJIAN

BAHAGIAN 1 : MAKLUMAT PENYELIDIK

1.1 Ketua Program

Nama:	PROF DR ROBIAH YUNUS
Jawatan:	PROFESSOR
Nombor Kad Pengenalan :	
Alamat :	INSTITUT TEKNOLOGI MAJU UNIVERSITI PUTRA MALAYSIA 43400 UPM, SERDANG
Telefon Bimbit :	

1.2 Alamat Kumpulan

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A. PROGRAMME/PROJECT OVERVIEW

1.	Programme Title	**ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF PALM OIL MILLING INDUSTRY**
2.	Project titles under the programme	Proj. 1: Studies on the use of advanced manufacturing technology in improving oil extraction rate (OER) and reducing oil losses in palm oil mill Proj. 2: Studies on novel and practical automated monitoring and removal technology of free fatty acid (FFA) in palm oil condensate and crude palm oil Proj. 3: Studies on formulation of locally effective microorganisms (EM) from oil palm wastes to enhance the degradation of empty fruit bunches (EFB) during composting process Proj. 4: Development of green technology to recover oil and kernel losses from palm press cakes Proj. 5: Development of sensor technology for fruit grading at the palm oil mills Proj. 6: Development of waste water processing technology towards zero discharge Proj. 7: Studies on economic and financial feasibility of new technologies of the Malaysian palm oil milling industry
3.	Duration of the programme	5 years (2012-2016)
4.	Total budget requested	RM 14.2 million
5.	Executing IPTA/IPTS	Universiti Putra Malaysia (UPM)
6.	Collaborating IPTA/IPTS (minimum 3 including executing IPTA/IPTS)	1. Universiti Teknologi Mara (UiTM) 2. Universiti Teknologi Malaysia (UTM) 3. Universiti Kebangsaan Malaysia (UKM) 4. Universiti Sains Islam Malaysia (USIM) 5. Universiti Pertahanan Malaysia (UPNM) 6. Universiti Kuala Lumpur (UniKL)
7.	Programme Leader: affiliation (expertise)	Prof Dr Robiah Yunus , UPM Chemical Engineering: Product and Technology Development
8.	Project Leaders and Members: affiliation (expertise)	Project Leaders: Proj. 1: Prof. Dr. Robiah Yunus (UPM) – Chemical Engineering Members: Assoc Prof Dr Abdul Azis Ariffin (UPM) Dr Zurina Zainal Abidin (UPM) Dr Chong Gun Hean (UPM) Dr. Mohd Halim Shah Ismail (UPM) Assoc Prof Mustapha Kamal Abdul aziz(UTM) Dr. Anhar Suki (Asuki Sdn Bhd) Dr Shafiie (UPM) Dr. Dayang Radhiah Awang Biak (UPM)
		Proj. 2: Assoc. Prof. Dr. Nor Azah Yusof (UPM) - Leader Members: Dr. Nurul Amziah Md Yunus (UPM) Assoc. Prof. Dr. Mohd Nizar Hamidon (UPM) Dr. Shahrul Ainliah Alang Ahmad (UPM) Dr. Wan Zuha Wan Hassan (UPM) Prof. Dato' Dr. Wan Zin Wan Yunus(UPNM) Dr. Zurina Zainal Abidin (UPM)

		Prof. Dr. Musa Ahmad (USIM)
		Proj. 3; Dr. Alawi Sulaiman (UiTM)- Leader Assoc. Prof. Dr. Toshinari Maeda (Kyushu Inst. Tech, Japan) Dr. Azhari Samsu Baharuddin (UPM) Asst. Prof. Dr. Meisam Tabatabei (ABRI, Iran) Prof. Dr. Ku Halim Ku Hamid (UiTM) Assoc. Prof. Dr. UmiKalsom Md. Shah (UPM) Assoc. Prof. Dr. Ayub Md. Som (UiTM) Prof. Dr. Mohamed Hanafi Musa (UPM) Dr-Ing. Mohd Noriznan Mokhtar (UPM) Mr. Zainuri Busu (FELDA Palm Industries S/B) Dr. Mohd Nazli Naim (UPM)
		Proj 4: Assoc Prof Mustapha Kamal Abdul Aziz (UTM) Assoc Prof Dr Norazian Morad (UTM) Dr Mohd Azizi Mohd Yunus (UTM) Dr. Mohd Halim Shah Ismail (UPM) Dr Mohamad Amran Mohd Salleh (UPM) Dr Rosnah Shamsudin (UPM) - Leader Dr Azhari Shamsu Baharudin (UPM) Prof Dr Wan Ramli Wan Daud (UKM) En Mohd Rosdi bin Ngah (FELDA)
		Proj.5: Dr. Zulkifly Abbas, UPM (Sensor Materials/Technolgy) Members: Prof Dr Azmi Zakaria (UPM) Assoc Prof. Dr. Abdul Rashid Mohamed Shariff (UPM) Professor Reza Ehsani - University of Florida Dr.You Kok Yeow (UTM) Mr.Cheah See Siang - Sime Darby Dr Aimrun Wayayok - (UPM) En. Hishamuddin Jamaluddin - Uni KL Assoc Prof Dr Mansor Talib (UPM) Assoc Prof Dr Nizar hamidon (UPM)
		Proj 6: Dr Mohamad Amran Mohd Salleh (UPM) Prof. Dr. Azni Idris (UPM) - leader Dr Alawi Sulaiman (UiTM) Prof Dr Mohd Fauzi Zakaria (UPM) En Mazlan Idrus(LUAS) Prof Dr Zulkarnain Zainal (UPM) Dr. Intan Salwani Ahamad (UPM) Assoc Prof Dr Halim Abdullah (UPM) Prof Dr John Ufanato (Univ of Ghana)
		Proj 7: Prof. Dr. Awang Noor Abd. Ghani (UPM) – Leader Prof. Dr. Nik Hashim Mustapha (UMT) Prof. Dr. Mohd. Shahwahid Hj. Othman (UPM) Prof. Dr. Noor Ghani (UKM) Dr. Khamuruddin Mohd Noor (UPM) Dr. Alias Radam (UPM)

EXECUTIVE SUMMARY

Malaysia's palm oil industry is the fourth largest contributor to the national economy and currently contributes RM53 billion in Gross National Income (GNI) in 2010. Productivity gains in palm oil industry have a significant impact on the GNI. The oil extraction rate (OER) is the most important parameter that is directly related to the productivity of oil palm mills. The national average of OER since 1980 has been fluctuating from a low of 18.5% to 20% in 2011. The improvement in OER by 2% can generate additional RM18 billion in GNI. One of the efforts to help improve the national OER is to improve the existing palm oil milling technology, of which has remained unchanged since 1960s. OER is mostly related to inefficient milling technology and poor oil/water separation that contribute to oil losses in the press cakes and waste water. Oil losses on FFB at the mills are generally very high at 1.8% (w/w). This translates into about 40 tons of oil losses/day per mill. Physico-chemical properties of fruits and oil will undoubtedly play key roles in the existing milling technologies for improving OER. However, the level of understanding of the fundamental issues related to these technologies is limited. Thus, the main objective of the program is to enhance the productivity and sustainability of the Malaysian palm oil milling industry by improving the existing milling technologies and increasing biomass utilization.The program covers all major aspects of palm oil mill technology from FFB grading, sterilization, stripping, digestion, pressing, clarification, purification, and drying. Besides, wastewater treatment and EFB composting will also be studied for opportunity to develop a new technology towards zero discharge. The target is to improve the OER to at least 25%. Finally, the economic and financial feasibility of the new technologies in Malaysian palm oil milling industry will also be evaluated.

1. GENERAL BACKGROUND AND RATIONALE OF LRGS CONCEPT PAPER

Palm oil industry is among the 12 National Key Economic Areas (NKEAs) areas which are at the core of the Economics Transformation Program (ETP). Malaysia's palm oil industry is the fourth largest contributor to the national economy and currently accounts for RM53 billion in Gross National Income (GNI). GNI from the saving in reducing palm oil losses alone is estimated at RM13.7 billion which contributes to 10,000 jobs involving more than RM3.0 billion investments. Crude palm oil output in the world's second largest producer could rise 2.2 per cent to 18.7 million tonnes from a projected 18.3 million tonnes in 2011 due to aggressive replanting. The oil palm industry is forecast to grow further at 7.1 per cent over the next five years, driven by further gains in average productivity. Malaysia's oil palm acreage will rise 4.1 per cent to 5.1 million hectares this year from 4.9 million hectares in 2010. Under the ETP, the palm oil industry is targeted to achieve a GNI of RM178bil in 2020.

Crude palm oil is extracted from the fresh fruit bunches (FFB) at the palm oil mills. A palm oil mill not only produces crude palm oil and kernels, as primary products but also biomass as secondary product. The capacity of mills varies between 60-100 tons FFB/h. An average size FFB weighs about 20-30 kg and contains about 1500-2000 fruits. A typical mill has many operation units comprises of sterilization, stripping, digestion and pressing, clarification, purification, drying and storage. In addition, for kernel production line, there are steps such as nut/fibre separation, nut conditioning and cracking, cracked mixture separation, and kernel drying, storage. The FFBs are harvested according to harvesting cycles, and delivered to the mills on the same day. The quality of crude palm oil depends on the manner the FFB are handled during harvesting and the effectiveness of milling process. Palm oil mills also use a large quantity of water in their pressing process and kernel separation. Thus, this project addresses the issues of the quality and quantity of the oil palm that can potentially be extracted from the fresh fruit bunches (FFB). This determination is made at the mill before extraction of the palm oil. This extraction is however dependent on the fruits that are harvested in the field. This project therefore targets the fruit grading, in order to identify and process the best quality FFB so that optimum oil extraction rate (OER) of good quality oil can be obtained at the mill. For the extraction process at the mill, a new and novel method to increase OER of good quality palm oil will be researched into. This project will also introduce new and advanced devices for identifying and grading ripeness of the FFB. The output of this research is essential as in addressing a listed area of the National Transformation Plan.

2. GENERAL OBJECTIVE

To enhance the productivity and sustainability of the Malaysian palm oil milling industry by improving the existing milling technologies and increasing biomass utilization

Specific Objectives

i. To elucidate the fundamentals issues in the existing milling technology for possibility of improving oil extraction rate (OER) by reducing oil losses in palm oil mill
ii. To study novel materials and technologies in monitoring and reduction of FFA in palm oil condensate
iii. To examine the impacts of locally produced effective microbes (EM) on the properties of EFB composts to improve biomass utilization.
iv. To elucidate the physico-chemical properties of press cake for opportunity to improve pressing technology, and enable the use of green technology (solvent-free process) to recover oil and kernel losses in the press cake

v. To improve fruit grading schemes by developing sensors based on microwave and dielectric properties for quick and accurate determination of the quality of FFB at palm oil mills
vi. To identify and characterize the wastewater from palm oil mill for opportunity to develop new treatment technology towards zero water discharge
vii. To determine the economic and financial feasibility of the new technologies in Malaysian palm oil milling industry

3. DESCRIPTION OF RESEARCH PROGRAMMES

i. Studies on the use of advanced manufacturing technology in improving oil extraction rate (OER) and reducing oil losses in palm oil mill

- Analyzing the chemistry of fruit-stalk carbohydrate bond and factors that affect the hydrolysis of the binding carbohydrates during sterilization of FFB.
- Understanding the underlying mechanisms of oil extraction based on conventional mechanical pressing
- Improving the processing conditions of existing pressing process to maximize oil recovery
- Developing an ultrasound assisted digestion process to enhance oil yield in pressing steps
- Reducing oil losses by improving the centrifugal separation with the assistance of ultrasonication and use of biocoagulants in improving oil and water separation.

Research team

Prof. Dr. Robiah Yunus (UPM) - Leader	Assoc Prof Dr Abdul Azis Ariffin (UPM)
Dr Zurina Zainal Abidin (UPM)	Dr Chong Gun Hean (UPM)
Dr. Mohd Halim Shah Ismail (UPM)	Dr. Anhar Suki (Asuki Sdn Bhd)
Prof Dato' Rosli Mohd Yunus (UMP)	Dr. Dayang Radhiah Awang Biak (UPM)
Assoc Prof Mustapha Kamal Abdul Aziz (UTM)	Dr Mohd Halim Shah Ismail (UPM)

ii. Studies on novel and practical automated monitoring and removal technology of free fatty acid (FFA) in palm oil condensate and crude palm oil

- Studying new materials (magnetic nanoparticles and silicon nanostructure) and reaction scheme (enzymatic reaction) for novel FFA detection system.
- Developing rapid and automated monitoring system for FFA in palm oil utilizing advanced materials and techniques (Microwave based technique, lab on chip based technique and enzymatic based technique).
- Synthesis and characterization of new materials (chemicals and biochemicals) for novel materials in removal of FFA in palm oil condensate.
- Studying the potential of enzymatic reaction as novel technique in removal of FFA in palm oil condensate.

Research team

Assoc. Prof. Dr. Nor Azah Yusof (UPM) - Leader	Dr. Nurul Amziah Md Yunus (UPM)
Assoc. Prof. Dr. Mohd Nizar Hamidon (UPM)	Dr. Shahrul Ainliah Alang Ahmad (UPM)
Dr. Wan Zuha Wan Hassan (UPM)	Prof. Dato' Dr. Wan Zin Wan Yunus(UPNM)
Dr. Zurina Zainal Abidin (UPM)	Prof. Dr. Musa Ahmad (USIM)

iii. Studies on formulation of locally effective microorganisms (EM) from oil palm wastes to enhance the degradation of empty fruit bunches (EFB) during composting process

- Developing the formulated effective microorganisms via aerobic microbial microbiota approach to enhance the degradation of empty fruit bunches (EFB) during composting.
- Formulating a cocktail of superior microorganisms isolated from different sources of oil palm wastes such as palm oil mill effluent (POME) as an effective microbial seeding to enhance EFB composting process.
- Evaluating the biodegradation kinetics of heterogeneous composting materials treated with formulated effective microorganisms, incorporating the effect of mass and energy transfer.
- Optimizing the composting process of formulated effective microorganisms and formulated POME anaerobic sludge using advanced composting system, incorporating the effect of physicochemical factors.

Research team

Dr. Alawi Sulaiman (UiTM)- Leader	Assoc. Prof. Dr. Toshinari Maeda (Kyushu Inst. of Tech, Japan)
Dr. Azhari Samsu Baharuddin (UPM)	Asst. Prof. Dr. Meisam Tabatabei (ABRI, Iran)
Prof. Dr. Ku Halim Ku Hamid (UiTM)	Assoc. Prof. Dr. UmiKalsom Md. Shah (UPM)
Assoc. Prof. Dr. Ayub Md. Som (UiTM)	Dr-Ing. Mohd Noriznan Mokhtar (UPM)
Prof. Dr. Mohamed Hanafi Musa (UPM)	Dr. Mohd Nazli Naim (UPM)
Mr. Zainuri Busu (FELDA Palm Industries S/B)	

v. Development of green technology to recover oil and kernel losses from palm press cakes

- Determining the physico-chemical composition of palm press cake to analyse its interphase behaviour
- Studying the mass and heat transfer mechanisms involved in solvent free extraction of oil
- Evaluating the interactions between materials properties and fatty acid content in high temperature environment to reduce corrosion activities in extraction equipment.
- Evaluating the kinetics of oil extraction
- Investigating the safety, health, environment and economics of the process as opposed to conventional process
- Developing the effective method for dry separation of broken palm kernels from palm kernels
- Understanding the effects of different air velocity to the separation of loose fibres from palm kernel

Research team

Assoc Prof Mustapha Kamal Abdul Aziz (UTM)- leader	Dr. Mohamad Amran Mohd Salleh (UPM)
Assoc Prof Dr Norazian Morad (UTM)	Dr Rosnah Shamsudin (UPM) -
Dr Mohd Azizi Mohd Yunus (UTM)	Prof Dr Wan Ramli Wan Daud (UKM)
Dr Mohd Halim Shah Ismail (UPM)	En Mohd Rosdi bin Ngah (FELDA)
Prof Dr Robiah Yunus (UPM)	Dr Azhari Shamsu Baharudin (UPM)

iv. Development of sensor technology for fruit grading

- Establishing the relationship between microwave reflection, moisture content and oil content of fruits at various stages of bunch ripeness
- Developing a microwave sensor for quick and accurate determination of the quality oil palm fruits by
- Establishing the relationship between the dielectric properties of oil palm mesocarp and palm oil with frequency at various temperatures
- Developing a microcontroller based microwave sensor for fruit grading.
- Developing a remote sensor technology to identify and harvest the best quality FFB at the field.

Research team

Dr Zulkifly Abbas (UPM) – Leader	Prof Dr Azmi Zakaria (UPM)
Assoc Prof. Dr. Abdul Rashid Mohamed Shariff (UPM)	Professor Reza Ehsani - University of Florida
Dr.You Kok Yeow (UTM)	Mr.Cheah See Siang - Sime Darby
En Ismayadi Ismail - (UPM)	En. Hishamuddin Jamaluddin - Uni KL
Assoc Prof Dr Mansor Talib (UPM)	Assoc Prof Dr Nizar Hamidon (UPM)

vi. Development of waste water processing technology towards zero discharge

- Identifying potential and effective biopolymer that can treat palm oil mill waste water treatment to a very high water quality standard (boiler water).
- Understanding the characteristics of active agents and its mechanism in the selected natural coagulant.
- Studying the feasibility of selected natural coagulants for an actual implementation at selected palm oil mill waste water treatment plant.
- Evaluating the potential of selected natural coagulants using newly specially fabricated pilot scale waste water treatment plant at selected palm oil mill waste water treatment plant.

Research team

Dr. Mohamad Amran Mohd Salleh (UPM) - leader	Prof Dr Azni Idris (UPM)
Assoc. Prof Dr Mohd Fauzi Zakaria (UPM)	En Mazlan Idrus (LUAS)
Prof Dr Zulkarnain Zainal (UPM)	Dr. Intan Salwani Ahamad (UPM)
Assoc Prof Dr Halim Abdullah (UPM)	Prof Dr John Ufanato (Univ of Ghana)
Dr Alawi Sulaiman (UiTM)	Dr Zurina Zainal Abidin

vii. Economic and financial feasibility of new technologies of the Malaysian palm oil milling industry

- Identification of costs and benefits including the environmental effects of new technology developed for the Malaysian palm oil milling industry and under the conventional technology
- Estimating the costs and benefits of the new technology and conventional technology based on prevailing market prices in order to calculate the incremental benefits and costs
- Determining the economic and feasibility of new technology using investment criteria in terms of net present value (NPV), benefit cost ratio (B/C ratio) and internal rate of return (IRR)

- Conducting sensitivity analysis of the effects of market parameters such as price, cost, interest rate on investment criteria
- Evaluating distribution impact analysis for different groups (consumer, government, and industry) resulting from an introduction of new technology for the Malaysian palm oil industry

Research team

Prof. Dr. Awang Noor Abd. Ghani (UPM) – Leader	Prof. Dr. Nik Hashim Mustafa (UMT)
Prof. Dr. Mohd. Shahwahid Hj. Othman (UPM)	Prof. Dr. Noor Ghani (UKM)
Dr. Khamuruddin Mohd Noor (UPM)	Dr. Alias Radam (UPM)

4. RESEARCH METHODS

i. Studies on the use of advanced manufacturing technology in improving oil extraction rate (OER) and reducing oil losses in palm oil mill

This project will explore potential ways to improve the oil extraction and yield by using various operational strategies and also with the assistance of ultrasound at digestion, pressing and also oil/water separation process. Firstly, the fundamental mechanisms of oil extraction using mechanical press will be studied. The project next focuses on ways to improve oil yield at digestion process by using ultrasound and also reduce oil losses during centrifugal separation. Studies will also be conducted to see the potential of using solid liquid extraction with or without ultrasound on the palm press fruit bunches (product after pressing) to recover more oil. Project will also look into the use of biocoagulants to assist oil/water separation to minimize oil losses.

ii. Studies on novel and practical automated monitoring and removal technology of free fatty acid (FFA) in palm oil condensate and crude palm oil

This project will be divided in to two sections, which are on monitoring and removal technology of FFA. For monitoring of FFA, study on synthesis and characterization of new materials (magnetic nanoparticle and silicon nanostructure) to be incorporated in the FFA detection system will be carried out. Studies also will be carried out on optimization of the detection system to ensure rapid and automated monitoring of FFA can be done. New technique which is based on enzymatic reaction will also be studied and optimized. As for the removal of FFA from the palm oil condensate, new chemical or biochemical for example polymer will be synthesized and characterized for effective, selective and rapid removal of FFA. Another novel method that will be explored is enzymatic reaction as potential novel technique in removal of FFA in palm oil condensate.

iii. Studies on the formulation of locally effective microorganisms (EM) from oil palm wastes to enhance the degradation of empty fruit bunches (EFB) during composting process

This study consists of both fundamental scientific and engineering approaches. The development of effective microorganisms (EM) will be carried out by investigating the superior local strains from oil palm wastes that are capable to enhance the degradation of EFB lignocellulosic structure during composting process. The formulation of EM will be based on the microbial succession from different oil palm wastes and information on the microbiota analysis such as metagenomic library approach. The isolated EM will be further evaluated to determine their capability in accelerating EFB composting process. In addition, engineering fundamental studies such as biochemical reactions kinetics that are involved in the material degradation and microbial growth during EFB composting will be conducted, incorporating mass and energy transfer. The study on the kinetic modeling will help researchers to understand the process behavior and to improve the composting process. The performance of the EFB composting process will be evaluated under windrow or closed composting system.

iv. Development of green technology to recover oil and kernel losses from palm press cakes

The press cake will be analyzed to determine the water, solid and oil content and the components of the oil. The process will be designed based on the analysis and mass and energy balance. The new technique is based on utilizing hot inert gas to extract the oil from press cake. It also will allow for energy recovery and recycle during the extraction. The oil extraction, oil recovery, separation efficiency, energy for heating, energy recycles, heat loss, and inert gas loss will be studied. At the end of the research a new safe, environmental friendly and economically viable technique to extract oil from press cake in oil palm industry will be achieved. For kernel recovery, the dry separation method will be developed to replace the current wet method which uses water (wet separation) to separate the palm kernel from broken kernel and press fiber. The existing wet method incurs higher operating costs and results in additional waste water from palm oil mill. In this study, the physico-chemical composition of palm kernel cake such as proximate analysis; total oil content, pH, water activity, specific heat, thermal conductivity, density, will be determined using AOAC standard. The parameters will be used in the conceptual design of the dry separation scheme to reduce kernel losses and percentage of broken kernels**.**

v. Development of sensor technology for fruit grading at the field and at palm oil mills

This project addresses the issues of quality and quantity of the oil palm that can potentially be extracted from the fresh fruit bunches (FFB). It shall focus on the determination of the sensor characteristics that will provide the highest sensitivity of the sensor with respect to the quality of fruit. Theoretical electromagnetic analysis shall be done to predict the relationship between oil content and reflection coefficient of the microwave sensor. Measurements shall be carried out to establish the actual relationship between oil content, water content and microwave reflection coefficient. The amount of oil content shall be predicted directly from microwave reflection measurement. The microwave measurement shall consist of a microcontroller, microwave sensors, coupler and detectors. The accuracy of the technique shall be calculated by comparing the predicted oil content with the true oil content using standard method.

vi. Development of waste water processing technology towards zero discharge water

This project will focus on the development of natural biopolymers in the treatment of waste water of palm oil mill towards zero discharges. A number of biopolymers from plant origin and fungi origin will be used to remove organic, suspended solids as well as the colour in POME effluent. By treating effluent to get boiler water standard will change the industrial practice towards zero discharge. Results from the coagulation study, together with biological treatment, and feasibility studies will enable us to select the best biopolymer suitable for the waste water treatment. This novel biopolymer will then be extracted, purified and concentrated for the purpose of handling, storage and to increase shelf life. A pilot study will be done on a selected palm oil mill waste water treatment plant to test the capability of the pilot plant and biopolymer in handling the waste water, with the target of having zero discharge.

vii. Economic and financial feasibility of new technologies in Malaysian palm oil milling industry

This project will involve the economic and financial feasibility of the new technology developed for the Malaysian palm oil milling industry using the "with" and "without project" approach based on incremental net benefit concept. The "with" project is the proposed new technology while the "without project" is the conventional technology which is being practiced at present. All the costs and benefits including environmental effects of new technology and conventional technology will be identified and estimated based on records or estimated data in this study. The financial costs and benefits as well as the environmental effects will be converted into economic costs and benefits using conversion factor developed by EPU (Economic Planning Unit). The non-market valuation technique will be employed to estimate the costs and benefits of environmental effects under the new and conventional technologies. The expected future costs and benefits will determined based on baseline data obtained in this study and previous records. The economic and feasibility of new technology will be evaluated based incremental net benefit using three investment criteria: net present value (NPV), benefit cost ratio (B/C ratio) and internal rate of return (IRR). The interest used will be 10%. Sensitivity analysis will be conducted to determine the effects of changes of market parameters such as price, cost, and interest rate on NPV and IRR. The distribution impact analysis for different groups (consumer, government, and industry) resulting from an introduction of new technology for the Malaysian palm oil industry will be computed to determine the distribution of costs and benefits to these groups. The economic impact to national income will also be analyzed.

5. TRACK RECORD OF PROJECT LEADERS

i. Publications

	h-index	citation		h-index	citation
Prof. Dr. Robiah Yunus	10	217	Dr Zulkifly Abbas	5	95
Assoc Prof Dr Nor Azah	7	142	Dr Alawi Sulaiman	3	20
Prof Dr Awang Noor Abd Ghani	2	6	Assoc Prof Mustapha Kamal Abdul Aziz		
Dr Mohd Amran Mohd Salleh	4	75			

ii. Commercialized products: 3

iii. Patent filed: 10 (3 granted)

6. EXPECTED OUTPUT / OUTCOMES

10 PhD and 10 MS graduates	100 journal publications and 2 patents
3 commercial products and 2 technology-know-how	Reduced total oil losses to below 10%
Improved OER to 25% ~ RM40 million / year	Reduced kernel losses to below 5%
Fully automated oil palm grading system	Palm oil milling process with zero discharge

Recommended by Vice Chancellor/Deputy Vice Chancellor (Research and Innovation)/Director of Research Management Center
Perakuan Naib Canselor/Timbalan Naib Canselor(P & I)/Pengarah Pusat Pengurusan Penyelidikan

Please tick (√)
Sila tandakan (√)

Recommended:
Diperakukan:

☐ ***A.*** **Highly Recommended**
Sangat Disokong

☐ **B.** **Recommended**
Disokong

☐ **C.** **Not Recommended (Please specify reason)**
Tidak Disokong (Sila Nyatakan Sebab)

Comments:
Ulasan:

Excellent program with the potential of contributing at least RM12 billion to GNI (gross national income) annually. The output of this research is essential in addressing one of the NKEA areas of the National. Transformation Plan

Name:
Nama:

***Signature:**
Tandatangan:

Date:
Tarikh:

***** ***Tandatangan*** **(Timbalan Naib Canselor (Penyelidikan dan Inovasi)**