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Editorial Board

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Editorial

About 80% of the crude palm oil (CPO) produced in Malaysia is used for edible purposes. Food safety is now the emerging issue due to health conscious among consumers. Ministry of Health (MOH) has introduced Food Safety is the Responsibility of the Industry (MeSTI) free certification scheme based on Food Hygiene Regulations 2009 requirements and urged all Malaysian palm oil mills to implement food safety assurance programs such as MeSTI, Hazard Analysis Critical Control Point (HACCP), *etc*. Food contamination is one of the major concern in all food safety assurance programs. Mineral Oil Saturated Hydrocarbons (MOSH) and Mineral Oil Aromatic Hydrocarbons (MOAH) contamination can potentially cause adverse effect on human's health. Thus, mineral oil-based lubricants need to be replaced with synthetic H1 lubricants which are designed for incidental, unintentional food contact and complied with 21 CFR 178.3570 issued by the United States Food and Drug Administration (FDA), in all palm oil processing steps.

Oil palm needs fertiliser for growth and fruit bearing. Palm oil mills put aside about 23% empty fruit bunches (EFB) and 60% palm oil mill effluent (POME) based on the fresh fruit bunches (FFB) processed. Both by products need to be duly disposed according to standard guidelines. Studies showed that EFB and POME co-composting could produce organic fertiliser which is useful as substitute for conventional chemical fertiliser in oil palm plantations. Carbon: Nitrogen (C/N) ratio and soil types are crucial parameters that may affect the performance of palm biomass composted organic fertiliser.

Palm oil consists of a wide array of triacylglycerol (TAG) that predominantly contribute to its distinct physical and chemical properties. Various fractions with improved quality and higher degree of selectivity could be produced via multiple stages fractionation. Although solvent fractionation is used in specialty fractions production required by confectionery manufacturers, dry fractionation is the most preferred process for palm oil presently due to its green technology approach where chemicals or additives are not used. Entrainment, either intra-particle or inter-particle, prevents clean separation of solid crystals from liquid, hence, reduces the separation efficiency of fractionation and complicates the filtered products enrichment. Various studies have demonstrated that a combination of dry crystallisation and membrane filter press with reduced chamber width and higher squeezing pressure is ideal to increase olein yield and minimised entrainment.

Malaysian palm oil mills is a typical Industrial Revolution 2.0 setup when labour intensive of with manually operated machineries. Recent labour shortage issue has driven the palm oil industry to strive for alternative solution and advancement. Automation would be a feasible solution and high technology advancement towards National aspiration of Industrial Revolution 4.0. Innovative automated mill algorithms with Internet of Things has been developed, consisting of few integrated operations (IO) systems to regulate the dilution water to the required density and viscosity at operating temperature while managing oil in wet basis (OIWB) in underflow to below 6.5%.

Knowledge is the essential tool for the palm oil industry to prosper in sustainable manner. Hopefully all the articles published in *Palm Oil Engineering Bulletin No. 137* would spark ideas for new inventions bringing continuous advancement to the industry.

CALL FOR ARTICLES

Researchers are cordially invited to submit articles related to the palm oil industry for publication in ***Palm Oil Engineering Bulletin***.

The topics of interest are:

1. Plant modifications or innovations that have improved the mill performance.
2. Research findings that have enhanced oil extraction rate (OER) and product quality.
3. Current issue facing by the industry and solution experience.

The published articles will be circulated throughout the industry and MPOB offices worldwide.

For enquires and submission, please email to: *milling@mpob.gov.my / rohaya@mpob.gov.my / fidos@mpob.gov.my*

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PROJECT

- *To retrofit a 38-year-old 60TPH mill constructed in Year 1979*

SCOPE OF WORK

- *FFB and SFB handling system*
- *Taner Vertical Sterilizer (VS) system*
- *Civil and structure works to house the new system*
- *SCADA for FFB handling and sterilization system*
- *Electrical works*

RESULTS

- **Increase mill capacity** by 20% without additional cost or footprint
- **Reduce manpower** at front end by 75%
- **Reduce steam consumption** by 30% and its relative condensate produced
- **Reduce sterilization cycle time** by 30%
- **Reduce operating cost** at front end by 65%

BONUS

- Completed in 8 months with no mill stoppage
- Automation enabled
- Enhanced work safety
- Industrial 4.0 ready

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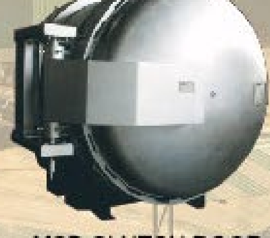

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Sustainable, Safe, Efficient and Modern Food Grade Lubricants (NSF-H1 Lubricants) Minimise Risk of Food Contamination

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INTRODUCTION

Palm oil is a vegetable oil with the highest production rate in the world. It is omnipresent in our everyday lives, from bread spreads in the morning to baby food or face cream in the evening. One aspect, which is increasingly gaining the attention of operators and end users is the potential contamination of palm oil during its extraction and manufacture.

One of the many potential source of contaminations is the lubricants used in lubricating machines during extraction and processing of palm oil. This is particularly problematic in applications where contact with the product cannot be ruled out. Even small traces of mineral oil hydrocarbons (MOH) in food, so-called Mineral Oil Saturated Hydrocarbons (MOSH)/ Mineral Oil Aromatic Hydrocarbons (MOAH) contamination, can potentially cause an adverse effect on human health. MOSH and MOAH not only accumulate in human tissues, they may also cause adverse effect in the liver. Moreover, their carcinogenic effect cannot be ruled out. The European Union (EU) therefore called for stronger control on the monitoring of mineral oil hydrocarbons in food, and in materials or articles intended to come into contact with food.

Such demand caused a considerable amount of uncertainty among food manufacturers, as reports about MOSH/ MOAH findings can have negative effect, such as expensive call-backs, as well as damage to the company's reputation. Leading food manufacturers are thus increasingly pushing for the replacement of mineral oil-based products with synthetic H1 lubricants in the machines and plants in all production steps involved in palm oil processing.

HIGH-PERFORMANCE LUBRICANTS FOR HIGHEST HYGIENIC REQUIREMENTS

One way in which traces of mineral oils such as the chemical compounds MOSH and MOAH can enter the food chain is the production process and the process aids used, including lubricants selected for the production of food and food packaging*.

Lubricants for incidental food contact can be based on non-alkane oils, such as silicone oil or perfluoropolyether (PFPE), or synthetic or non-synthetic hydrocarbons. Non-synthetic white oils used for NSF-H1 products should be highly purified and thus, virtually free of aromatic compounds.

*Note: For an overview, please see: 'Scientific opinion on mineral oil hydrocarbons in food EFSA panel on Contaminants in the Food Chain (CONTAM)'. Retrieved from: https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2012.2704.

REGULATIONS AND LIMIT VALUES

Complied with 21 CFR 178.3570 issued by the United States Food and Drug Administration (FDA), H1 lubricants are designed for incidental, unintentional food contact. The amount used must be the minimum required to accomplish the desired technical effect and no non-H1 product should be used in and around the food-processing area. Correct use of H1 lubricants normally means that there is no contact with food at all. In case of unavoidable food contact, the amount of lubricant in food must not exceed 1 ppm for silicone oils and 10 ppm for all other base oils. Due to the complexity of MOH determination in food, there is currently no standardised analytics and no legal limits for MOH in food in Europe. The German Bundesministerium für Ern ührung und Landwirtschaft (BMEL) has been working on statutory limits for migration through packaging in which maximum 2 mg MOSH kg^{-1} food and 0.5 mg MOAH kg^{-1} food are being discussed.

Very small quantities of modern, innovative high-performance lubricants are sufficient to achieve the desired lubricating effect thus reduces the risk of contamination. Even with the highest hygienic standards, a contamination or cross-contamination with these substances during production, transport and stock, due to leakages, vapours, evaporation loss or ventilation, cannot be ruled out.

USING SYNTHETIC BASED FOOD GRADE H1 LUBRICANTS PAYS OFF

There is a persistent prejudice that food grade lubricants are expensive and lagged behind mineral oil-based products in terms of performance. However, using them could pay off in many ways: Today's modern specialty lubricants are developed for specific applications and are therefore characterised by their enormous efficiency. With these specialty products, energy efficiency can be significantly increased, while maintenance and relubrication frequency, as well as downtimes of the machines are reduced.

ACHIEVING HIGHEST PERFORMANCE WITH SYNTHETIC GEAR OILS

In addition to wide service temperature range, synthetic gear oils offer many advantages. Among the most important benefits are their oil change intervals, which are three to five times longer compared to mineral oils. *Figure 1* shows the service life of gear oils with different types of base oils according to the oil sump temperature. Synthetic gear oils also offer higher wear protection and better cold start with the same nominal viscosity (ISO VG).

In addition, they may not require oil coolers due to reduced temperatures. The prolonged service life of synthetic lubricants and the consequent longer oil change intervals can reduce equipment downtime and save resources.

SUPERIOR TEMPERATURE PERFORMANCE, IMPROVED EFFICIENCY IN GEARBOXES

In the worm gear test rig, different base oils were tested at 350 min^{-1} input speed and 300 Nm output torque for 300 hr. The results confirmed a significant improvement in efficiency and reduction of wear when food grade synthetic oils of high quality were used (*Figure 2*).

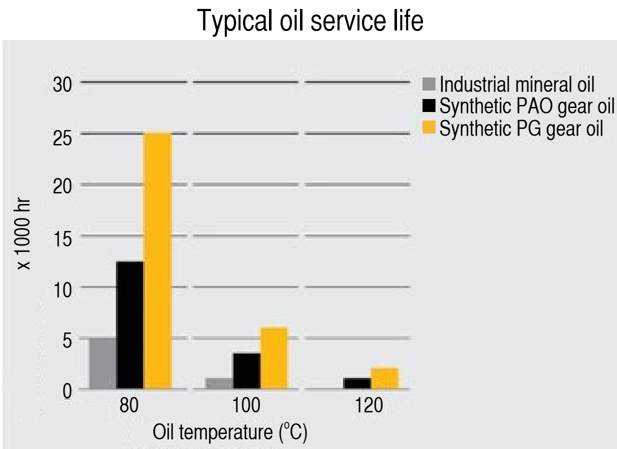

Figure 1. Typical oil service life.

Changing over from mineral to synthetic based gear oils in worm gears also offered very good potential for temperature reduction in the gearboxes. The same is true for spur gears, the most-used type of gearbox in the food industry. Thermal pictures showed considerable lower oil temperatures in this kind of gearbox when specialty synthetic gear oils were used indicated a significantly higher efficiency than standard gear oil.

Synthetic polyalphaolefin, ester or polyglycol based gear oils showed considerably lower gear friction coefficient than mineral oils due to their particular molecular structures. The frictions generated in gears with synthetic oils can be 30% lower or more, than with industrial EP mineral gear

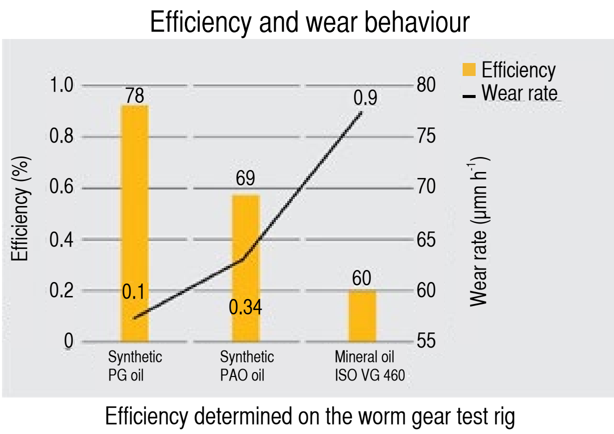

Figure 2. Efficiency and wear behaviour.

oil. Even in spur gears, an oil temperature reduction from 85°C (with mineral oil) to 80°C (with high quality synthetic gear oils based on PAO) can be achieved. This resulted in reduction of energy consumption, longer lifetime of the gearbox and less maintenance (*Figure 3*).

suitable lubricant from a brochure for these complex applications. Only with competent advice a lubricant concept that takes all the food safety and hygiene aspects into account and helps companies achieve their sustainability goals can be developed.

The synthetic gear oils offer significantly higher efficiency than a standard gear oil based on mineral oil, resulting in a lower oil temperature even in spur gears, as shown in the thermal pictures.

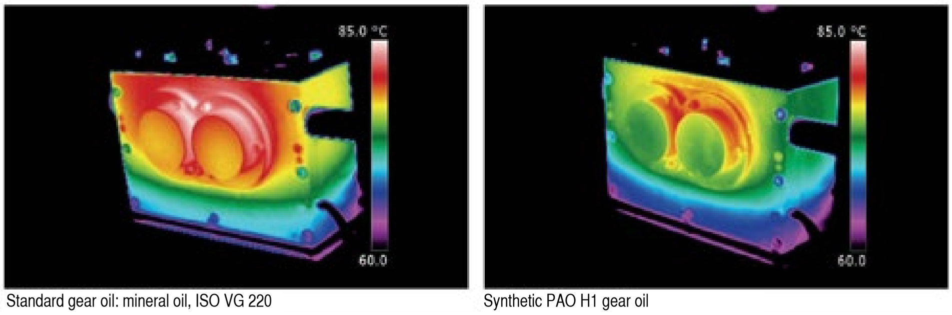

Figure 3. Synthetic gear oils offers higher efficiency than a standard gear oil.

Due to the lower friction coefficients of synthetic gear oils, gearing losses were considerably reduced, hence gear efficiency is increased. Particularly in gearboxes with high proportion of sliding friction, *e.g.* worm or hypoid gears, a changeover from mineral to synthetic gear oils can lead to more than 20% increases in efficiency. Reduced friction, of course, also led to lower energy cost.

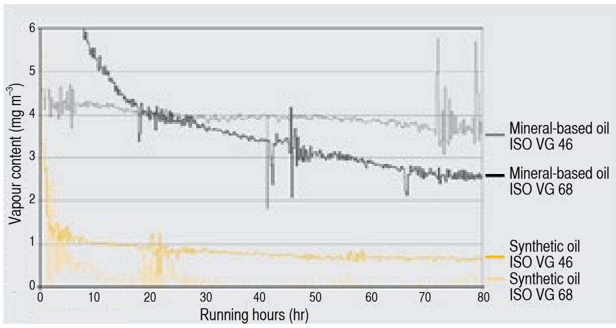

Figure 4. Oil content in the compressed air at 100°C.

REDUCTION IN OIL CONSUMPTION DUE TO LOW OIL CONTENT IN COMPRESSED AIR

Figure 4 shows the oil content (measured in mg m^{-3}) in the compressed air when different types of oils were used in a system operated at 100°C. In general, compressor oils with higher base oil viscosity will offer better stability against evaporation. Food grade synthetic compressor oils led to lower oil vapour content in the compressed air when compared to mineral based products. This positive impact contributed to less oil consumption, better efficiency and longer lifetime. As a result, compressors operating with synthetic oil required less maintenance due to reduced residual oil content in the compressed air, thus increases filter lifetime. This enabled savings in terms of maintenance costs.

A RELIABLE, COMPETENT PARTNER IS KEY

Today, there are quite a number of lubricant manufacturers who have high-quality food grade lubricants in their portfolios. However, it is not enough to simply select a

Last but not least, on top of reducing the risk of mineral oil contamination at production area, a tribology expert can also help identify points in production with is potential for energy efficiency increases and improving production efficiency as value added services.

With this in mind, Klüber Lubrication has developed a comprehensive range of services (*Figure 5*) that enabled existing optimisation potentials to be identified and systematically implemented. In close cooperation with the operator, tribology experts at Klüber Lubrication work on systematic optimisation of lubrication processes of machinery and equipment. All services and expert consultations are precisely tailored to the requirements and tasks of the respective customer and go well beyond the selection of lubricants. The aim of all measures is optimised use of the machinery. Special energy saving programs helped to systematically identify existing potential in increasing company's energy efficiency and to implement all modifications necessary to reach this goal. This way, we can save energy cost, with relatively little effort when the right type of lubricant is used.

Klüber Lubrication's services help to optimise maintenance in a plant and ensure that the machines run efficiently and reliably, for a long time. This includes complete preparation of a professional operational lubrication plan for all lubrication points in the plant with the aim of optimising the lubrication processes and reducing the risk of contamination.

This also includes the prevention of over- or under-lubrication through correctly dosed lubricant, determining precise re-lubrication interval and quantity needed, as well as lubricant and component analysis services. The consultation is preceded by a comprehensive examination of all relevant factors, and there is a clear report at the end that gives precise overview of the relevant parameters such as cost savings, CO_2 balance and energy consumption.

Figure 5. Klüber Lubrication's services.

INDUSTRY 4.0 - THE *EFFICIENCYMANAGER*

To control all these activities effectively, a systematic and reliable program to manage all these tasks is required. For example, Klüber Lubrication has developed the *EfficiencyManager*, a mobile software solution that enabled operators to map the entire infrastructure, including all maintenance elements to be coordinated, with just one tool (*Figure 6*). This includes, in particular, information on the required relubrication and maintenance intervals. With this software, which is also available as an app, it's maintenance and repair work on site can be carried out and documented. This gives operators an overview of the status of all maintenance tasks and a transparent overview of all relevant components and equipment, as well as existing optimisation potential.

CONCLUSION

While having major impact on total cost of ownership, the cost for necessary lubricants is only about one percent of the operating budget. The savings are reflected in the three largest items of operating costs: maintenance and repair, components (spare parts stocks), and energy consumption. With a precisely tailored specialty

Figure 6. The EfficiencyManager App allows you to access your data anywhere, anytime, including unplanned occurrences on site.

lubricant, maintenance intervals is extended as the machines no longer have to be relubricated as often. We save spare parts costs as the individual components last longer. Last but not least, the use of high-quality synthetic food grade lubricants increased the efficiency of the systems and thus reduced overall energy consumption and enabled full compliance to maximise food safety against contamination from MOSH and MOAH.

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Field Trial Evaluation of Specially Formulated Palm Biomass Compost Fertilisers

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ABSTRACT

Empty fruit bunch (EFB) and palm oil mill effluent (POME) co-composting could produce organic fertiliser which is good for conventional straight chemical fertiliser substitution in oil palm plantations. Field trial performance evaluation of specially formulated palm biomass compost fertilisers known as 'Living Organic Fertiliser' and 'Fortified Organic Fertiliser' in various soil types showed that organic fertiliser application had improved the fresh fruit bunch (FFB) yield significantly compared to conventional straight chemical fertiliser application, except for clay-sandy soil.

Keywords: C:N ratio, organic fertiliser, palm biomass composting.

INTRODUCTION

Empty fruit bunches (EFB) have been used for mulching in oil palm plantations to increase soil organic matter content (Hamdan *et al*., 2006). About 260 kg ha^{-1} of nutrients are lost from the field through harvesting of fresh fruit bunches (FFB), as shown in *Table 1*.

Although about 27% of nutrients lost could be restored by the EFB mulching practice, the long degradation period and expensive transportation suggests that co-composting of EFB and palm oil mill effluent (POME) would be a better way to restore nutrients to the field.

Composting is a high-temperature aerobic biological process that accelerates the organic solid waste decomposition and converts it into a stable humus-like organic material known as compost (Bertoldi *et al*., 1983).

The predominant microorganism types present during the composting process are bacteria, fungi and actinomycetes which are commonly found in the mill's surrounding environment. Studies showed that a weight ratio of one part EFB to three parts POME with an initial Carbon Nitrogen (C:N) ratio of about 25 to 40 w/w is optimal to reduce 70% of EFB volume and concentrate nutrients with a stable chemical composition after seven to 22 weeks.

TABLE 1. NUTRIENT NET LOSS DUE TO FRESH FRUIT BUNCH (FFB) HARVESTING AND EMPTY FRUIT BUNCH (EFB) MULCHING

Nutrient	Nutrient loss/ returned (kg ha^{-1})		
	Lost - FFB harvesting	Returned - EFB mulching	Net loss
Nitrogen (N)	88.2	19.6	68.6
Phosphorus (P)	13.2	1.1	12.1
Potassium (K)	111.3	42.7	68.6
Calcium (Ca)	24.3	4.5	19.8
Magnesium (Mg)	23.1	2.7	20.4
Total	260.1	70.6	189.5

C:N ratio determines compost quality. EFB is a high carbon source whereas POME is a high nitrogen source, as shown in *Table 2*. The finished compost with a C:N ratio of less than 20 can be considered to have reached maturity stage.

The objective of the study is to carry out field trial performance evaluation using specially formulated palm biomass compost fertilisers known as 'Living Organic Fertiliser' and 'Fortified Organic Fertiliser' and to compare these with conventional straight chemical fertiliser.

TABLE 2. CARBON AND NITROGEN COMPOSITION OF VARIOUS PALM OIL MILL WASTES

Type of waste	Total C (%)	Total N (%)	C/N ratio [w/w]
POME	31.50	4.70	6.70
Decanter slurry	51.70	2.38	21.72
EFB	48.64	0.86	56.15
Pressed fibre (PF)	45.21	0.50	91.45
Oil palm trunk (OPT)	34.14	0.26	176.10

METHODOLOGY

A field trial was conducted at Bukit Berembun Estate in Pahang for five years starting from 2016-2020, as shown in *Figure 1*. The field trial studied the efficacy of Living Organic Fertiliser (during the first year of trial) followed by Eureka Fortified Organic Fertiliser at 5:5:10:2MgO and 12:12:17:2MgO formulations in the subsequent years, and the efficacy was compared to control plots which had been applied with straight chemical fertilisers. Different types of soil in Bukit Berembun Estate had been selected to observe the effect of the organic fertilisers, including laterite, clay and clay-sandy soil.

At the end of 2019, another field trial was conducted with an oil palm estate in Perak (Perak Motor Estate) by comparing the effects of Fortified Organic Fertiliser 5:5:10:2MgO and straight chemical fertiliser on the growth of oil palm trees at their prime ages between 10-11 years old.

Figure 1. Bukit Berembun Estate field trial.

RESULTS AND DISCUSSION

Based on *Figures 2a* and *2b*, Plot 1 and 2 (laterite soil) showed an average increase of 4.91 Mt ha^{-1} yr^{-1} in FFB yield from 2016-2017, before the field was subjected for replanting in 2018.

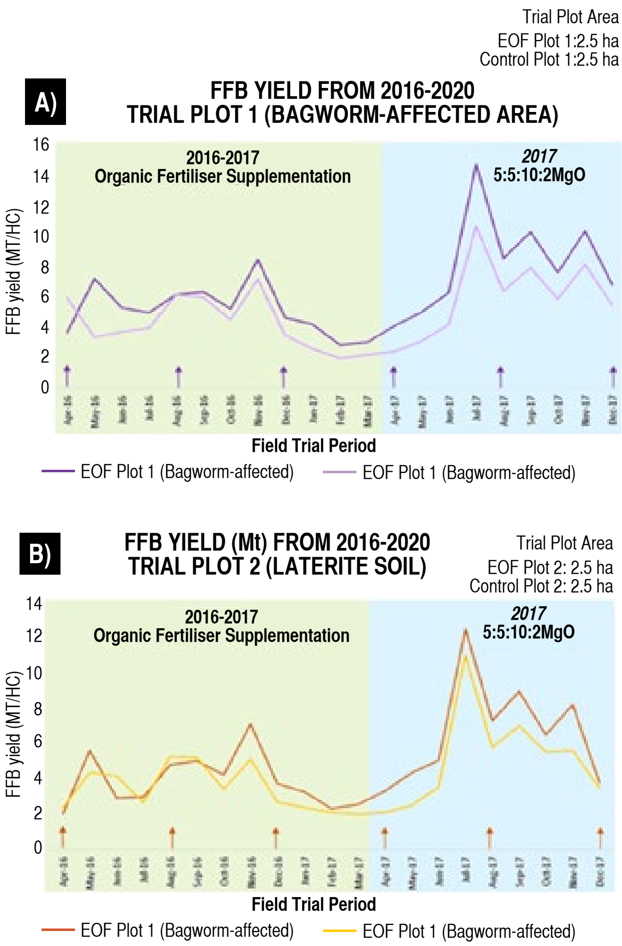

Figure 2. Fresh fruit bunches (FFB) yield of (A) trial Plot 1 and (B) trial Plot 2 treated with Living Organic Fertiliser and Eureka Fortified Organic Fertiliser (EOF) 5:5:10:2MgO as compared to normal fertiliser (control) from 2016-2017.

From *Figure 3*, the results of FFB yield from the organic fertiliser were remarkable as there was an average increase of 7.26 Mt ha^{-1} yr^{-1} in FFB yield in Plot 3 (clay soil) from 2016-2020 as compared to the control plot.

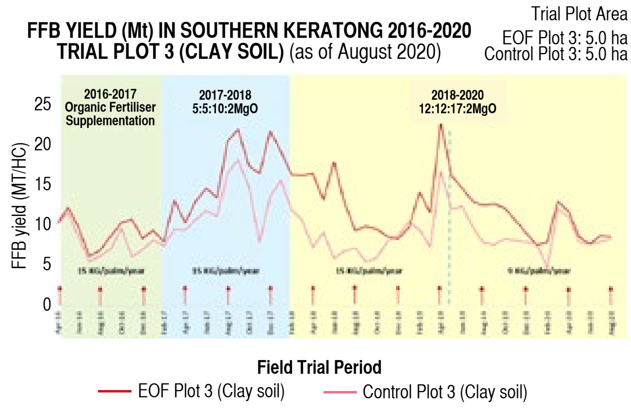

Figure 3. Fresh fruit bunches (FFB) yield of trial Plot 3 treated with Living Organic Fertiliser, 5:5:10:2MgO and 12:12:17:2MgO Eureka Fortified Organic Fertiliser as compared to normal fertiliser (control) from 2016-2020.

Nevertheless, there was no significant change in the FFB yield results as observed from Plot 4 which is made up of clay-sandy soil as shown in *Figure 4*; this trial plot began from 2018 to replace Plot 1 and 2 which had been replanted.

The increase in FFB yield from laterite and clay soil trial plots was mainly due to the increase in the average number of FFB bunches of up to 160 extra bunches from Field P, as shown in *Figure 5*. The average bunch weight recorded from the trial plots had also increased slightly by 1-2 kg/bunch, as shown in *Figure 6*.

Overall, the FFB yield of trial plots in Bukit Berembun treated with Living Organic Fertiliser and Eureka Fortified Organic Fertiliser had improved significantly, with a minimum of 2 Mt ha^{-1} yr^{-1} up to 11 MT ha^{-1} yr^{-1}, as observed in the summary of FFB yield in *Figure 7*. The effects of organic fertiliser were more significant in laterite and clay soils, as compared to clay-sandy soil due to the high porosity in sandy soil which reduces the holding power of organic fertiliser in the soil.

Based on the FFB yield results from the estate as shown in *Table 3*, the total FFB (Mt ha^{-1} yr^{-1}) yield from the control plot was 11.47 Mt from January to December 2020; equivalent to 28.34 Mt ha^{-1} yr^{-1}. In contrast, the total FFB yield from the plot treated with Fortified Organic Fertiliser 5:5:10:2MgO was higher at 14.37 Mt ha^{-1} yr^{-1} during the same period; equivalent to 35.49 Mt ha^{-1} yr^{-1}. This showed a total increase of 2.90 Mt ha^{-1} yr^{-1} in the oil palm FFB yield of the trial plot at Perak Motor estate, which is equivalent to an increase of 7.15 Mt ha^{-1} yr^{-1}. *Figure 8* shows the comparison results.

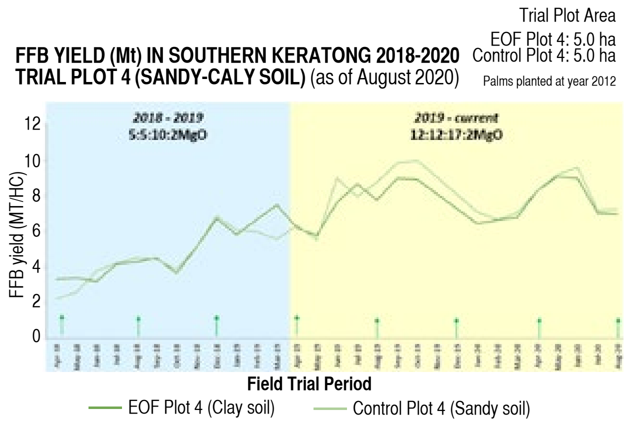

Figure 4. FFB yield of trial Plot 4 treated with Living Organic Fertiliser and Eureka Fortified Organic Fertiliser 5:5:10:2MgO as compared to normal fertiliser (control) from 2018-2020.

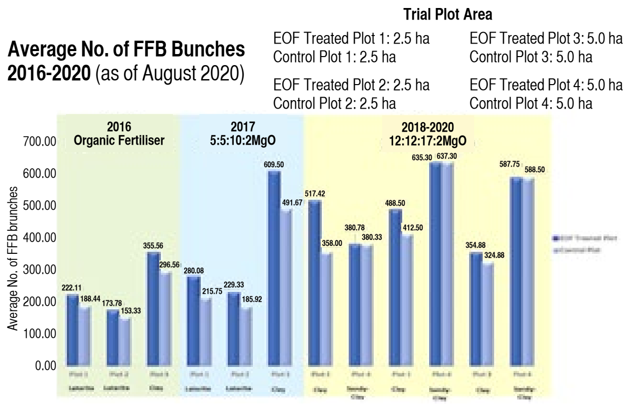

Figure 5. Number of fresh fruit bunches (FFB) bunches (ha^{-1} yr^{-1}) of trial plots treated with Living Organic Fertiliser, 5:5:10:2MgO and 12:12:17:2MgO Eureka Fortified Organic Fertiliser as compared to normal fertiliser (control) from 2016-2020.

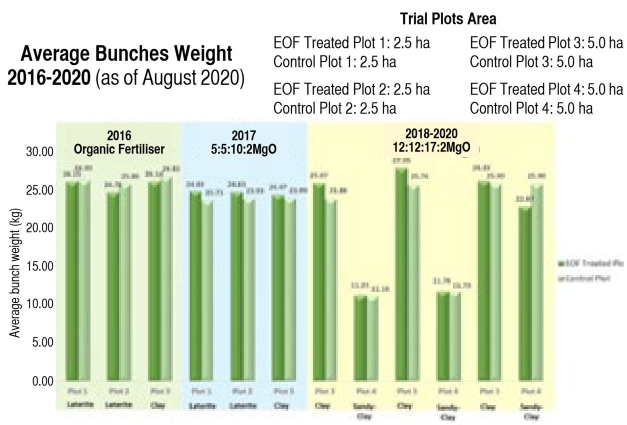

Figure 6. Average bunch weight (ha^{-1} yr^{-1}) of trial plots treated with Living Organic Fertiliser, 5:5:10:2MgO and 12:12:17:2MgO Eureka Fortified Organic Fertiliser as compared to normal fertiliser (control) from 2016-2020.

TABLE 3. FFB YIELD COMPARISON OF EUREKA FORTIFIED ORGANIC FERTILISER *vs.* STRAIGHT CHEMICAL FERTILISER IN 2020

Month	Control Plot (Straight fertiliser)		Trial Plot (Eureka fortified fertiliser)	
	Total yield (Mt)	Yield/acre (Mt)	Total yield (Mt)	Yield/acre (Mt)
January	769.78	0.78	69.02	0.99
February	1 167.12	1.19	95.48	1.36
March	1 071.79	1.09	88.30	1.26
April	874.56	0.89	87.04	1.24
May	954.60	0.97	86.12	1.23
June	1 196.62	1.22	88.19	1.26
July	1 044.02	1.06	93.94	1.34
August	1 073.48	1.09	103.91	1.48
September	1 045.58	1.06	90.28	1.29
October	822.78	0.84	79.07	1.13
November	592.11	0.60	64.53	0.92
December	667.47	0.68	59.79	0.85
Average	**964.77**	**0.96**	**83.81**	**1.20**
Total	**11 279.91**	**11.47**	**1 005.67**	**14.37**
Yield	**28.34 Mt ha^{-1} yr^{-1}**		**35.49 Mt ha^{-1} yr^{-1}**	

Note:

(a)	Straight chemical fertiliser total plot area:	983 acres
	Eureka Fortified Organic Fertiliser trial plot area:	70 acres
(b)	Straight chemical fertiliser application:	7 rounds / year (total 12 kg $palm^{-1}$ yr^{-1})
	Eureka Fortified Organic fertiliser application:	3 rounds / year in Apr, Aug, Dec (total 9 kg $palm^{-1}$ yr^{-1})

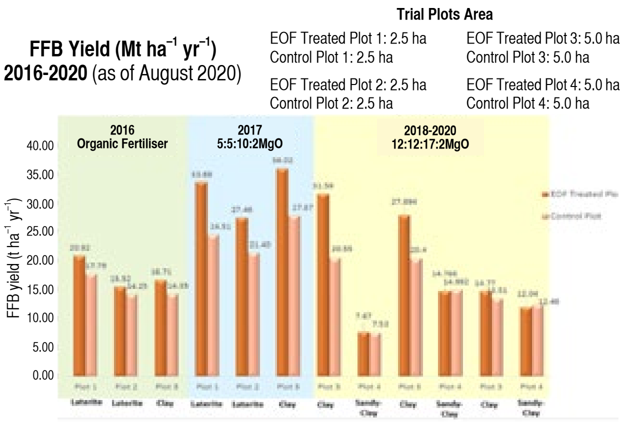

Figure 7. Fresh fruit bunches (FFB) yield (Mt ha^{-1} yr^{-1}) of trial plots treated with Living Organic Fertiliser, 5:5:10:2MgO and 12:12:17:2MgO Eureka Fortified Organic Fertiliser as compared to normal fertiliser (control) from 2016-2020.

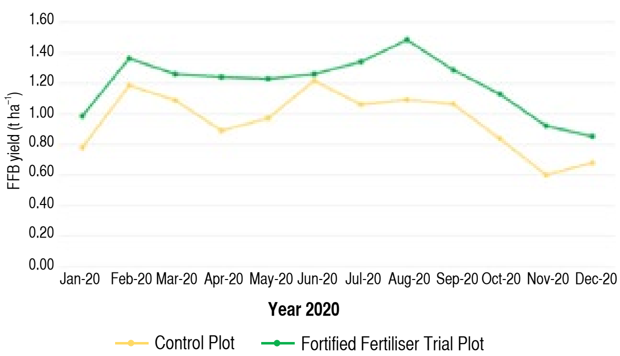

Figure 8. Fresh fruit bunches (FFB) yield (Mt ha^{-1} yr^{-1}) of trial plots at Perak Motor Estate treated with Fortified Organic Fertiliser 5:5:10:2MgO as compared to normal fertiliser (control) starting from 2020.

CONCLUSION

Living Organic Fertiliser and Eureka Fortified Organic Fertiliser with 5:5:10:2MgO and 12:12:17:2MgO formulations have showed excellent performance compared to conventional straight chemical fertiliser application. The organic fertiliser effects were more significant in laterite and clay soils compared to clay-sandy soil where no significant change in the FFB yield was observed. Fortified Organic Fertiliser 5:5:10:2MgO application increased the oil palm FFB yield by 7.15 Mt ha^{-1} yr^{-1} to 35.49 MT ha^{-1} yr^{-1} compared to 28.34 Mt ha^{-1} yr^{-1} achieved by conventional straight chemical fertiliser application at the same trial plot.

ACKNOWLEDGEMENT

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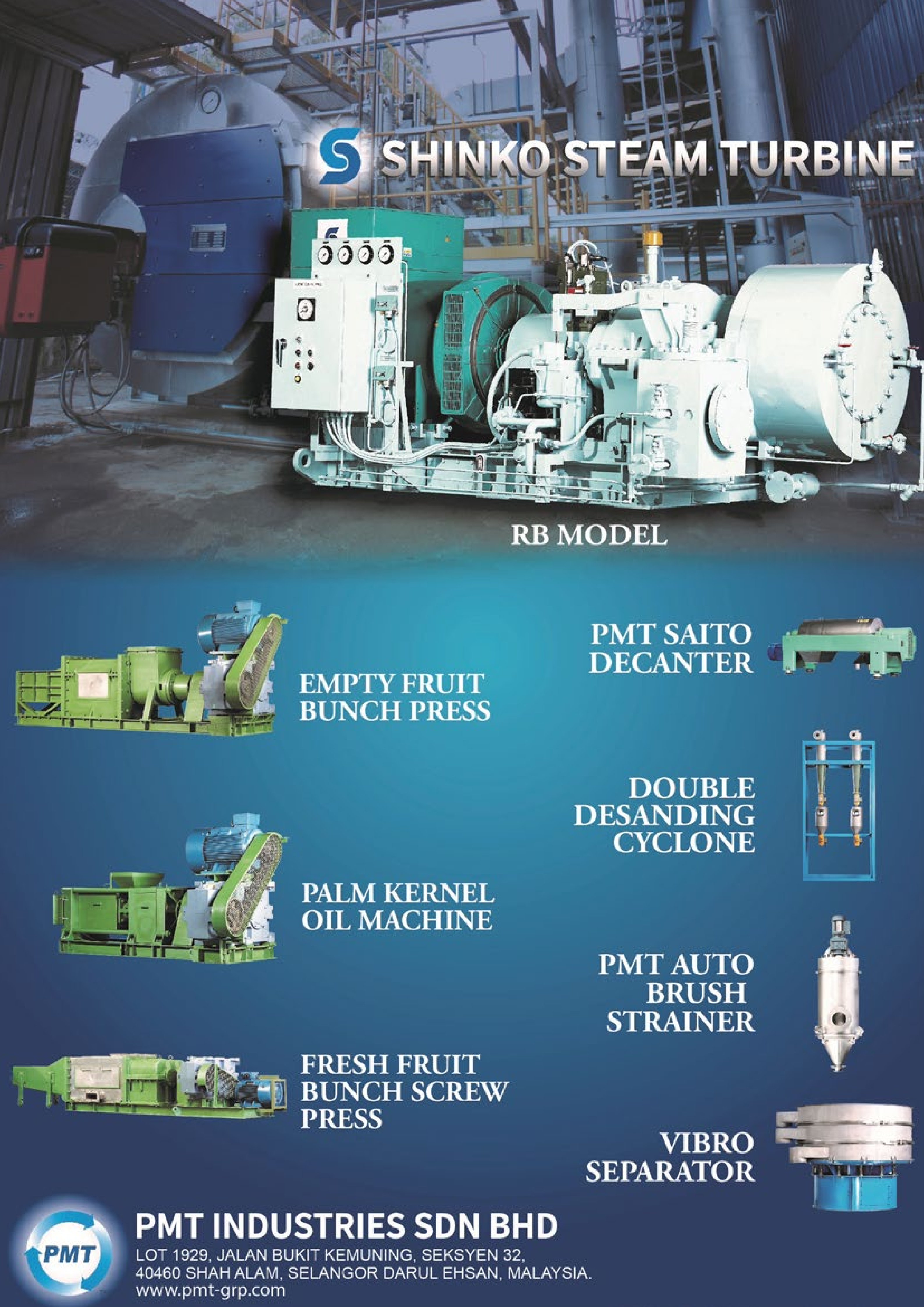
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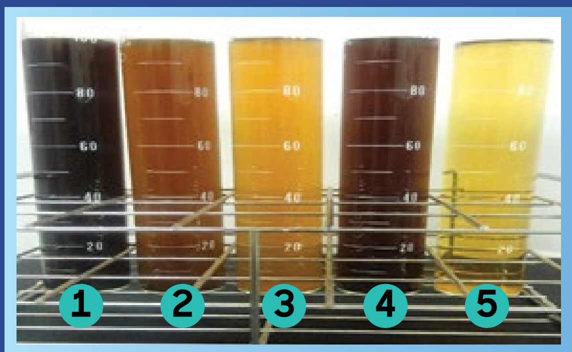

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The Role of Liquid Entrainment and its Effect on Separation Efficiency in Palm Oil Fractionation

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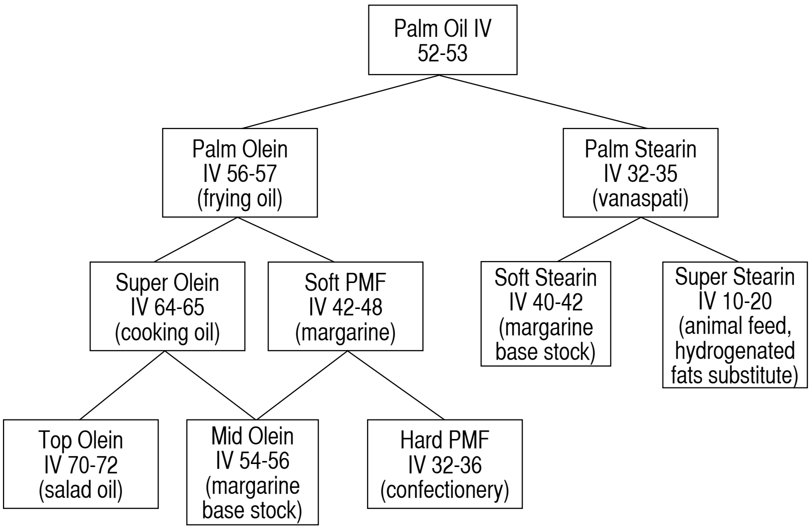
INTRODUCTION

Palm oil is one of the most unique oils and fats. The oil consists of a wide array of triacylglycerols (TAG) which predominantly contribute to its distinct physical and chemical properties. In its natural state, palm oil is semi-solid at room temperature which allows the oil to undergo fractionation to enhance its characteristics while increasing its functionality as an ingredient in a multitude of edible and non-edible applications (Deffense, 1985; Deffense, 1998). Over the last half century, the fractionation process has become the dominant modification process for the Malaysian palm oil industry, together with the steady growth in palm oil production (Kellens *et al*., 2007). Palm oil fractionation produces a liquid fraction (palm olein) and a solid fraction (palm stearin), which are two major palm-based fractions produced and traded from Malaysia (Parveez *et al*., 2020). In 2020, Malaysia produced over 14.2 million tonnes of refined, bleached and deodourised (RBD) palm oil while the production of RBD palm olein and RBD palm stearin were in excess of 10.1 million tonnes and 2.9 million tonnes, respectively, in the same year (MPOB, 2020). Palm oil can also undergo fractionation in multiple stages to further produce various fractions with improved quality and at a higher degree of selectivity, as shown in *Figure 1* (Kellens *et al*., 2007; Deffense, 2009).

In principle, fractionation involves partially crystallising the melted oil under controlled cooling conditions followed by separation of the solid crystals from the crystallising liquid slurry by filtration (Kellens *et al*., 2007). Several types of fractionation processes which have been employed by the palm oil industry with some still operating today are detergent fractionation, solvent fractionation and dry fractionation. Dry fractionation is currently the most preferred fractionation process for palm oil. The advantages of dry fractionation in comparison with other fractionation processes are that it is a purely physical, fully reversible and economical process due to the absence of chemicals or additives, and it has a low environmental impact making it a 'green' technology (Timms, 2005a; Kellens *et al*., 2007). A number of factors which affect the quality of the solid and liquid fractions obtained by fractionation include the origin and quality of raw material, crystalliser design, processing conditions, polymorphism and separation technique (Deffense, 2009). However, one of the main limiting aspects of the fractionation process is the difficulty in clean separation of solid crystals from liquid due to entrainment (Deffense, 2000).

WHAT IS ENTRAINMENT?

Entrainment is the physical trapping or retention of the liquid fraction by the solid crystalline fraction during the separation stage of the fractionation process (Timms, 1994). This happens as a result of the 3D structure of agglomerated crystals where liquid is held within crystal fissures by capillary and viscous forces. Two types of entrainment can occur during the separation stage: (1) intra-particle entrainment, where liquid oil is trapped within a particle or particle agglomerates and (2) inter-particle entrainment, where uncrystallised liquid is trapped between agglomerates (*Figure 2*). Among the factors which have a direct influence on entrainment include the operating conditions applied during crystallisation, the hydrokinetics and design of the crystalliser and the type of separation technique used (Bemer and Smits, 1982). The level of entrainment in the stearin cake consequently determines the yield but not the quality of the olein fraction, whereas for the stearin fraction, both quality and yield are affected (Timms, 2005b). Entrainment is a well-known phenomenon which reduces the separation efficiency of fractionation and complicates enrichment of the filtered products.



Adapted from Kellens *et al*., (2007); Deffense, (2009).

Figure 1. Multi-stage dry fractionation of palm oil and usage of fractions.

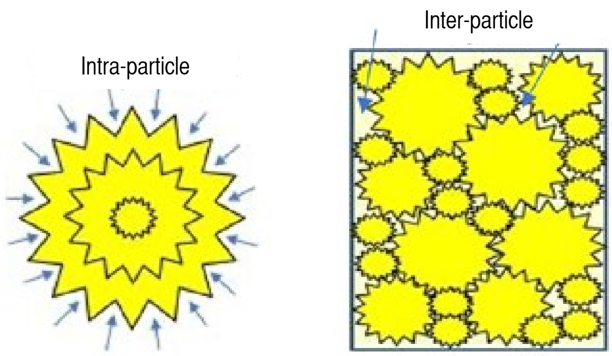


Figure 2. Intra-particle and inter-particle entrainment.

METHODS FOR ESTIMATING ENTRAINMENT

There are several methods that can be employed to measure the level of liquid entrainment within the stearin cake. One of the pioneering studies for entrainment calculation was conducted by Bemer and Smits (1982). Their study incorporated in the mass balance of the filter cake the radioactivity of the samples from the crystal-liquid slurry and from the pure liquid phase using liquid scintillation spectrometer. Other methods which have been proposed since then by several authors include those by Hamm (1986) using the olein fraction composition, applying iodine values of both solid and liquid fractions in the mass balance of the filter cake (Timms, 1994) and correlating entrainment to the degree of filter cake porosity (Hamm, 2005). Nowadays, the most popular method for measuring entrainment is through direct measurement by pulsed nuclear magnetic resonance (pNMR) of the solid fat content (SFC) of the crystallising slurry (Calliauw *et al*., 2007) or SFC of the filter cake immediately following filtration (Arnaud and Collignan, 2008) at the filtration temperature. This method provides a quick way in estimating the separation efficiency of the fractionation process.

A more recent method by Hishamuddin *et al.,* (2020) was developed based on an overall mass balance involving the mass and TAG compositions by high performance liquid chromatography of the olein and stearin products obtained from filtration. The application of this method considers that the melting points of triunsaturated TAG in palm oil which all lie below 0°C allows the them to remain uncrystallised in a liquid state at crystallisation operating conditions. Thus, the presence of triunsaturated TAG in the stearin filter cake is proposed to be ascribed purely to the entrapped olein within stearin crystals. The mass balance equation for the stearin cake is given by:

$$M_E x + M_C y = (M_E + M_C) z \qquad \text{Equation (1)}$$

where M_E is the mass (g) of entrained olein in the stearin cake, M_C is the mass (g) of crystals in the stearin cake, y is the composition of the triunsaturated TAG (g TAG/g crystals) in the crystals, and x and z are the compositions of the triunsaturated TAG in the corresponding olein (g TAG/g olein) and stearin cake fractions (g TAG/g stearin cake) after filtration, respectively, as determined by high performance liquid chromatography. *Figure 3* illustrates M_E and M_C within the cross-section of a stearin filter cake.

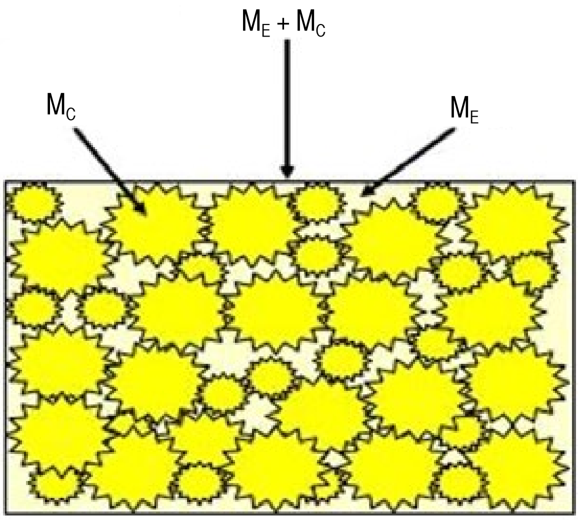
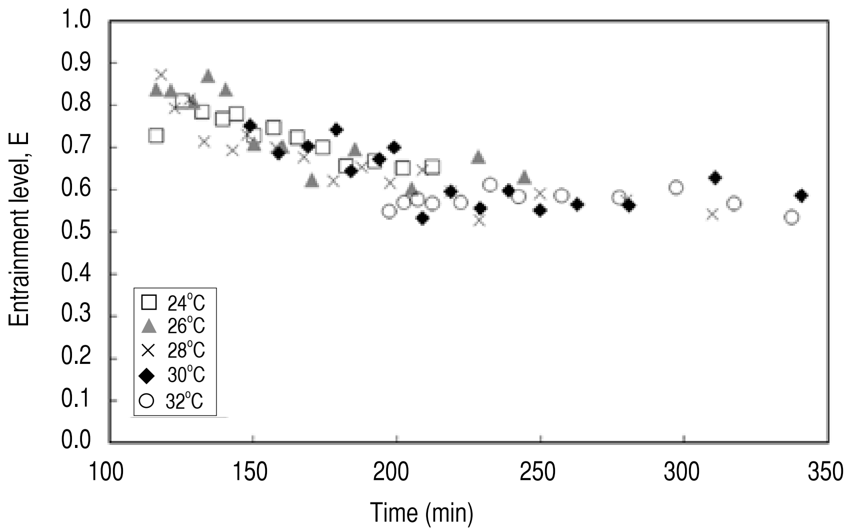


Figure 3. Distribution of mass of crystals (M_C) and mass of entrained olein (M_E) within a stearin filter cake.

The method proposed by Hishamuddin *et al*. (2020) found that entrainment levels in the stearin cake during the early stages of palm oil crystallisation at isothermal temperatures between 24°C and 32°C ranged from 70%-90% on the basis of filter cake mass. Their study concluded that the large surface to volume ratio of the high number of nuclei during this stage caused intra-particle occlusion in the growing crystals structure, in addition to the inability of uncrystallisable TAG species to rapidly diffuse away from the surface of crystals. A gradual decrease in entrainment values to between 54% and 65% was observed at the end of the crystallisation stage, owing to the reduced surface area to volume ratio of the crystals as a result of crystal growth (*Figure 4*). The entrainment values presented in their study were consistent with those reported in earlier observations (Hamm, 1986; Timms, 2005a; Kellens *et al.*, 2007). The proposed method provides an alternative for measuring the SFC in the absence of NMR facilities and avoids the need for strict sample temperature control which is usually required in SFC measurements using NMR.

SEPARATION PROCESSES AND THEIR EFFICIENCIES

In the last few decades, various types of separation processes have been commercially applied in palm oil fractionation. These include vacuum filtration using rotary drum or belt filter, decanting, centrifugation, hydraulic press and membrane filter press (Timms, 2005b). Earlier studies on palm oil fractionation have reported a substantial increase in the SFC of the stearin cakes produced by the membrane filter press to 55% compared to those obtained through vacuum filtration at 41% (Kellens, 1994; Hamm, 2005). Higher olein yields can be obtained with significant reductions in entrainment levels when using membrane filter press compared to vacuum filtration and centrifugation, as presented in *Table 1* (Timms, 2005a; Kellens *et al.*, 2007). The application of pressure during the filtration stage has also been shown to significantly affect the quality of fractionated products. During the operation of membrane filter presses, squeezing pressure is applied to compressible filtration chambers to expel entrapped olein from the slurry. This produces a better quality 'dry' stearin cake and greater olein yield due to the increase in the separation efficiency (Willner, 1994).



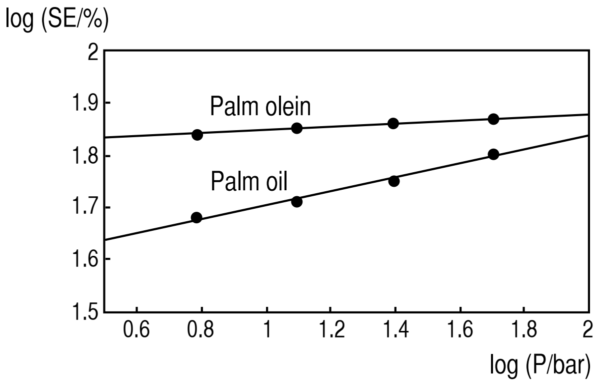
Source: Hishamuddin *et al*. (2020).

Figure 4. Entrainment levels in stearin cakes at different isothermal temperatures as a function of time.

TABLE 1. COMPARISON OF FILTRATION DATA BETWEEN DIFFERENT FILTRATION TECHNIQUES IN A PALM OIL FRACTIONATION PLANT

Filtration data	Vacuum filtration (drum/belt)	Centrifugation (nozzle)	Membrane press (6 bar/16 bar)
Entrained oil in filter cake (%)	59	53	45 / 35
Olein yield (%)	71-72	74-76	78 / 82

Source: Adapted from Timms (2005a), Kellens *et al*. (2007).



Source: van den Kommer and Keulemans, (1994).

Figure 5. Effect of pressure on separation efficiency (SE) in palm oil and palm olein fractionation.

Various studies in the past have demonstrated that separation efficiency or the amount of solid crystalline phase in the stearin cake depends on the level of filtration pressure applied. Increasing filtration pressure has a more pronounced effect on palm oil fractionation compared to palm olein fractionation, as illustrated in *Figure 5* (van den Kommer and Keulemans, 1994). The production of oleins (normal and superoleins) through single and double stage fractionations typically requires a filtration pressure of 15 bar, while higher pressures of about 30 bar are essential to produce cocoa butter equivalent products with qualities similar to those obtained by solvent fractionation (Kellens, 1996). It has also been reported that stearin cakes with entrainment levels reduced to 20% can be achieved with the application of filtration pressures of up to 50 bar (Willner, 1994; Hamm, 1995). Despite the substantial entrainment reduction, high filtration pressures may result in the passage of the stearin cake through the filter cloth. One way to overcome this problem is by applying a lower pressure on a thinner stearin cake. *Table 2* shows the effect of filter chamber width and squeezing pressure on separation efficiency in palm oil fractionation. Similar entrainment levels and olein yields obtained when using a 50 mm filter chamber at 30 bar squeezing pressure can also be achieved by employing a lower pressure of 15 bar on a 25 mm filter chamber (Kellens *et al.*, 2007).

The polymorphism and morphological aspects of crystals also play important roles in achieving good olein-stearin separation. Crystal spherulites in the β' form are easier to filter due to their uniform size and firmness, and have the tendency to remain suspended in the liquid oil due to the higher degree of stability compared to the

TABLE 2. EFFECT OF SQUEEZING PRESSURE AND FILTER CHAMBER WIDTH ON THE SEPARATION EFFICIENCY IN PALM OIL FRACTIONATION

Chamber plate width (mm)	Squeezing pressure (bar)	Liquid oil entrained in filter cake (%)	Yield (%)	
			Stearin	Olein
50	6	45	23.6	76.4
	15	39	20.0	80.0
	30	35	18.3	81.7
25	6	40	20.6	79.4
	15	34	18.8	81.2
	30	30	16.7	83.3

Source: Adapted from Kellens *et al*. (2007).

more metastable α-form crystals (Deffense and Tirtaux, 1989; Kellens *et al*., 2007). The use of additives such as polyglycerol fatty acid esters in palm oil crystallisation has been shown to produce smaller and even-sized crystals, leading to increased olein yields and entrainment reduction (Kuriyama *et al*., 2011; Saw *et al*., 2017; 2020). Moreover, in the case of palm olein fractionation, better separation efficiency and higher superolein yield can be attained when a small number of nuclei and similar crystal sizes exist during crystallisation (Deffense, 1998; Yoong *et al*., 2019). Seeding is often practiced on an industrial scale in palm olein fractionation to induce nucleation and generate uniform, dense and hard crystals with excellent filterability, which can withstand squeezing pressures of up to 30 bar (Deffense, 2009).

Table 3 tabulates the estimated entrainment levels in palm stearin from various fractionation processes employing different separation techniques to produce palm olein IV 56-57 over the last half century (Timms, 2005b). With the continuous developments and improvements in separation techniques over the years, the level of olein entrainment in stearin has seen a significant reduction from about 70% in the 1970s to 30% in the 2000s. The most effective separation process has been reported as solvent crystallisation in combination with belt filtration and washing. However, the process is too costly and is only used for producing high quality solid fractions for the confectionery industry. Currently, a combination of dry crystallisation and membrane filter press is capable of producing palm mid-fractions equivalent to those produced by solvent fractionation (Timms, 2005a).

CONCLUSION

The palm oil industry has seen significant advancements in the fractionation process over the last half century. Various research studies have demonstrated that a combination of dry crystallisation and membrane filter press with reduced chamber width and higher squeezing pressure is ideal in increasing olein yields and keeping entrainment to a minimum, rivalling that of solvent fractionation. Although solvent fractionation is still used in the production of specialty fractions required by confectionery manufacturers, current developments in fractionation would need to carefully consider evolving global consumer demands for safer and healthier ingredients that are free from chemicals and additives. As dry fractionation adopts a green technology approach, further enhancement on existing techniques could possibly look into optimising process conditions with

TABLE 3. ESTIMATED ENTRAINMENT IN PALM STEARIN FROM VARIOUS INDUSTRIAL FRACTIONATION PROCESSES EMPLOYING DIFFERENT SEPARATION TECHNIQUES

Year	Company	Process	Yield (%)	IV of stearin	Entrained olein (% of stearin)
Mid 1960s	Unilever	Continuous Acetone Tube Crystalliser + Belt Filter + washing with pure solvent	10-11	~8	~0
Mid 1970s	Bernardini	Batch Hexane Crystalliser + Drum Filter	37-40	44-46	70-73
Early 1980s	De Smet	Batch Dry Crystalliser + Drum Filter	37-40	45-47	70-73
Mid 1970s	Tirtaux	Batch Dry Crystalliser + Belt Filter	28-33	28-33	60-67
Mid 1970s	Alfa Laval	Batch Crystalliser + Detergent + Centrifugation (Lanza/Lipofrac Process)	17-23	25-35	35-52
Late 1980s	De Smet	Batch Dry Crystalliser + Membrane Filter Press	20-21	32-33	47-50
2000	De Smet	Batch Dry Crystalliser + Membrane Filter Press (50mm chamber width and 6 bar squeezing pressure)	~24	~40	~45
2000	De Smet	Batch Dry Crystalliser + Membrane Filter Press (25 mm chamber width and 30 bar squeezing pressure)	~17	~32	~30

Source: Timms (2005b).

the aim for higher separation efficiency and maximising entrainment reduction. Newer technologies in crystalliser and filtration designs can be explored to sustainably produce even higher quality and niche oleins and stearins down the multistage fractionation route, thereby ensuring increased value addition and functionality of palm oil and its fractions in the future.

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1. The above emission guarantee is for full combustion of the fuel in the boiler.
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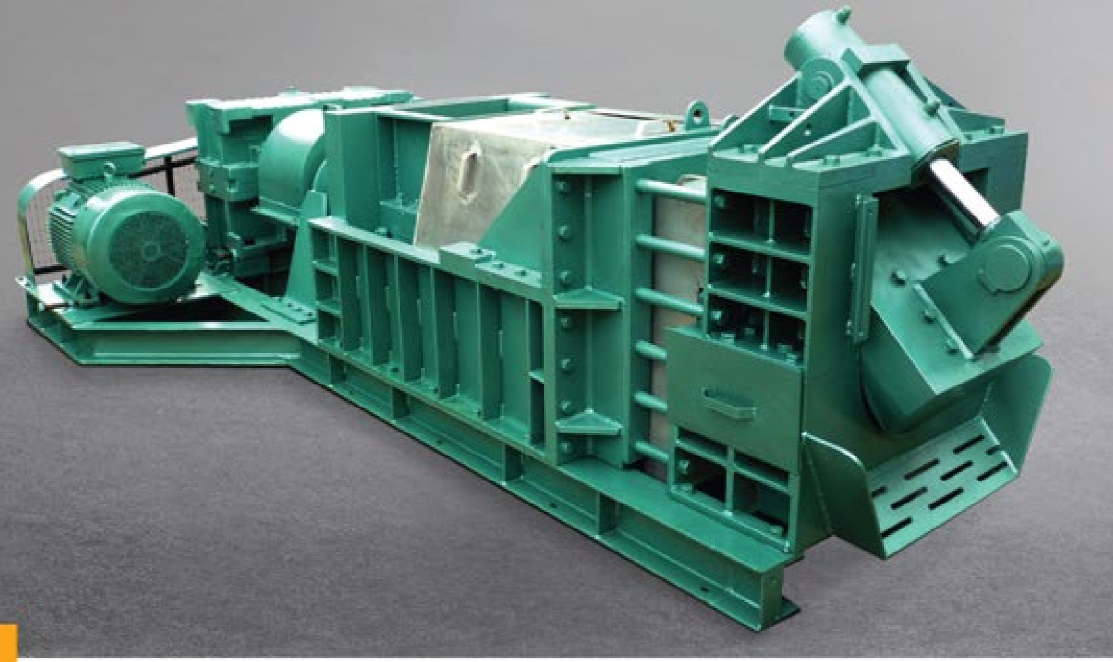

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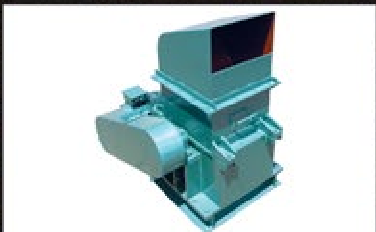
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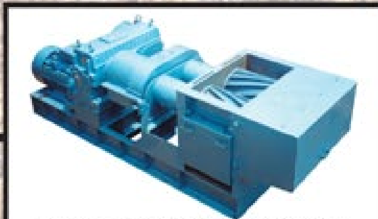
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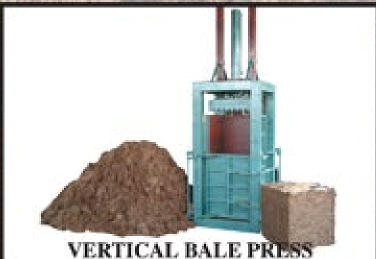
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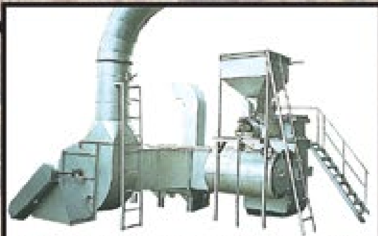
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Automated S.M.A.R.T Mill'S Algorithms with Internet of Thing (IOT)

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INTRODUCTION

Palm oil mills (POM) in Malaysia are still backward in embracing new technologies compared to other key economic sectors such oil and gas, automotive, construction, etc. despite being one of the major oil palm producer in the world and core income in Malaysia under National Key Economic Area (NKEA). Process automation is one of the hurdles in productivity as it is rarely seen in place or if it is installed, the capability of the instrument is not fully maximised.

Majority of POM intervention process is manually operated and despite its dynamic process; it is heavily dependent on labour in managing process control and quality. Insufficient process and engineering knowhow and insufficient manual data logging contributed to low productivity, significant negative environment impact due to black particles and smoke, foul smell and oil losses to environment in uncontrollable manner.

It is Government's aspiration to transform the industries towards digitalisation via high technology advancement innovation to boost POM productivity, environment protection and less dependency on foreign labour under Industrial Revolution 4.0 (IR4.0). However, there is a huge gap in implementing economically feasible, robust automation system, computers and electronic devices *i.e.* IR3.0 before IR4.0 as shown in *Figure 1*. Equipments and machines need to communicate with each other via Internet of Things (IoT) based on pre-determined set-points or desired values. Machines and equipments will learn over time based on statistical data and adjusting themselves regardless of the weather or type of crops towards the pre-determined setpoints. Thus, we would reduce the dependency on labour in carrying out repetitive and routine procedures (*Economic Transformation Programme; Chapter 9*).

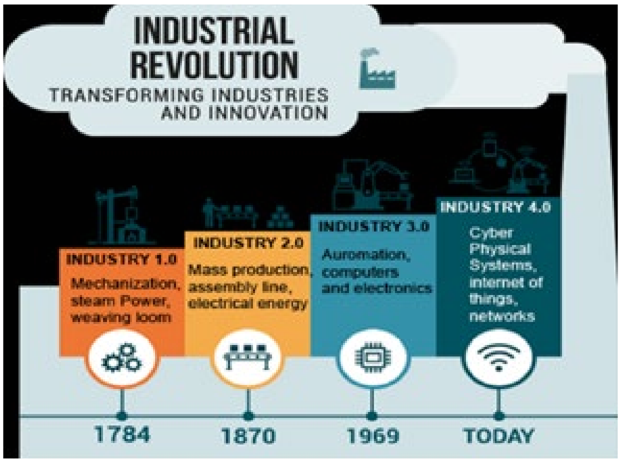

Figure 1. World industrial revolution.

PROBLEM STATEMENT

This article aims to attract readers' attention to look into minimising palm oil losses in the oil room and effluent emission such as bad odour, wastewater, greenhouse gases (GHG) that are uneconomical and has adverse effect on the environment if they are not efficiently managed by employing proven advanced technology leverages such as from oil and gas upstream (offshore operations) sector. Oil and gas upstream have vast similarities palm oil industry. For information and comparison, oil loss in offshore operation shall not exceed more than 100 ppmV or 0.01%, which is equivalent to 0.1 g for every 1 kg water discharged to open sea.

Figure 2. Typical offshore oil production platform operations.

In upstream offshore oil production (*Figure 2*), hydrocarbon produced from oil and gas wells consist of hydrocarbon gas, crude oil and free water, along with some fine sand that flow up to the surface of the topside facility via well heads and separated via separation vessels. Upon separation of hydrocarbon gas, crude oil is separated from free water in few stages until it meets the required basic sediment and water (BS&W) quality measurement which is similar to moisture and impurity (M&I) in POM. Due to the nature of the oil and gas industry that deals with flammable hydrocarbon, the technology employed need to be robust and reasonably accurate to ensure high safety integrity. Therefore, equipment and technology from automation that links to the communication network to ensure erratic and dynamic process to be predictively controlled in efficient manner. The equipment and technology needs to be selected so that the desired output is safely achievable at minimal operating cost, environmental- friendly and required minimal trained personnel on site.

Majority oil loss in POM comes from empty fruit bunch (EFB), pressed cake fibre and clarifier's underflow (Othman and Ng, 2013). Minimising oil loss in oil room indirectly means improving the oil extraction rate (OER) of the mill. *Figure 3* shows the integrated operation systems adopted from oil and gas offshore (upstream) practice in reducing oil loss (Othman and Ng, 2013; Andrew, 2006; Ropandi *et al*., 2017) odour (Andrew, 2018), black emission (Environmental Quality Act 1974) and untreated water discharge in POM in order to overcome the problem statements.

The output of the OER Based Algorithm and Mass Balance Automation (OBAMA) -6 is to ensure minimum oil loss in wet basis in the heavy phase and pressed fibre, minimal water released to the environment (hence zero discharge), minimal greenhouse gas (GHG) emission and foul odour. Oil is further extracted from water and recycled into oil room. Meanwhile trace of oily water is leached (Perry and Green, 1997; Coulson *et al*., 1999; Donald, 2009) and treated by using excess heat from boiler via Waste Heat Recovery Unit (WHRU) (Perry and Green, 1997; Coulson *et al*., 1999; Donald, 2009; McCabe *et al*, 1993; Ravi, 2015 and later cooled down as distilled water condensate. Recovered distilled water is later sparged into exhaust of hot flue air to recover CO_2, PM 2.5 and PM 10. Excess recovered water can be used for process and utility consumption.

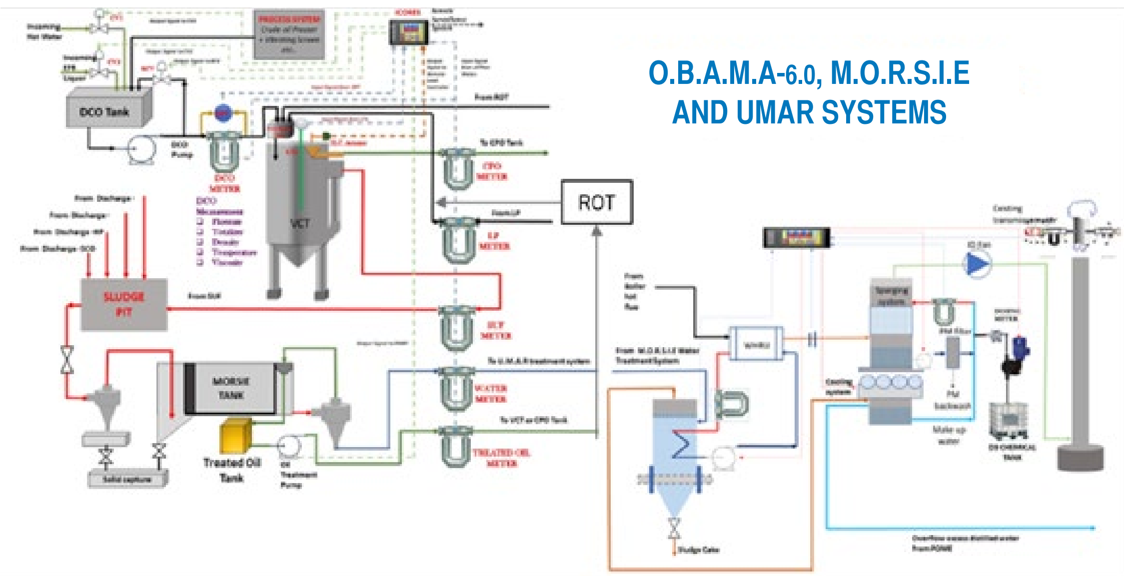

Figure 3. Integrated operations in reducing oil loss, foul odour, black emission and clean water recycling.

What is A.S.M.A.W.I?

Automated	:	operated by large automatic equipments.
S.M.A.R.T.	:	specific, measurable, achievable, realistic, timebound.
Mill's	:	referring to palm oil mill (POM).
Algorithms	:	processes or set of rules to be followed in calculations or other problem-solving operations, by programmable logic controller (PLC).
IoT	:	IoT is a system of interrelated computing devices, mechanical and digital machines, objects and people provided with unique identifiers (UIDs) and the ability to transfer data over a network or internet without requiring human-to-human or human-to-computer interaction.

The flow chart of control algorithms embedded in the PLC to calculate various measurement devices and command controlling devices to desired set-points for OBAMA-6+ is shown in *Figure 4*.

OBJECTIVES

The Government through its special agency has set some key performance index (KPI) to boost the oil palm industry via NKEA 2.0 initiative. However, despite its size in economy's contribution, Government also recognised the adverse effect of the industry on the environments. Therefore, the objectives of our innovations (A.S.M.A.W.I) are:

a. To improve palm oil's productivity by improving its OER to 23% by 2020.
b. To reduce GHG or methane formation by palm oil mill effluent (POME).
c. To reduce emission of black smoke and particle by mills to environment by June 2019 according to Ringlemann Chart 1 and below 150 ppmV.
d. To reduce odour released by microbes' activities in anaerobic pond below 12 000 OU number.

A.S.M.A.W.I addresses the above objectives with targeted deliverables of S.M.A.R.T mill concept (high productivity, environmental friendly and technology spearhead) (*Figure 5*) consisting of few integrated operations (IO) systems namely:

a. OBAMA-6 (OER Based Algorithm and Mass-balance Automation).
b. MORSIE (Mobile Oil Recovery System in Effluent).
c. UMARS (Unwanted Matters in Air Recovery System).

OBAMA CASE STUDY

The primary objectives of the case study are:

To regulate the dilution water to the required density and viscosity at operating temperature. To manage OIWB in underflow to below 6.5%.

The focus of this article is to discuss the OBAMA system that has been installed at 13 locations nationwide.

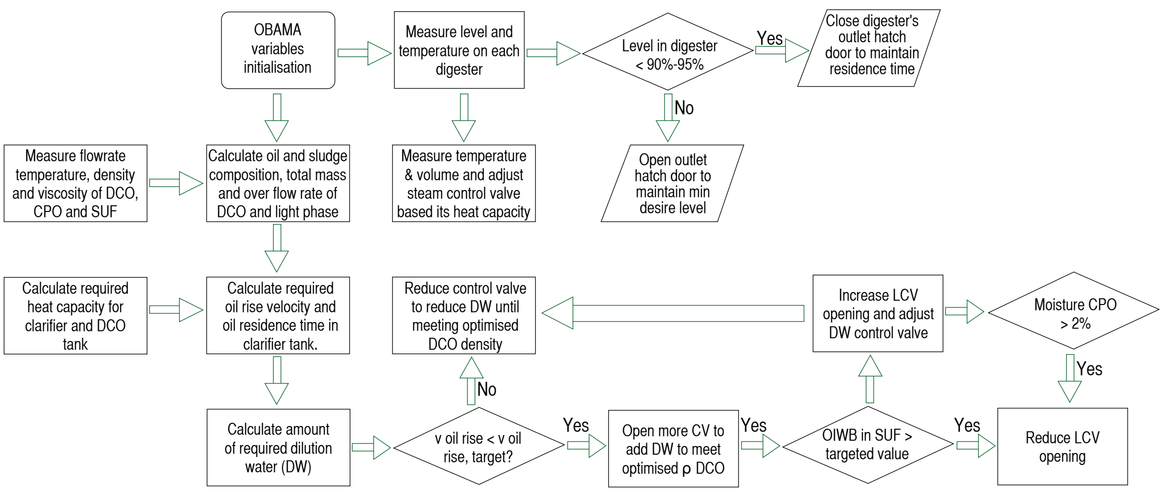

Figure 4. Flow Chart of the OBAMA-6 Control Algorithms.

Figure 5. A.S.M.A.W.I deliverables are addressing environment issues, oil loss reduction and enhancing productivity via IR4.0.

It has evolved to the 6+ version, also known as OBAMA-6+, addressing stand-alone automated process control system in oil room without the need for dedicated control room but rather mobile devices such as laptops, tablets or handphones by capitalising mobile internet network that is accessible anywhere to notify operators or management team while the system is controlling, monitoring and generating the big data. *Figure 6* shows one of the integrated OBAMA panel with field mounted display equipped with uninterrupted power system and internet connection.

Site display for operator to interface with the OBAMA panel as in *Figure 7.*

Figure 6. OBAMA panel at one of the site.

OBAMA-6+ is a series of algorithms that integrates with few operations across digesters, diluted crude oil tanks (DCOT) and clarifier tanks that are backed by real time OER based heat and mass-balance algorithms. *Figure 7* shows a typical Human-Machine Interface display on site and *Figure 8* depicts the key process equipment installed across a digester. *Figure 9* shows the typical equipment installed on a clarifier tank.

Fluid and heat transfer across inlets and outlets of clarifier tank(s) are measured and analysed by a few equipments connected to a PLC and interfaced to operators and other equipments via SCADA software. From SCADA, data is transmitted out via modem through internet service provider to an external secured server (VPN or cloud computing) and further analysed through a customised dashboard management as shown as in *Figure 10*.

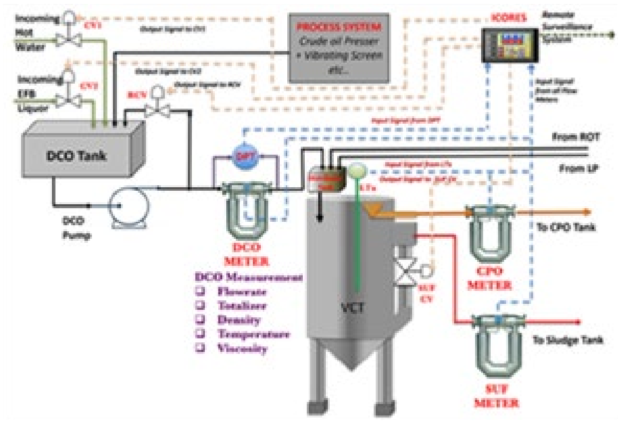

Figure 7. OBAMA panel at one of the site.

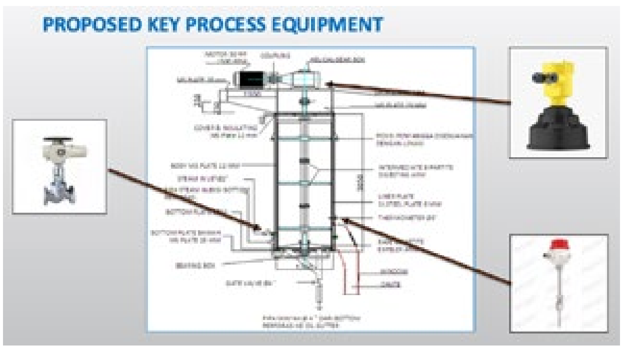

Figure 8. Typical installation of the devices within a digester unit.

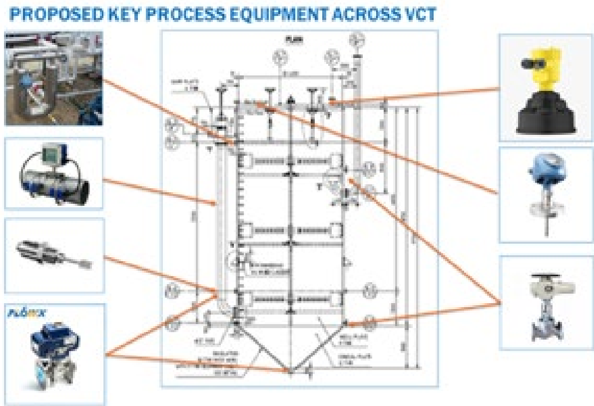

Figure 9. Typical equipment installed within a clarifier tank.

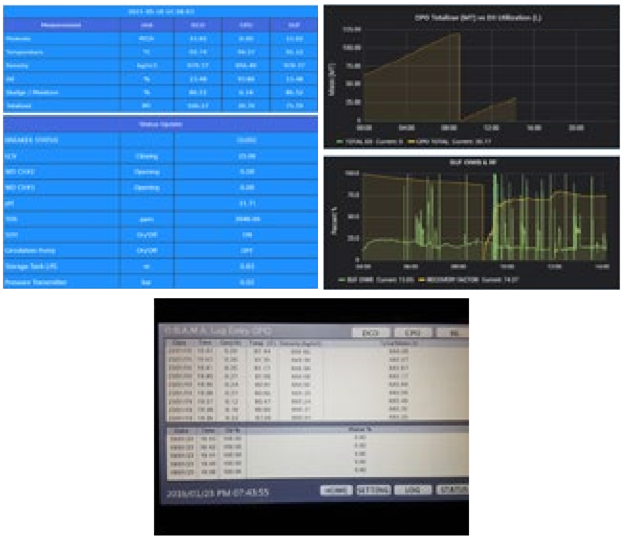

Figure 10. Remote monitoring system accessible via internet connection where instantaneous and cumulative data can be monitored and extracted.

OBAMA-6 is specifically designed to manage mechanics and thermodynamics of the fluid within the clarifier tank where:

a. dilution water meet required density and viscosity,
b. constant overflow rate into clarifier tank,
c. minimal oil in wet basis (OIWB) in underflow,
d. less than 2% moisture in crude oil,
e. oil layer control to prevent sludge/ water to oil tank,
f. heat capacity via steam management,
g. hold-up volume in the clarifier for constant overflow rate,
h. heat and mass balance across clarifier tank.

whereby, additional features of OBAMA-6+ compared to OBAMA-6 are:

a. digester volume hold up control.
b. digester steam management.

METHODOLOGY

A case study for OBAMA system was carried out at a 45MT hr^{-1} capacity POM with small DCOT (2.24 m^3) and 30 m^3 horizontal clarifier. The mill acquired fresh fruit bunch (FFB) from surrounding areas and weather alternated between hot and rain alternately.

The baseline was set based on two sets of OIWB% in underflow recorded using POM's lab data. One baseline set was set up without OBAMA system (August 2020) and another set was set up with OBAMA system but without any controls by OBAMA system. The baseline study was made for a week in March 2021. The purpose study was to compare the baseline made by the system against lab data. Mean or average of both OIWB% data in sludge underflow (SUF) was determine by carrying out Standard Distribution analysis.

Study in August 2020 (*Figure 11)* showed that OIWB% in underflow were in the region between 9.54%-14.64% with average about 12.09% (*Figure 12)* while 20% of data sampled (OIWB% in underflow) were in the region between 4.44%-9.54%.

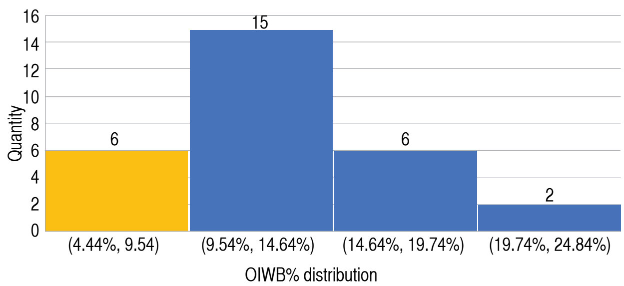

Figure 11. Clustered distributed data of OIWB % in SUF in August 2020.

Another round of baseline analysis using lab data on OIWB% in underflow was carried out after commissioning of OBAMA system for a week without any controls from the system. The OIWB% data showed an uptrend with average OIWB% in underflow at 11.58% (*Figure 13*).

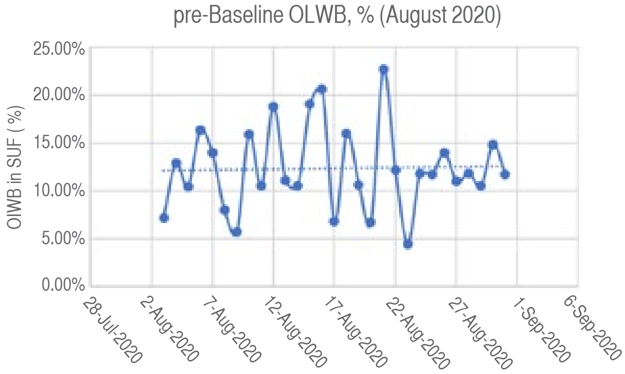

Figure 12. OIWB data in August 2020 prior to installation of OBAMA system.

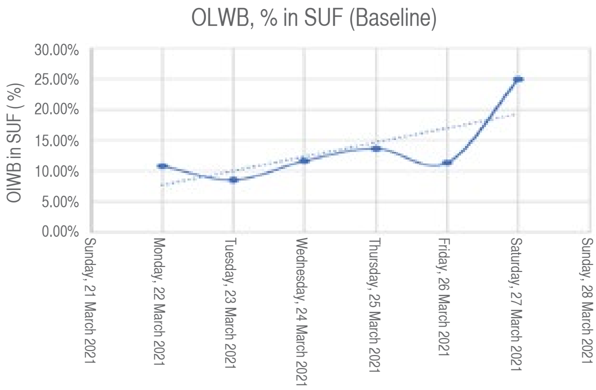

Figure 13. Second baseline without OBAMA system's control.

Upon activating the control system, the OIWB% in underflow showed downtrend (*Figure 15*) but *Figure 14* shows the increment in population of the OIWB% in SUF at the lowest range *i.e.* 5.25%-9.65%.

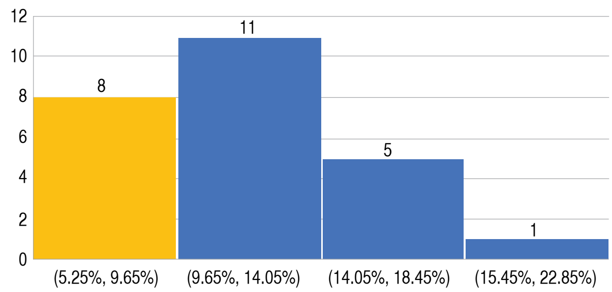

Figure 14. Clustered distributed data of OIWB% in SUF in April 2021.

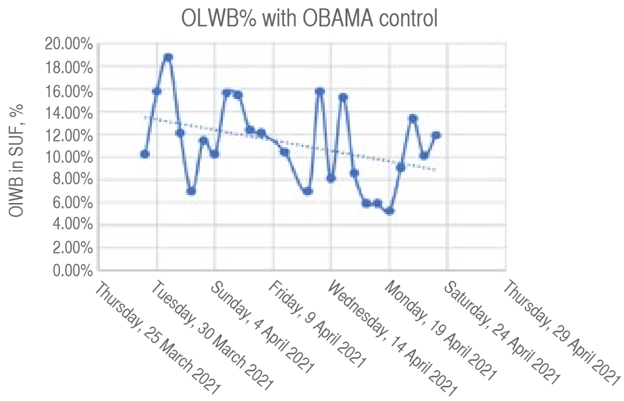

Figure 15. OIWB% in SUF population in April 2021.

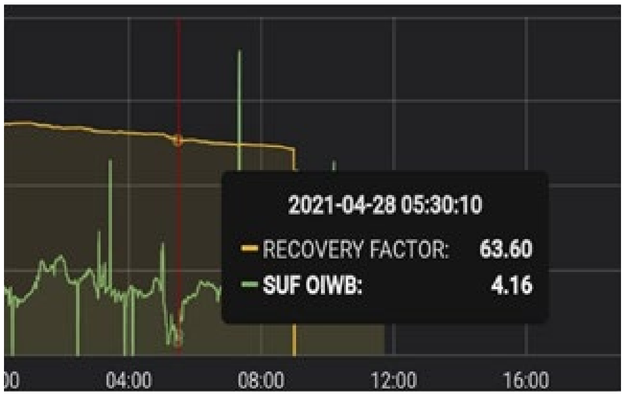

Figure 16. Reduction in OIWB% in SUF is possible down to less than 5%.

Data on April 2021 showed that OIWB% in underflow distributed mostly in the region between 9.65%-14.05% (*Figure 14*) with an average of 11.03%. 32% of data sampled was in the region of 5.25%-9.65% (*Figure 14*).

Although OIWB reduction from 11.58% to 11.03% in SUF seemed insignificant, however, initial oil loss reduction (recovery) in underflow equivalent to 0.2% OER was observed, hence reducing oil loss at SUF (*Figure 16*). Further process tuning and external factors management will further enhance the oil recovery.

However, some external factors need to be managed separately, which includes:

1. Manual intervention in:
    i. oil skimming activity
    ii. opening bypass valve
2. High mill's throughput up to 75MT hr^{-1} beyond clarifier capacity.
3. System familiarisation from manual to automation.

Therefore, as machine learns in due time, further improvement of OIWB in SUF could bring less oil loss and therefore improving the OER when:

a. Controlling layer is much tighter *i.e*. less manual intervention.
b. Constant over flowrate (OFR) proportionates to clarifier's dimensions.
c. Sufficient amount of dilution water in accordance to separation requirement *i.e.* Stoke law.

DISCUSSION

Key challenge in oil room area is controlling the dilution water regardless of the number of operating digesters/ pressers, origin of crops and crops quality as well as source of hot water or/ and oily water (steriliser condensate oil or/ and empty fruit bunch (EFB) liquor) against dynamic undiluted crude oil and non-oily solid (NOS) flow rate. Although there is a rule of thumb for fluid composition as undiluted crude oil (UCO) and diluted crude oil (DCO) as mentioned by Stork (1960) and Mongana Report (1955) however, process dynamic in a POM is unique from one to another (Adzmi *et al*., 2012; Andrew, 2006; Othman and Ng, 2013).

Clarifier tanks are designed to separate oil from its sludge gravimetrically and exits as underflow rich in water and NOS. The intent was to minimised oil loss in underflow to as minimal as possible. Thus, fluid mechanic and thermodynamic aspects within clarifier tank are critical to ensure optimum oil separation in hindered settling process condition (Sulaiman, 1998).

To attain optimum oil terminal velocity within clarifier tank and its composition which relates to its density and viscosity at specific operating temperature, it is important to be predetermined according to clarifier tank's dimension at constant overflow rate so that it is within its residence time (Sulaiman, 1998; Perry and Green, 1997; Coulson *et al*.,1999).

Temperature also played an important role in breaking up the surface tension between oil and water, especially in tight emulsion and therefore heat supplied by steam needs to be regulated without overboil to prevent water boils up and created vortex movement inside the clarifier tank (Perry and Green, 1997; Coulson *et al*.,1999). Usage of designed ionic wetting agent or surfactant promoted the acceleration of interfacial surface tension break up.

To attain optimum separation of oil from sludge in clarifier tank, a steady over-flowrate (OFR), density and viscosity at specific operating temperature or heating capacity is required to optimise oil rise velocity with minimal oil loss to sludge underflow of the vertical clarifier tank (VCT).

OBAMA-6 primarily functioned to determine the diluted crude oil (DCO), sludge under flow (SUF) and purified crude palm oil (CPO) mass rate, analysing the composition (oil, water and non-oil solid (NOS), temperature, density and viscosity via mass balance.

Additional dilution water will be consumed and controlled by control valves in accordance to Stoke Law' (Equation 1) with optimum oil rise velocity (Perry and Green, 1997; Coulson *et al*.,1999). *Figure 17* shows typical dilution water supply into the system that managed the dilution, either via EFB liquor (condensate) or hot water.

Figure 17. Dilution water control valves regulate accordingly to process requirement as computed in OBAMA panel.

Figure 18. Recycle valve to manage constant over flow rate (OFR).

The constant overflow rate (OFR) will be managed by a recycle valve back to DCO tank as shown in *Figure 18* to ensure consistent feeding to clarifier tank and heat distribution.

Key parameters such as density, viscosity and temperature of fluids under assessment were manually measured for baseline as shown in *Figure 19*.

$$v = \frac{d^2.(\rho_{DCO} - \rho_{oil}) \cdot g}{18\mu_{DCO}} \qquad \text{(Equation 1)}$$

where;

d	=	diameter of pure oil molecule
ρ_{DCO}	=	density of diluted crude oil (DCO) at operating temperature
ρ_{oil}	=	density of pure oil (CPO)
g	=	gravitational force
μ_{DCO}	=	viscosity of diluted crude oil (DCO) at operating temperature

These parameters were measured and analysed by a few equipments installed at specific locations across clarifier tank and computed by PLC to determine the required amount of dilution water.

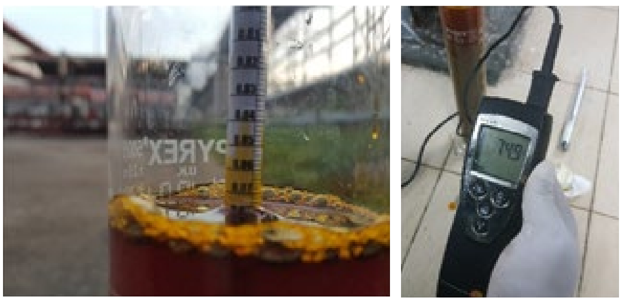

Figure 19. Field test and data acquisition at site on temperature and density on various process points.

Apart from managing dilution water to ensure spot on density and viscosity of DCO is achieved so that optimum oil rise terminal velocity in clarifier, residence time of the clarifier was controlled via oil in underflow measurement by regulating level control valve as shown in *Figure 20*. Concurrently, oil layer was measured by an interface level transmitter to feedback to level control valve to be regulated accordingly to its predetermined oil layer.

Interface level transmitter for measuring oil-water contact closely

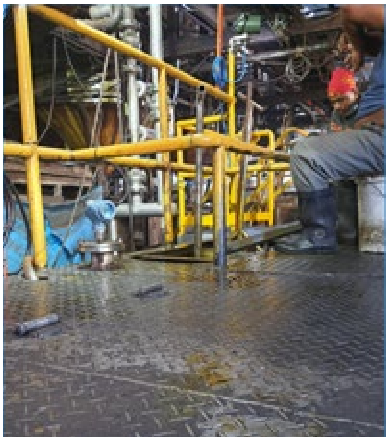

Figure 20. Strategic location of the interface level transmitter to control OIWB and oil layer in clarifier.

The level in the clarifier was further balanced by using Bernoulli equation (Equation 2) across the clarifier (Perry and Green, 1997; Coulson *et al.,*1999; McCabe *et al.,* 1993).

$$P_1 = P_2\ ;\ \frac{F_1}{A_1} = \frac{F_2}{A_2}\ ;\ \frac{m_1 g}{A_1} = \frac{m_2 g}{A_2} \qquad \text{(Equation 2)}$$

where;

P	=	Pressure of load in the clarifier
F	=	Force applied by load onto the surface sectional area
A	=	surface area where force is applied perpendicularly
m	=	mass of load where force is applied on the area
g	=	gravitational force

As oil in wet basis was calculated by PLC OBAMA panel, oil layer/band was optimally controlled to ensure low moisture CPO exit the clarifier tank. In the event where moisture in CPO exceeding 2%, oil layer was increased by closing the control valve as shown in *Figure 21*. Subsequently, as the valve closed, residence time in clarifier was prolonged, hence less oil exit via underflow.

Figure 21. Level control valve at the SUF line responding to interface level transmitter.

To ensure good separation break-out in emulsion, steam supplied to the clarifier tank were distributed to open and close the loop system at the bottom and at the middle of the clarifier tank. The steam supplied was controlled based on latent heat capacity calculation (Equation 3) of the steam where heat was measured by flowmeters that equipped with built in thermocouple (Perry and Green, 1997; Coulson *et al*.,1999; Donald, 2009; McCabe *et al*., 1993).

Amount of steam used was registered to enable user to determine clarifier tank's steam consumption timely.

$$Q = m . Cp . \Delta T = \lambda T \qquad \text{(Equation 3)}$$

where;

Q	=	heat capacity of the fluid or steam
M	=	mass of liquid (CPO and SUF)
Cp	=	heat capacity of the liquid (CPO and SUF)
ΔT	=	change in temperature
λ	=	latent heat of evaporisation
T	=	temperature of supplied steam

PLC received output of mass rate, liquid composition and temperature of SUF and CPO exiting the clarifier from the flowmeters installed (*Figure 23*). Based on the difference between setpoint and the measured temperature, demand of heat capacity across the clarifier was calculated to determine the amount of steam supplied to each open and close loop as shown in *Figure 22*.

Figure 22. Steam supplied based on heat capacity required by regulating steam control valve into the system computed by OBAMA system.

Figure 23. Vertically mounted flowmeters to promote self-draining effect measuring mass rate and fluid properties.

Maintaining active hold up volume is crucial to ensure sufficient retention/ residence time of fluid. Any excessive sludge build up at the bottom of the clarifier tank would increase the residence time for oil separating from water, causing CPO impurity or excessive OIWB in SUF. Thus, having an active level measurement on solid build up at the bottom of the clarifier tank would be able to discharge solid via control valve to prevent heat loss and loss of active separation volume/ space.

Figure 24. Position of discharge control valve to evacuate sludge at the bottom conical.

CONCLUSION

Implementing automation and link up to IoT facility would be able to accelerate the industry from IR2.0 to IR4.0. Availability of big data equipped process engineer and mill's operations and advisors with information to further improve productivity by minimising oil loss.

By employing automation, repetitive actions such as sampling, dilution control, oil layer control, steam management and desanding can be automated with less dependency on labour.

Dilution required to carry out separation in the clarifier tank was accurate and responsive regardless of the number of pressers and digesters in operations, weather, crops quality as well as the dilution water added with respect to composition of undiluted crude oil or pressed juice.

Oil layer was managed by a couple of controlled algorithms where optimum oil layer is built up in the clarifier to maintain the CPO quality more than 98% pure thus giving ample residence time for oil to rise up and minimising OIWB in underflow.

Steam supplied to the system will be automatically adjusted to ensure sufficient heat to break the surface tension between oil and water in emulsion by employing thermocouple sensor in the flowmeters and actuated globe valve.

With Government incentive and financial supports via its agencies such as MIDA, automation can be rolled out to improve mill's processing efficiency and productivity in embracing IR4.0 with minimal dependency on foreign labour, thus empowering profitability with less adverse environment impact.

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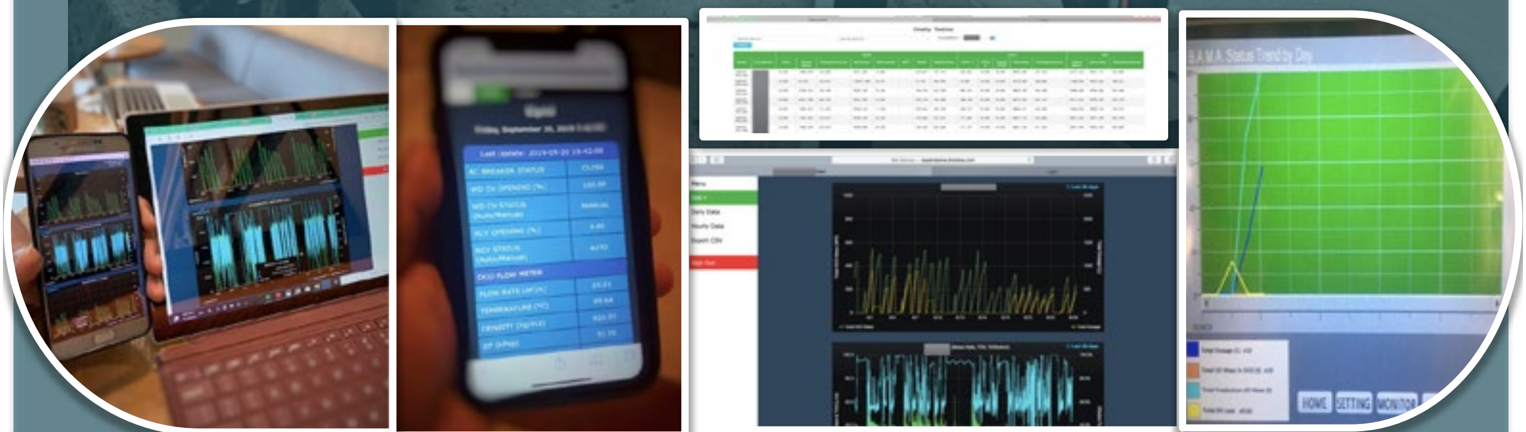

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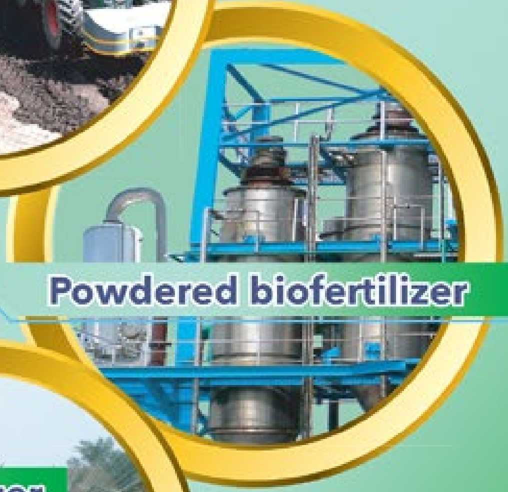

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Palm Oil Industries and Pandemic COVID-19: How Vaccines and Immunisation Helps to Recover Losses

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ABSTRACT

Medical society believes that vaccination is the most effective method to address the COVID-19 pandemic which has brought excessive deaths worldwide. Generally, three different vaccine mechanisms are available to induce adaptive immunity against the sickness. COVID-19 vaccines have been enhanced with the 2P mutation technique to stabilise the virus in the pre-fusion form for antibody-dependent enhancement (ADE) avoidance.

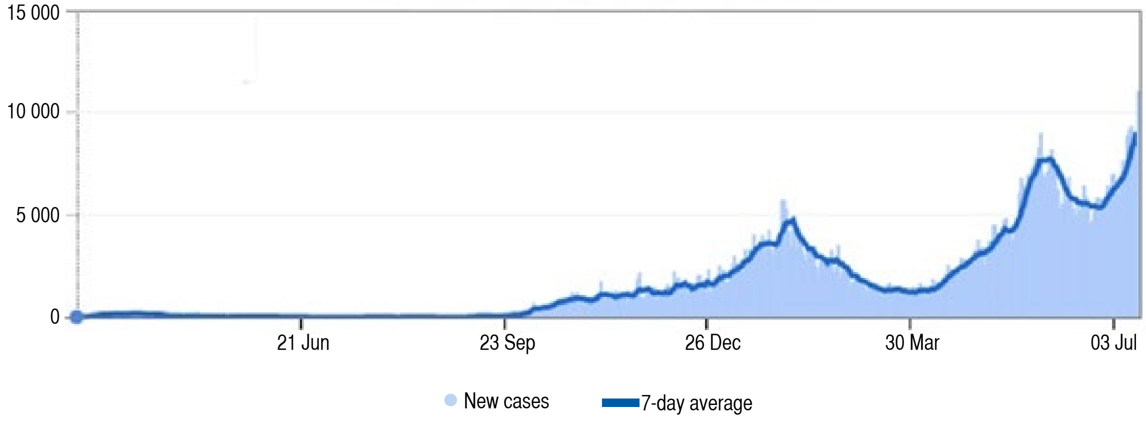
INTRODUCTION

COVID-19 pandemic has widely spread through the Malaysian community beyond contact tracing control. Most of the reported cases were sporadic that authorities were unable to determine the spreading source (Boo, 2021). Ministry of Health no longer releases cluster data to public medium since 29 May 2021 (Aidila *et al.,* 2021). Hence, palm industries personnel are exposed to the infection from other unidentified persons via social contact anytime anywhere through respiratory droplets, which are released during sneezing, coughing or talking. Infectious respiratory droplets form aerosol then lands on any surfaces and form fomites. Thus, infection mainly occurs via short-range aerosols inhalation, close contact and fomite transmission.

Severe acute respiratory syndrome (SARS) known as COVID-19 due to coronavirus (*Appendix*) infection was declared as a pandemic on 11 March 2020. Although the pathogenic virus has many variants, no consistent nomenclature has been established until January 2021 when the World Health Organization (WHO) proposed a standard nomenclature for SARS-CoV-2 variants, which is geographically and politically neutral. The virus variants are put into larger groupings such as lineages or clades. As of January 2021, Global Initiative on Sharing Avian Influenza Data (GISAID) had identified eight global clades (S, O, L, V, G, GH, GR and GV) of the SARS-CoV-2 while Nextstrain, a real-time pathogen evolution tracking, had identified 11 major clades (19A, 19B and 20A–20I). The Phylogenetic Assignment of Named Global Outbreak Lineages (PANGOLIN) on the other hand, identified six major lineages (A, B, B.1, B.1.1, B.1.177, B.1.1.7) until February 2021.

The pandemic affects all the economic sectors and the impact severity is unprecedented. About 25% of the world populations are directly involved in agriculture which is closely related with food chain and has always been an important pillar to the country stability. Many economy activities standstill during pandemic due to country lockdown worldwide. Thus, the B40 low-income groups number in Malaysia has been predicted to increase during and after the pandemic. Subsidies, moratorium, tax reductions *etc.* may able to stabilise the market in short term only. Organisations must accelerate become resilient and agile to adapt and thrive during recession.

Malaysian Government is implementing Movement Control Order (MCO), which is a series of national quarantine and cordon sanitaire measures in response to the COVID-19 pandemic since 18 March 2020. Later National COVID-19 Immunisation Program was announced on 24 February 2021. Unfortunately, the public health situation seems to be worsen as shown in *Figure 1*. National reserves have been nearly exhausted and recovery plan is urgently required for generating



Data source: JHU CSSE COVID-19

FIGURE 1. COVID-19 daily new cases reported in Malaysia.

sustainable economic resources in order to gain balance between health and wealth matters. Thus, Malaysian Prime Minister announced 4-phase National Recovery Plan on 27 June 2021.

Virologists predict that the COVID-19 virus may not become extinct in the near future due to mutation capability. Vaccination with standard operation procedures (SOP) compliance is the only solution to achieve permissible public health conditions for civilians to get back normal life activities.

Viruses usually mutate to new variants over time. An emerging variant is the variant that appears to be growing in a population. The sample obtained from a symptomatic COVID-19 patient on 30 December 2019, labelled as WIV04/2019 had the sequence belonging to the GISAID S clade/ PANGOLIN A lineage/ Nextstrain 19B clade, which was believed to reflected proximately the original virus sequence that has infected humans, thus, is referred as 'sequence zero' (Wikipedia, 2021). *Figure 2* shows the typical SARS-CoV-2 genome based on the National Center for Biotechnology Information (NCBI) sequence.

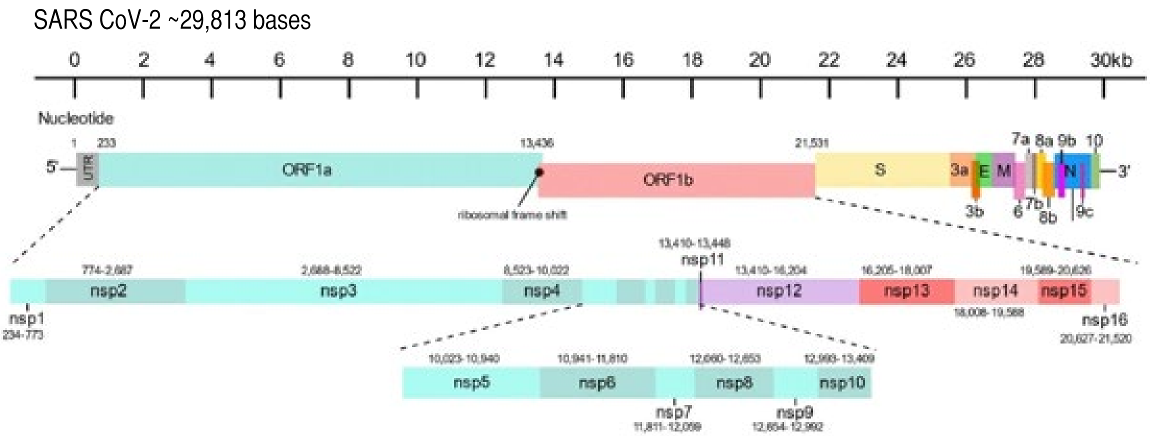


Figure 2. Typical SARS-CoV-2 genome schematic diagram.

Infection occurs when a pathogen invades a human's body and attacks specific host cells in order to reproduce. Such undesirable invasion causes illness. White blood cells or immune cells would fight against the infection in various ways in the effort to recover from the sickness. Macrophages engulf the dead cells and pathogen prior to digestion. Parts of the invading pathogen will be left behind as antigens for identification. B-lymphocytes (bursa-derived cells) recognise the antigens and produce appropriate antibodies to neutralise respective pathogens while T-lymphocytes (thymus cells) produce granular antigens specific enzymes that attack the infected cells. The adaptive immunisation over the particular infection could take several days to weeks, depending on an individual's health condition.

Patients would recover if the adaptive immunity is duly established before the affected organs malfunction. Most COVID-19 patients experienced mild to moderate symptoms such as fever, dry cough, tiredness and would recover within 14 days without any special treatment. Most of the related mortality in hospitalised patients had pulmonary infiltrates on chest radiography (Thomas *et al.,* 2020) indicating massive lungs damage.

Infection would cause the formation of antigen-specific, long-lived memory T-lymphocytes so that effector T-lymphocytes could proliferate quickly whenever the similar antigen is detected again with low activation threshold. Vaccines are antigens in an immunogenic form administered intentionally into a recipient in order to induce adaptive immunity against the related pathogen antigens that invade in the future. Vaccines work in three different ways to offer protection as shown in *Figure 3* but all vaccines stimulate memory T-lymphocytes as well as B-lymphocytes that form adaptive immunity system to provide effective protection from future infection.

Nucleoside-modified messenger ribonucleic acid (mRNA) vaccines contain genetic material from the pathogen that could instruct ribosome to synthesis a unique, harmless viral protein as shown in *Figure 4.* The mRNA delivery is achieved by a molecule co-formulation into lipid nanoparticles that protect the RNA strands and assists the absorption into the cells. The synthesised protein then destroys the genetic material from the vaccine. The immune system could now recognize the hazardous antigen and releases T-lymphocytes based on the relevant memory T-lymphocytes while B-lymphocytes produce antibody to react against the pathogen in future infection.

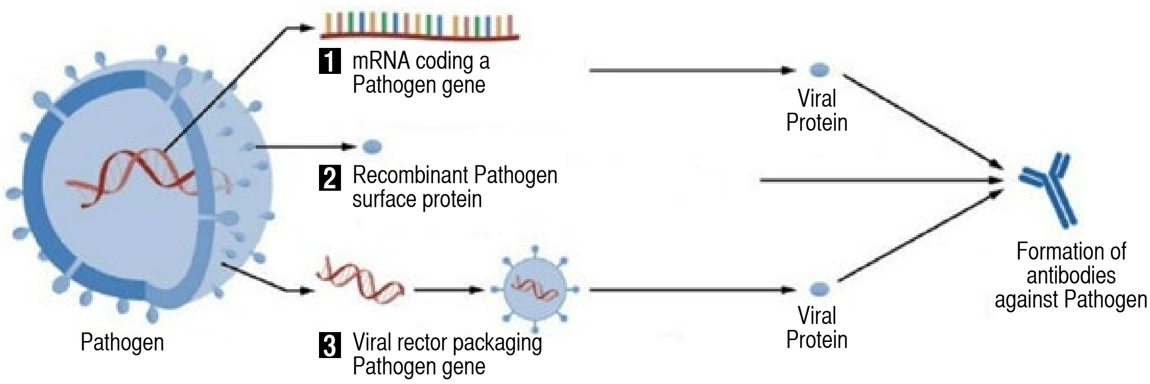


Figure 3. Vaccine mechanisms to induce adaptive immunity.

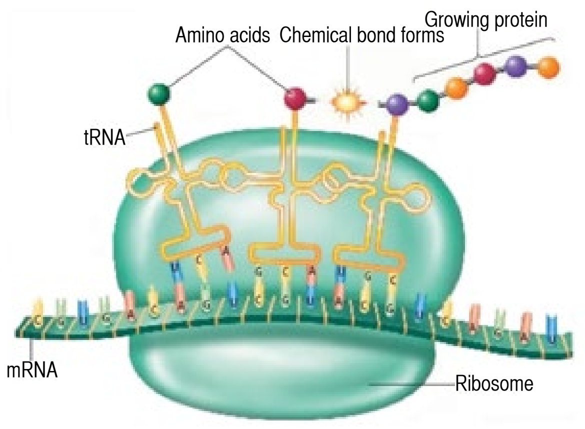


Figure 4. Unique viral protein synthesis mechanism based on mRNA.

Subunit proteins from vaccines include harmless surface proteins instead of the entire pathogen. Vaccination enables the immune system to recognise the antigen and forms memory T-lymphocytes in order for it to react together with B-lymphocytes against the pathogen in future infection.

Vector vaccines contain a modified pathogen that with non-replicating viral vectors inside an adenovirus shell to produce an antigen that elicits only a systemic immune response. The vaccine releases the viral vector into host cells so that the genetic material could give instructions to synthesis copies of the viral protein that is unique to the pathogen. Thus, adaptive immunity towards the antigen can be established, enables it to build appropriate T-lymphocytes and B-lymphocytes in future infection (CDC, 2021).

The T-lymphocytes and B-lymphocytes would be produced, typically a few weeks, after vaccination and the immunity building process can cause symptoms such as fever, muscle ache, *etcetera* which are normal signs. Such mild symptoms should disappear after a short while except in some rare allergy cases where appropriate medical treatment is necessary.

TYPES OF COVID-19 VACCINES

Various technology platforms have been used to create effective vaccines against COVID-19 but most of the clinical trials are focused on the coronavirus spike protein and its variants as the primary antigen infection. Recently developed platforms involved nucleic acid technologies (nucleoside-modified messenger RNA and DNA), non-replicating viral vectors, peptides, recombinant proteins, live attenuated viruses, and inactivated viruses as shown in *Figure 5*. Pharmaceutical manufacturers are producing COVID-19 vaccines commercially by different technology platforms as shown in *Table 1*. All types of vaccines will not cause COVID-19 but induce adaptive immunity to protect the recipients from the SARS-CoV-2 virus future infection.

TABLE 1. COMMON COVID-19 VACCINES

Vaccine producer	Technology platform	Required dose	Storage temperature
Astra Zeneca	Adenovirus vector	2	2 - 8°C
Pfizer–BioNTech	RNA	2	–70 ± 10°C
Sputnik V	Adenovirus vector	2	≤ –18°C
BBIBP-CorV	Inactivated SARS-CoV-2	2	2 - 8°C
Moderna	RNA	2	–20 ± 5°C
Johnson & Johnson	Adenovirus vector	1	2 - 8°C
CoronaVac	Inactivated SARS-CoV-2	2	2 - 8°C
BBV152	Inactivated SARS-CoV-2	2	2 - 8°C
Ad5-nCoV	Adenovirus vector	1	2 - 8°C
Sputnik Light	Adenovirus vector	1	2 - 8°C
WIBP-CorV	Inactivated SARS-CoV-2	2	2 - 8°C
EpiVacCorona	Subunit	2	2 - 8°C
ZF2001	Subunit	3	2 - 8°C
CoviVac	Inactivated SARS-CoV-2	2	2 - 8°C
QazCovid-in	Inactivated SARS-CoV-2	2	2 - 8°C
Minhai	Inactivated SARS-CoV-2	2	2 - 8°C

PANDEMIC PREVENTIVE STANDARD OPERATION PROCEDURE

Palm oil mills have been categorised as an essential sector and are allowed to operate with adherence to respective directives during country lock-down, standard operation procedures for workplace infection prevention should be established as recommended (DOSH, 2021).

Normal Daily Attendance Procedure

- Palm oil mill personnel who enter the workplace shall wear a facemask.
- Report to security personnel or scan the provided MySejahtera application QR code.
- Undergo body temperature measurement which should below 37.5°C.
- Comply with physical distancing requirement via work from home policy.
- Palm oil mill personnel should not enter the workplace if:
    1. body temperature is above 37.5°C.
    2. become Person Under Investigation (PUI).

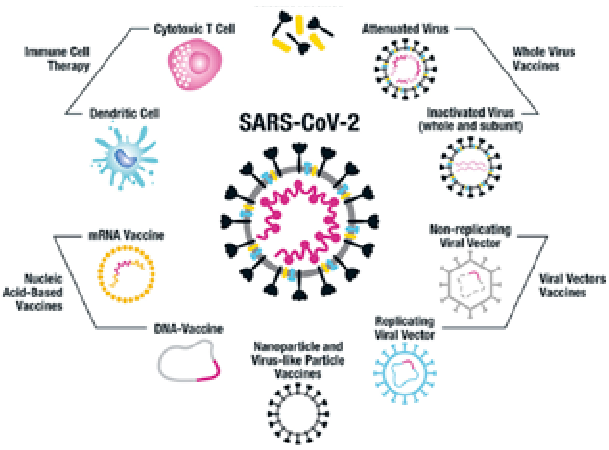


Figure 5. Various technology platforms for COVID-19 vaccine production.

Normal Daily Routine Duty

- Implementing alternative communication methods such as virtual meetings.
- Avoid unnecessary visitors and physical meetings.
- Common areas such as toilet should undergo disinfection process as recommended.
- Do not share personal items such as personal protection equipment (PPE).
- Facemask and hand sanitiser should be provided adequately.

Managing Emergency Situation

In the event, any worker showing COVID-19 symptoms during on duty,

- Mill Supervisors assisted by Emergency Response Team (ERT) should isolate the symptomatic worker in a special setting. Gather information on the situation and inform the mill management.
- The ERT involved in the first aid treatment must comply with established procedures and wear appropriate PPE.
- The symptomatic worker should be sent to the hospital for further examination.
- Mill management needs to identify other employees having close contact with the symptomatic worker.
- Mill management needs to identify the affected areas for immediate cleanup and disinfection process according to the recommended method.

NATIONAL VACCINATION PROCEDURE

The National COVID-19 Immunization Program (PICK) provides free vaccines for the whole of Malaysia society above the age of 18, regardless of whether they hold citizenship or not on a highly encouraged voluntary vaccination basis. A total of 66.7 million doses of the vaccine have been procured from various producers worldwide. Three vaccine distribution strategies and target groups have been identified. The first strategy is to vaccinate front liners to ensure that the health sector continues to operate optimally. The second strategy is to reduce the high-risk groups disease burden thus, reduce the load on the public health system. The third strategy is to carry out vaccination in high-risk areas through risk assessment so that the disease spreading could be controlled.

The vaccination process is carried out through the MySejahtera application and website https://www.vaksincovid.gov.my or manual registration at public and private health facilities. Appointment details such as dates and vaccination center location will be informed through the MySejahtera application, phone calls or short message service (SMS). *Figure 6* shows the standard operation procedure (SOP) for COVID-19 vaccination in Malaysia (JKJAV, 2021).

In an effort to contain workplace clusters, The PICK Phase 4 involving critical economic sectors commenced at industrial areas recently while Program Imunisasi Industri Covid-19 Kerjasama Awam-Swasta (PIKAS) for the manufacturing sector was launched. More industry vaccination centers (PPV) will be opened to other sectors such as manufacturing, construction, plantation, retail and hospitality in the later stages. On-site vaccination at designated factories and industrial locations would also be implemented (BERNAMA, 14 June 2021).

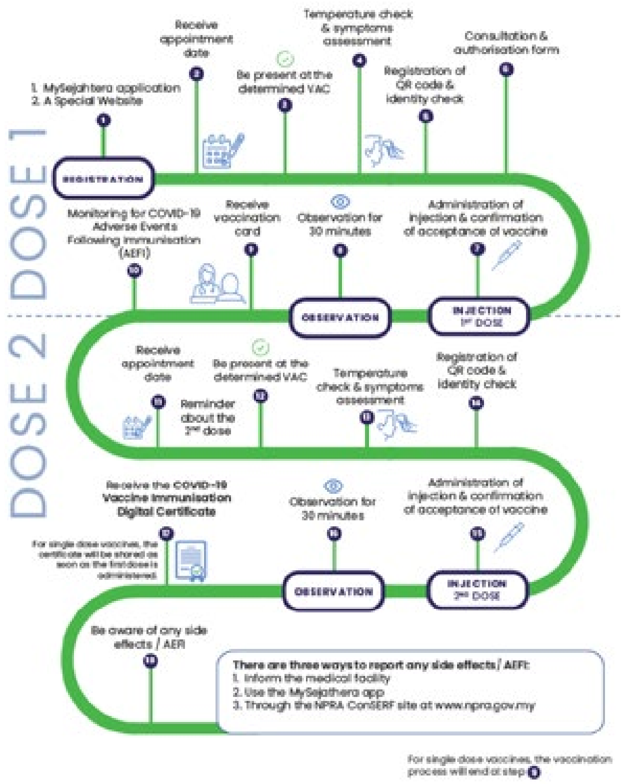


Figure 6. Standard operating procedure for COVID-19 vaccination.

DISCUSSION

Coronaviruses are studded with spikes that undergo dramatic transformation once attached and stretched before partially turned inside out to fuse forcefully with host cells. Immune systems must develop antibodies that target the pre-fusion conformation spike protein to prevent cell fusion in order for COVID-19 vaccines to be effective. Unfortunately, spike proteins spring from stubby pre-fusion shape into elongated post-fusion form on a hair trigger as shown in *Figure 7*.

Structural biology and persistent protein engineering showed that adding two prolines (C5H9NO2) to a vaccine

Figure 7. Pre-fusion and post-fusion spike conformation.

spike protein key joint could stabilise the pre-fusion structure shape. This technique is known as 2P mutation that may herald a new generation of vaccines.

Classical vaccines use an entire virus that has been weakened or deadened with formalin. Contemporary vaccines contain certain critical proteins that could induce appropriate antibodies creation to react against an infection. Modern vaccines deliver mRNA that encodes the viral protein. However, in some cases referred to as ADE, the viral protein may induce antibodies synthesis to act against the virus but failed to protect against infection instead, making the disease worse.

An antibody that is dependent enhancement (ADE) occurrences are due to F protein metamorphosis during infection similar to spikes. The adaptive immune system produces antibodies against post-fusion F but failed to neutralise the virus. If the F protein could be locked in pre-fusion form, viral fusion could be prevented and the immune system might be able to produce antibodies that could prevent infection. The pre-fusion form was successfully locked via the 2P mutation technique where the addition of two prolines in the loop between two helices clamps the spring together. However, SARS-CoV-2 pre-fusion stabilised spike protein structure study suggested additional four prolines on top of 2P mutation to further stabilise other protein regions (Ryan Cross, 2020).

CONCLUSION

The vaccine is vital to establish adaptive immunisation for COVID-19. Malaysia National COVID-19 Immunisation Program targets to achieve 80% herd immunity by the end of 2021. Several COVID-19 synthetic vaccines use the 2P mutation technique to lock the spike protein into pre-fusion configuration to enable an immune response to the virus. Vaccine development platforms improve antigen manipulation flexibility to address virus mutation to new variants matter in order to ensure the vaccine's effectiveness over time. Homo sapiens and COVID-19 viruses are predicted to be co-existence even public health condition will be recovered in the near future thus, new living norms are inevitable nationwide. Post pandemic era will likely witness the Industrial Revolution 4.0 due to labor shortage in the industry sector and environment sustainability issues.

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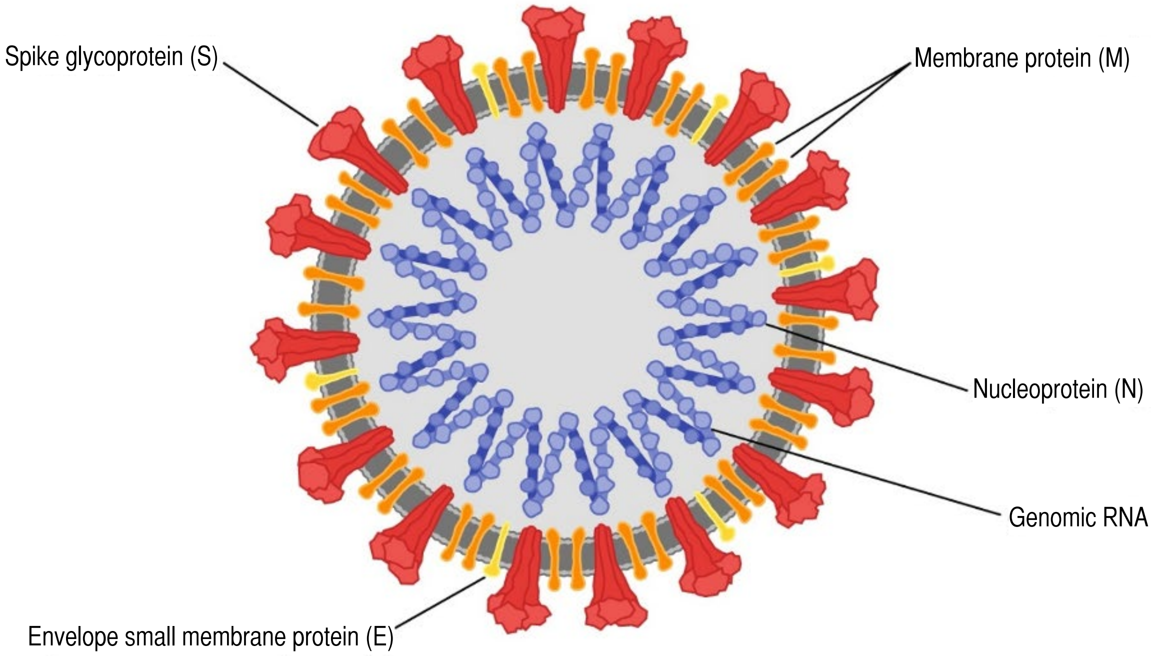
Appendix



Coronavirus structure.

KURSUS PENYELIA KILANG SAWIT 2021

8–15 NOVEMBER 2021

OBJEKTIF KURSUS

Untuk meningkatkan kemahiran teknikal dan menambahkan pengetahuan anggota penyelia kilang sawit.

MODUL KURSUS

1. Pengenalan kepada Pokok Sawit
2. Penerimaan dan Pengendalian Buah Tandan Segar (BTS)
3. Kod Amalan Baik Pengilangan Sawit
4. Pensterilan Tandan Sawit
5. Peleraian dan Pemerahan Buah Sawit
6. Penjernihan Minyak Sawit Mentah
7. Pemprosesan Isirung Sawit
8. Operasi Dandang (*Boiler*)
9. Operasi Turbin (*Turbine*)
10. Kejuruteraan Asas Mekanikal dan Elektrikal
11. Kawalan Kualiti Minyak Sawit dan Isirung Sawit
12. Rawatan Air Mentah
13. Rawatan Efluen Sawit
14. Hak-Hak Pekerja di bawah Akta Perhubungan Perusahaan
15. Pencegahan Kemalangan di Kilang Sawit
16. Tanggungjawab Kilang Sawit terhadap Alam Sekitar

KAEDAH KURSUS

- Secara dalam talian (*online*) menggunakan platform Microsoft Teams Education
- Ceramah
- Peperiksaan (60%), Projek (40%)
- Bahasa Melayu sebagai bahasa pengantar

Nota: Peperiksaan, projek dan laporan diwajibkan. Kertas kerja projek perlu diserahkan dalam tempoh dua bulan dari tarikh peperiksaan kursus untuk status lulus/gagal.

PERMOHONAN KURSUS

- Melalui http://apps.mpob.gov.my/application/cms/2021_31penyeliakilang.nsf/Conference%20Registration%20Web?OpenForm atau imbas Kod QR.
- Laman web rasmi MPOB di www.mpob.gov.my

SYARAT KELAYAKAN

- Warganegara Malaysia.
- Dua tahun pengalaman bekerja di kilang sawit atau di bidang berkaitan

SASARAN PESERTA

Penyelia kilang sawit dan petugas yang terlibat dalam aktiviti kilang sawit.

TEMPOH KURSUS

Kursus : 8 – 12 November 2021 (5 hari)
Peperiksaan : 15 November 2021 (1 hari)

YURAN PENYERTAAN

RM700

PERTANYAAN

Untuk keterangan lanjut, sila hubungi:

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