

# THE DEVELOPMENT OF A RESIDUAL OIL RECOVERY SYSTEM TO INCREASE THE REVENUE OF A PALM OIL MILL

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## ABSTRACT

*The Malaysian oil palm industry is an export orientated industry which heavily relies on the world market. The Malaysian oil palm industry has shown stellar performance in 2011. The average annual price of palm oil for the year 2011 breached the RM 3000 mark to register at RM 3219, while the export revenue of palm products reached a record high of RM 80.4 billion. Since the 1980s, the judicious utilisation of the various by-products through nutrient recycling in the fields has reduced environmental impact, thus paving the way towards a zero-waste policy. Crude palm oil (CPO) is produced in the palm oil mills by mechanically extracting it from the digested mesocarp of the palm fruits. Currently, mills use screw presses for the oil extraction process. However, mechanical methods have their limitations, as some oil will still remain in the mesocarp, even after being subjected to high pressure mechanical squeezing in the screw presses. The pressed mesocarp fibre retains about 5.0%-11.0% oil expressed as a ratio to the dry matter. This translates into an oil loss per tonne of fresh fruit bunches (FFB) in the range of 0.25%-0.55%, at an average moisture content of 36% in the pressed mesocarp fibre. In order to recover part of this residual oil in the pressed mesocarp fibre, a residual oil recovery system (RORS) was developed. This system has the ability to recover the residual oil in the pressed mesocarp fibre by using a washing technique, followed by pressing to recover CPO. Water at a certain temperature is used to wash the pressed mesocarp fibre in the digester, following which the fibre is pressed in a screw press. The water and oil expelled by the pressing operation after channeling to a vibrating screen to filter out the solid tailings are directed to an oil recovery tank situated in the mill. The recovered oil is then fed into the clarification tank or the purifier tank while the water phase is either treated for recycling or disposed. The system is found to reduce the residual oil content in the pressed mesocarp fibre to as low as 2.0% on a dry basis. This translates into 0.72% on a wet basis. The normal oil loss in pressed mesocarp fibre in the mill is 5% to 11% on a dry basis (equivalent to 1.8% to 3.96% on a wet basis). The oil extracted by RORS also depends on the amount of oil loss, and will range from 3.0% to 9.0% on a dry basis, or 1.08%-3.24% on a wet basis. This translates into 0.15% to 0.45% oil recovery per tonne of FFB. CPO that is extracted from the pressed mesocarp fibre by RORS exhibits even better oil quality than the normal CPO.*

**Keywords:** palm oil mill, pressed mesocarp fibre, crude palm oil, residual oil recovery system.

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## INTRODUCTION

The Malaysian oil palm industry is an export orientated industry which heavily relies on

the world market. It has shown stellar performance with record highs in key performance indicators, namely price of palm oil products, crude palm oil (CPO) production, imports, exports volume as well as revenue. Average annual price of palm oil for the year 2011 breached the RM 3000 mark to register at RM 3219, while the export revenue of palm products reached a record high of RM 80.4 billion, an increase of 34.5% against RM 59.8 billion achieved in 2010 (Choo, 2012).

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CPO processing was carried out in Malaysia even as early as the 1920s as records show that some of the mills were built during the pre-war period. At that time, there were only five palm oil mills and since then these mills have been upgraded and refurbished. It was only in the 1970s that the World Bank identified the oil palm crop as a suitable alternative agricultural crop for Malaysia and since then the growth of this industry has been phenomenal (Chow *et al.*, 2001). However, the palm oil milling process has not witnessed significant improvements since its inception especially the techniques employed for extracting the CPO from the conditioned mesocarp of the palm fruits.

The process in the palm oil mill as shown in Figure 1 starts with the delivery of a consignment of fresh fruit bunches (FFB) at the mill weighing station. The consignment after weighing is unloaded into the mill hoppers from which it is discharged into sterilisation cages and is now 'sterilised' a term that performs the dual function of sterilisation as well as pressure cooking the FFB, a prerequisite for the subsequent process steps like stripping, digestion and pressing operation. The sterilisation process generally takes 90 min involving de-aeration phase of the steriliser chamber as well as the pressure cooking phase of the bunches. The sterilisation process loosens the fruits adhering to the sockets on the stalk so that during the stripping operation the fruits easily get detached. In addition, the steam also deactivates the enzymes responsible for the rapid break down of the oil and the rise of the free fatty acids (FFA).

The sterilised FFB are then sent to a stripper where the fruitlets are separated from the stalks or bunches, now called empty fruit bunch (EFB). The fruitlets from the stripper are then sent to a digester, where they are converted into a homogeneous oily mash by means of a mechanical stirring process. The digested mash is then pressed using a screw press to press out most of the CPO. At this point, the CPO comprises of a mixture of oil, water and solids which are screened using vibrating screen to remove as much solids as possible. The CPO is then clarified in a continuous settling tank. The decanted CPO passes through a centrifugal purifier and desander to remove any remaining impurities and then to the vacuum dryer to remove the moisture. The CPO is then pumped to storage tanks before it is despatched for export or refining at the refineries. The press cake comprising the nuts and the mesocarp fibre

are separated in the depericarp column when it is subjected to suction created by an induced draft fan located at the exit of a fibre cyclone. The separation is accomplished by using the difference in the separating velocities of fibre and nuts. The fibre will be drawn to the fibre cyclone whereas the nuts will drop into the polishing drum located directly underneath the separating column. The nuts are then cracked to produce kernel and shell. The kernels are transported to kernel crushing plants to be processed into crude palm kernel oil while the shell and pressed mesocarp fibre are used as boiler fuel.

Over the years the oil palm industry has been very responsible and all the by-products have gradually been utilised. Since the 1980s, the judicious utilisation of the various by-products through nutrient recycling in the fields has reduced the environmental impact thus paving the way towards zero-waste policy (Chan, 1999).

As described earlier, the CPO is produced by squeezing out the oil from the digested mesocarp of the palm fruits. Currently, mills use screw presses for this operation. However, mechanical methods have their limitations as some oil will still remain in the mesocarp even after being subjected to high pressure mechanical pressing in the screw presses. The problem that arises from applying too high a pressure to the mesocarp fibre and nut mixture to press out the CPO is that this will cause the nuts in the mixture to crack resulting in high amount of broken kernel. This directly affects the quality of the kernel and the quantity of kernel oil that can be obtained. In order to retain a balance between the oil loss in the pressed mesocarp fibre and kernel quality, mills limit the pressure of the screw press. As a result, there is some oil retained in the pressed mesocarp fibre and this loss is accepted as one of the allowable losses by the industry.

The pressed mesocarp fibre retains about 5.0%-8.0% (Harrison *et al.*, 2006) oil as a ratio to dry matter. Recent studies (Adzmi *et al.*, 2011) show that the oil retained in pressed mesocarp fibre in Malaysia ranges from 5.0% to 11.0% oil as a ratio to dry matter, which translates into an oil loss per tonne of FFB in the range of 0.25%-55% at an average moisture content of 36%. In the year 2011, 18.91 million tonnes of CPO were produced in Malaysia (Choo, 2012). This translates into approximately 94.55 million tonnes of FFB processed in 2011. This gives a national oil loss in pressed mesocarp fibre in the year 2011 in the range of 236 375 t – 520 025 t CPO which is equivalent to a loss of RM 700 million to RM 1.5



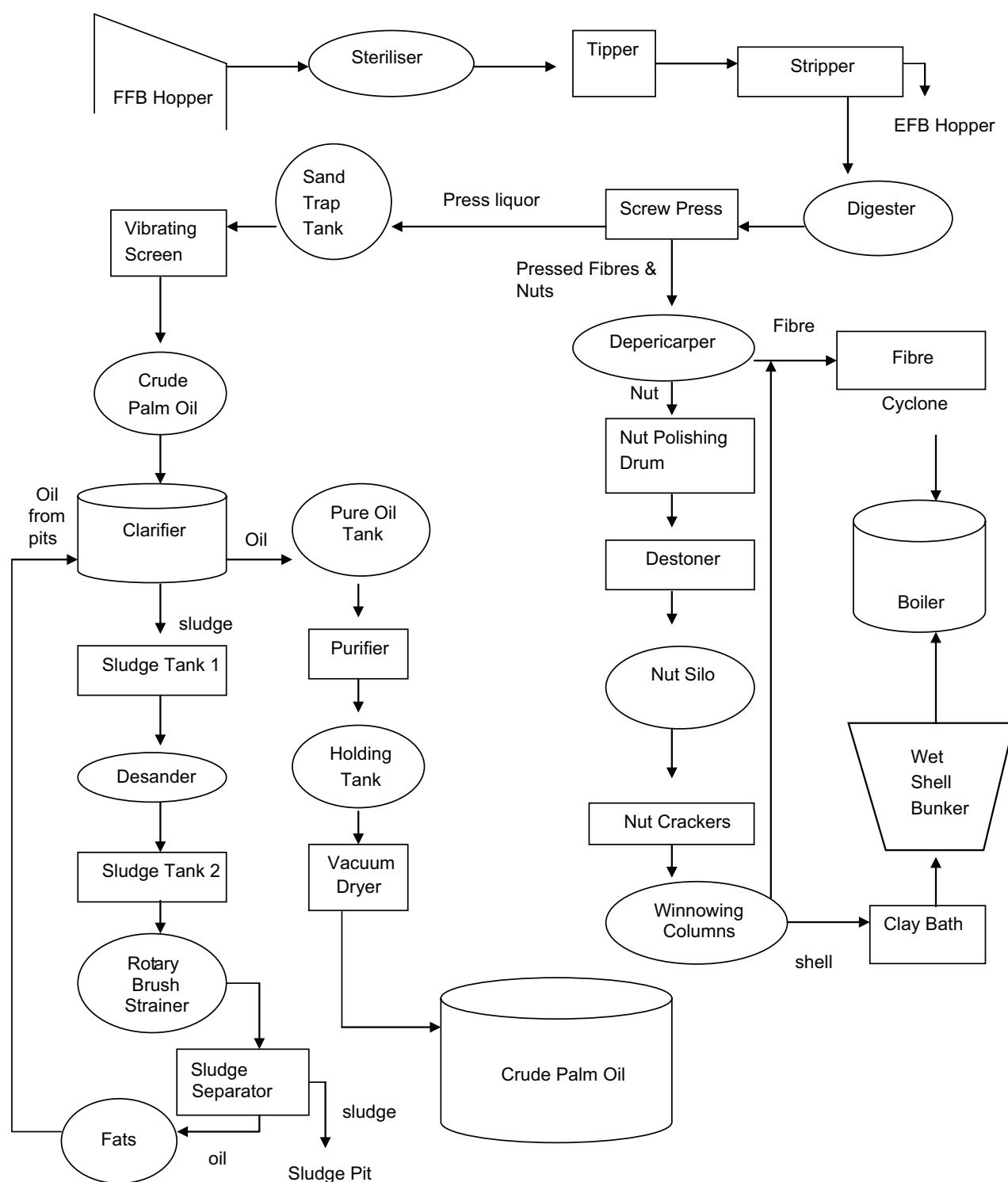


Figure 1. Palm oil milling process.

billion nationally in the pressed mesocarp fibre with CPO prices at RM 3000 in the year 2011 alone.

This study focuses on the process involved in extracting part of the oil that is lost in the pressed mesocarp fibre. There are many possible methods to recover the oil from the pressed mesocarp fibre. Among them are solvent extraction, enzymatic

treatment, supercritical carbon dioxide (SC-CO<sub>2</sub>) extraction, *etc.* The residual oil can be completely recovered in the solvent extraction process but the cost and safety issues have to be considered. This article focuses on the recovery of the oil from the pressed mesocarp fibre using the residual oil recovery system (RORS).

## OBJECTIVES

The objectives of this study are:

- to develop a simple and practical system that can recover the residual oil from the pressed mesocarp fibre; and
- to reduce the oil loss to the minimum in the pressed mesocarp fibre, during processing of FFB.

## METHODOLOGY

The RORS was developed to recover part of the residual oil in the pressed mesocarp fibre. This system uses the 'wet extraction' method that uses hot water to leach out the oil from the mesocarp fibre, which is retained after pressing. This method resembles both the solvent extraction method and the double squeezing method. Here, instead of a chemical solvent, hot water is used and the pressed mesocarp fibre is squeezed again. The RORS is applied to the pressed fibre after the fibre cyclone, where the pressed fibre which has been separated from the nut is channelled to the boiler. A simplified flow chart is shown in *Figure 2*.

Water at a certain temperature is used to wash the pressed mesocarp fibre in the digester, following which the fibre is pressed in a screw press. The water and oil expelled by pressing are then sent to a vibrating screen to remove coarse solids and are recovered in the oil recovery tank in the palm oil mill. The oil is then sent to the pure oil tank or clarification tank, while the water is sent for treatment or recycling. The pressed mesocarp fibre that has gone through the RORS is then channelled back to the boiler, to be burnt as boiler fuel together with the shell. *Figures 3 to 5* show various aspects of RORS.

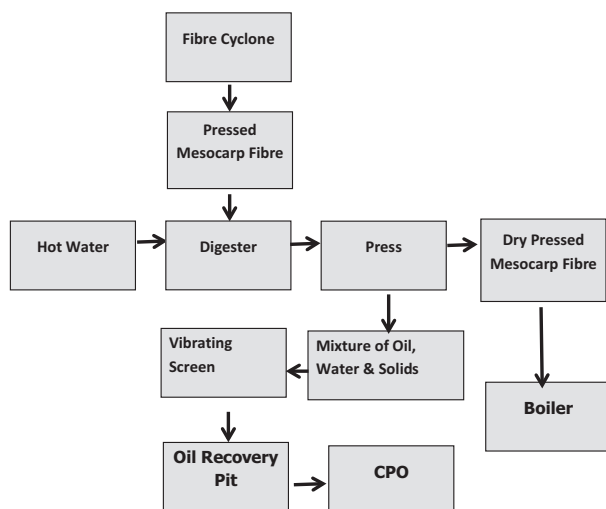


Figure 2. Simplified flow chart of the residual oil recovery system process.

## RESULTS AND DISCUSSION

The results show that the moisture content of the pressed mesocarp fibre decreases after going through RORS, which involves the pressed mesocarp fibre being washed and pressed again. The average moisture content of the pressed mesocarp fibre before entering RORS is 35.4%, and drops to 32.11% after passing through RORS.

According to the performance of the RORS, the system can bring down the amount of oil in the pressed mesocarp fibre to as low as 2% (dry basis) and 0.72% (wet basis). The amount of oil that can be recovered depends on the oil loss in the pressed mesocarp fibre of the individual mill, which ranges from 5% to 11% (dry basis) as shown in *Table 2*. *Figure 6* clearly shows the performance of the RORS whereby, the higher the oil loss the more oil can be recovered.



Figure 3. The residual oil recovery system.



Figure 4. A mixture of oil, solids and water coming out of residual oil recovery system process.

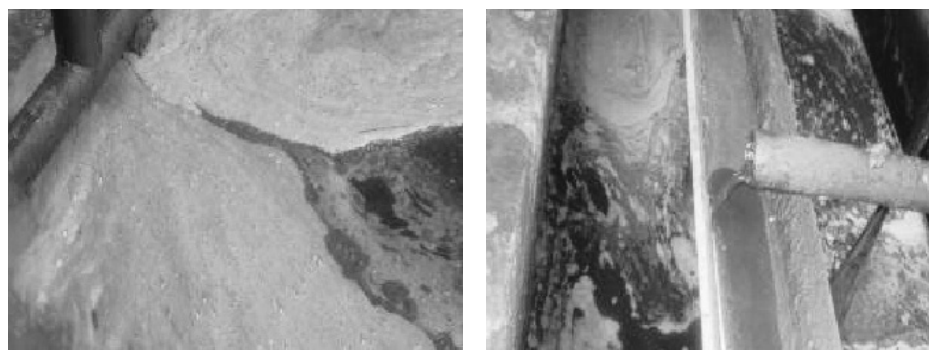


Figure 5. Oil extracted by residual oil recovery system process being recovered at the oil recovery tank in the palm oil mill.

**TABLE 2. THE AMOUNT OF CRUDE PALM OIL LOSS IN PRESSED MESOCARP FIBRE AND THE AMOUNT RECOVERABLE USING RESIDUAL OIL RECOVERY SYSTEM PROCESS (RORS)**

Oil loss in press fibre (dry basis) (%)	5	6	7	8	9	10	11
Oil loss in pressed fibre to fresh fruit bunches (%)	0.2520	0.3024	0.3580	0.4032	0.4536	0.5040	0.5544
Oil recovered using RORS from pressed fibre to fresh fruit bunches (%)	0.1512	0.2016	0.2520	0.3024	0.3528	0.4032	0.4536

**TABLE 3. RESIDUAL OIL RECOVERY SYSTEM PROCESS (RORS) PERFORMANCE RESULTS AND COST BENEFITS**

For a 45 t mill, average process (t FFB yr <sup>-1</sup> )	270 000	
Percentage of mesocarp fibre to FFB (%)	14	
Moisture content of meoscarp fibre (%)	36	
<u>According to the performance of the RORS, the oil left in fibre is as low as 2% (dry basis) and 0.72% (wet basis)</u>		
	Min	Max
Typical oil loss in pressed mesocarp fibre	5% (dry basis)	11% (dry basis)
	1.80% (wet basis)	3.96% (wet basis)
Typical oil loss in pressed mesocarp fibre /t FFB	0.25%	0.55%
Oil extracted out by RORS	1.08% (wet basis)	3.24% (wet basis)
Oil extracted out/t FFB	0.15%	0.45%
Oil extracted out per year	408.24 t	1 224.72 t
Extra revenue for mill per year		
(CPO average prices of RM 2500)	RM 1 020 600	RM 3 061 800
(CPO average prices of RM 3000)	RM 1 224 720	RM 3 674 160

Note: FFB - fresh fruit bunches.

CPO - Crude palm oil.

The oil extracted by RORS also depends on the amount of oil loss, and will range from 3.0% to 9.0% on a dry basis, or 1.08%-3.24% on a wet basis. This translates into 0.15% to 0.45% oil recovery per tonne of FFB.

As shown in Table 3, at a typical 45 t hr<sup>-1</sup> palm oil mill, a total of 270 000 t FFB is processed per year. At an average CPO price of RM 2500 t<sup>-1</sup>, the oil recovered by RORS will bring in an additional revenue ranging from RM 1.02 million to RM 3.06 million per year, depending on the oil loss of the mill. With CPO prices of RM 3000 t<sup>-1</sup> as it was in 2011, the additional revenue will range from RM 1.22 million to RM 3.67 million, depending on the

oil loss of the mill. The water required to extract the oil from the pressed mesocarp fibre is about 0.011 t/ t FFB. The wear and tear of the system is similar to that of the screw press, which has a life-span of more than 400 hr for 6000 t of FFB processed.

Studies have shown that recovered fibre oil from pressed palm fruits, which is normally burned as fuel to provide energy for the palm oil mills, has now been found to be a rich source of carotenoids, vitamin E (tocopherol and tocotrienols), and sterols (Choo *et al.*, 1996). In the same manner CPO that is extracted from the pressed mesocarp fibre using RORS also exhibits even better oil quality than normal CPO as is shown in Table 4.



## CONCLUSION

Currently, the pressed mesocarp fibre which contains 5%-11% oil is just burnt in the boilers. Even though this has been accepted as an allowable and normal oil loss in the palm oil mills, with the need to increase the oil palm industry's productivity, extracting this residual oil will definitely benefit the industry. It not only increases the revenue of the palm oil mills but also can help increase the OER of the country to a certain extent. RORS provides an avenue to extract this residual oil at the palm oil mills after which the pressed mesocarp fibre can be used back as fuel in the boiler as the normal practise.

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TABLE 4. OIL QUALITY PARAMETERS

	Oil extracted from pressed fibre by residual oil recovery system process	Normal crude palm oil
Vitamin E, ppm	1 700-2 600	600 – 1 000 ( Ng <i>et al.</i> , 2004)
Carotenes, ppm	1 400-1 600	500 – 700 (Bonnie, 2007)
FFA, %	3.33-4.85	5 (max.) (Siew, 2004)
DOBI	2.8-3.0	2.31 (min.) (Siew, 2004)

Note: FFA – free fatty acids.

DOBI – deterioration of bleachability index.

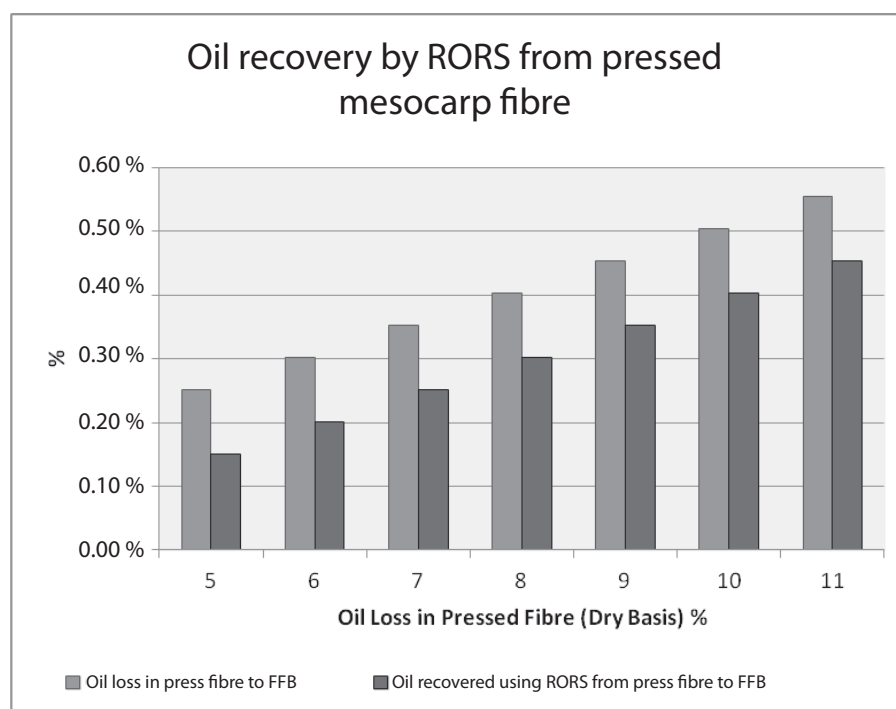


Figure 6. Graphical illustration of the amount of crude palm oil recovered by residual oil recovery system process (RORS) from the pressed mesocarp fibre.

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