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Determination of the optimum frequency for *Elaeis guineensis Jacq.* detachment

Wan Ishak Wan Ismail [1], Lam Wai Yip[1] and Mohd. Hudzari Razali [2*]

[1]Department of Biological and Agriculture Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
[2]Department of Agriculture Science, Faculty of Agriculture and Biotechnology, Universiti Sultan Zainal Abidin, 20400,UNiSZA Kuala Terengganu, Terengganu, Malaysia
*Corresponding author: Email: hud47@hotmail.com

Abstract: In *Elaeis guineensis Jacq* (oil palm) industry, fruit detachment and oil extraction of oil palm bunches are always being carried out in palm oil mill in a series of standard procedure. A lot of energy is needed and consumed throughout the procedure, especially during sterilization where a huge amount of energy is needed to produce pressurized steam in order to cook the fruit bunches, only to soften and weaken the stalk so as to facilitate the detachment of the fruits by threshing. This study was proposed to search for an alternative to this current practice. By developing a vibrational oil palm fruit detaching machine, fruitlets were detached from the bunch by means of vibration. The optimum vibration frequency for the detachment of fruitlets from the stalk was determined. On top of that, the use of ethephon hormone to loosen the fruitlets before they are detached from the bunch using the vibrational oil palm fruit detaching machine is also justified in this study. The designed and developed experimental vibrational oil palm fruit detaching machine was found to be able to detach fruitlets from the bunch when it is applied with vibration. Besides, the optimum frequency for the vibrational oil palm fruit detaching machine to detach the fruitlets from the bunch was determined to be 3.3Hz. The use of ethephon hormone (Esigel) in this project has been justified that it has no side effect on the fruit components and moisture content of the oil palm bunches.

Key words: *Elaeis guineensis Jacq. Detachment, Oil Palm Extraction, Vibrational Machine, ethephon hormone (Esigel)*

INTRODUCTION

Fruit detachment of oil palm (*Elaeis guineensis*) in palm oil processing has always been carried out in the palm oil mill, where sterilization is carried out to soften the fruits followed by threshing of bunches to detach the fruitlets from the stalks. In modern oil palm industry, there are several processes the fresh fruit bunches (FFB) had to go through before they can be sent into the mill to be processed into edible oil. These include harvesting and crop evacuation, which is a series of transportation of harvested crop from field to mill to be further processed. Before the extraction of oil palm products can be considered, the post harvesting activities actually need attention as this is where the free fatty acid (FFA) content in the bunches increases (Khaik et al., 1985; Hudzari et al,, 2011).

The process of harvesting is the start of bruising of the fruit. Harvesting operations started off with harvesters moving through the area to be harvested and identifying ripe bunches using visual or color judgment. Color usually used to recognize the maturity stage and harvesting process of agriculture products. Even the righteous book, Al-Quran in surah Al Hadiid, Chapter 57 of verse 20; the color of yellow was mentioned had related with the maturity stage of the agriculture product (Mohd. Hudzari et al., 2010). Basically a bunch is considered ripe when there are five or more loose fruits on the ground (Wan Ishak et al., 2000). Then, fronds obstructing retrieval of ripe bunches are removed. Fruits may be damaged during this process. After the bunch is reaped, the impact further damages the fruit as it falls to the ground. Furthermore, the fruit bunches are subjected to more bruises during the transportation of the fruit bunches to the mill.

In a fresh ripe and un-bruised fruit the FFA content of the oil is below 0.3 percent. However, in the ripe fruit the exocarp becomes soft and is more easily attacked by lipolytic enzymes, especially at the base when the fruit becomes detached from the bunch. The enzymatic attack results in an increase in the FFA of the oil through hydrolysis. Research has shown that if the fruit is bruised, the FFA in the damaged part of the fruit increases rapidly (Rajanaidu and Tan, 1983). Therefore, the composition and quality within the bunch can be greatly varied, depending on how much the bunch has been bruised. As far as the quality of the fresh fruit bunches before being processed is concerned, it is therefore very crucial to transport bunches rapidly to the mill after harvesting, to minimize bruising during handling and transport, and to process bunches as quickly as possible.

The oil winning process basically involves the reception of FFB from the plantations, sterilizing and threshing of the FFB to obtain the fruits, and pressing to get the crude palm oil. The crude palm oil is then clarified, purified, and go through the oil vacuum dryer to be dried before it is stored in the purified oil storage tank and exported (Azis, 1985). Throughout the process of transporting the FFB to the mill and the process of obtaining the fruits from the bunch, a lot of energy is needed and consumed. Especially during sterilization, a huge amount of energy is needed to produce pressurized steam in order to cook the fruit bunches, only to soften and weaken the stalk so as to facilitate the detachment of the fruits by threshing.

Ethephon is a widely used plant growth regulator. When it is metabolized by the plant, it is converted into ethylene, which is a potent regulator of plant growth and maturity. Esigel is a product of Advanced Agriecological Research Sdn. Bhd., which is a latex stimulation hormone based on improved formulation of ethephon which gives higher yield response of latex production. Even the formation of improved formulation in enzyme also had potential for enhancement of biotechnological application in animal feed, food nutrition, soil nutrient enhancement etc (Anis et al., 2009). Esigel is commercialized product and widely used by rubber trees grower all over the country to increase the yield of the latex. It is feasible that the application of ethephon can be extended to oil palm industry where oil palm fruit's maturity can be accelerated and therefore fruitlets can be detached more easily. Esigel, a latex stimulation hormone based on improved formulation of ethephon which gives higher yield response of latex production. Ethephon is a plant growth regulator. When it is applied to various growth sites of a plant, it regulates phases of plant growth and development. The mode of action of ethephon is through the release of ethylene, which is then absorbed by the plant and interferes in the growth process of the plant. Besides, its usage in accelerating the ripening of fruits and vegetables is also widely applied in modern agriculture. In our country, they are widely used by rubber trees grower to increase the yield of the latex (EXTOXNET, 1995).

The method used to process oil palm fruit bunches can affect the quality of extracted oil. J.H.R. Ohlson (1976) stated that processing can have rather strong effects on oil quality. It is very important to avoid deleterious factors such as long processing times, contact with oxygen, high temperature, light, and other oxidation catalysts if high quality oils are to be obtained. The initial quality of the oil-bearing material should be very high, and the processing should be continuous and rapid. He showed that the longer the time is taken to process the fruit, the lower the quality of oil obtained. On top of that, high temperature is also a factor which can greatly affect the quality of oil obtained.

Much research has been done to improve the current oil palm processing method. Different approaches have resulted in different methods of processing oil palm fruit bunches. Chow MC and Ma AN (2007) proposed to process fresh palm fruits using microwaves. Renu Jain et al., (2009) study about the time frequency that helpful for replacing in better microwave application on processing. Microwave heating was determined to be suitable for the detachment and drying of palm fruits from whole bunches, cut bunches and spikelets. Microwave treatment of the palm fruits was able to attain the objectives of conventional fresh palm fruits sterilization processes such as fruit softening, nut conditioning and halting of enzymatic lipolysis. Palm oil and kernel oil solvent extracted respectively from the microwave treated whole fruits and kernel were found to have a good quality of low free fatty acid content. Together with the solvent extraction of the dehydrated fruits, this technology proved may have the potential to be a continuous, dry and clean technology for palm oil milling.

Sukaribin and Khalid (2009) further the research to study the effectiveness of sterilization of oil palm using microwave technology. They suggested that the extraction of crude palm oil from oil palm bunches requires the bunch to be sterilized and the fruitlets detached before it can be further processed for oil recovery. They conducted a research to find ways to reduce oil loss in condensate and make sterilization a continuous process. This paper discussed a laboratory scale study on microwave sterilization, together with the microwave dielectric properties and moisture content surrounding the abscission layer of oil palm fruitlets. They found that the moisture content was higher in the abscission region as compared to the other regions of the fruitlet. With stripping efficiency above 80%, they concluded that microwave radiation is suitable for quick detachment of the fruitlets from the bunch since the abscission layer is heated-up and fruit loosening performed without damaging other regions of the fruit.

Vibration is used for detaching date fruits in Iran. Abounajmi. M. (2000) has designed and developed an experimental shaker for vibratory date detachment. The result of the study showed that the bunch shaker was capable of removing ripe fruit from the bunch at 5-7 second without imparting rubbing and bruising damage to the fruits. Besides, the author has also done another research on investigating the effects of shaking mode, frequency and amplitude on date fruit detachment. The results of this research indicated that bunch shaker was capable of removing marketable ripe dates from the bunch without imparting any significant rubbing or bruising damage to the fruits.

The objectives of this study are to develop a vibrational oil palm fruit detaching machine, to determine the efficiency of detachment of oil palm fruitlet by vibrational method, to determine the optimum vibration frequency for the detachment of fruitlets from the stalk, and also to determine the effectiveness of ethephon hormone as the detachment agent for oil palm. In addition to that, the use of ethephon hormone to loosen the fruitlets before they are detached from the bunch using the vibrational oil palm fruit detaching machine is also justified. If the vibration method works with oil palm bunches, it will ease the separation of fruitlets from the bunch and improve the efficiency in the mill. In this study, Esigel was used to loosen the fruitlets as its main ingredient is ethephon hormone. Esigel is a latex stimulation hormone based on improved formulation of ethephon which gives higher yield response of latex production formulated by Advanced Agrieclogical Research Sdn. Bhd.

METHODOLOGY

Before the design of the vibrational oil palm fruit detaching machine was being carried out, several experiments were conducted to justify the use of hormone ethephon and also to determine the optimum reaction time for Esigel to loosen the oil palm fruitlets.

Determination of Ethephon's Effect on Fruit Components and Moisture Content

Before proceeding to determine the optimum reaction time of Esigel and the design of the vibrational fruit detaching machine, the use of ethephon hormone has to be justified especially its effects on the fruit components and moisture content of the fruits. Any effect that causes deviation of these parameters from the current practice will affect the integrity of the research, which is very much undesirable and is against the objective of this project.

To determine the effect of ethephon on fruit components, bunch analysis was performed. A bunch was chopped into 2 identical halves where the first half of the bunch was processed with the common bunch analysis method, which is Blaak's method that will be described in 3.2.1. On the other hand, the second half of the bunch was processed with the new method. For the new method, 10ml of Esigel of 10% concentration was used for injection and the fruit detaching was done by the readily available fruit detaching machine in the seed production laboratory to replace the yet-to-be-fabricated vibrational oil palm fruit detaching machine. The same procedure was done to 6 bunches simultaneously. The data was recorded and the results were shown in Table 1.

On the other hand, to determine the effect of ethephon on moisture content of fruitlets, a bunch was chopped into 2 identical halves. Both of them were weighed (Weight 1) before one of them was injected with 10ml of Esigel of 2.5% concentration. Then they were left overnight and weighed (Weight 2) again on the second day. Moisture content is the difference between Weight 1 and Weight 2. The procedure was carried out for 5 bunches simultaneously. The data was recorded and the results are shown in Table 2.

Bunch Analysis –Blaak's Method

Basically bunch analysis is a technique to know bunch, fruit, and oil components. The experiment was carried out at Advanced Agriecological Research Sdn. Bhd. - Paloh Sub-station, since the station carries out bunch analysis on a daily basis and they are well equipped with the necessary instruments for bunch analysis which done before by Rao et al., (1983).After the collected bunches from the field are transported back to Bunch Analysis laboratory, the data on the "Bunch Analysis" tag is transferred to the "Bunch and Fruit Analysis" card before bunch analysis procedure is being carried out. The card is also used to record all the data obtained from the following procedure. A bunch is first cleaned from debris and weighed. The number of loose fruits is also recounted again. A fruit will be cut in the middle to determine the fruit type, which is normally *Tenera*. Next, chopping is done to separate the spikelet components from the stalk by using an axe. The stalk is weighed and recorded before the chopped spikelets are mixed thoroughly on the chopping table using a spade. Then, 5.2kg random sample of spikelets are taken for further processed while the rest of them are discarded together with the stalk. This is followed by fruit picking, where fruitlets are separated from the spikelets with a metal scissors. The carpels are then removed and at the same time, fruitlets are divided into fertile fruits and parthenocarpic fruits. Together with the empty spikelets, the parthenocarpic fruits are weighed and then discarded. As for the fertile fruits, they are weighed and sub-sampled using the random sub-sampling box. From the sub-sampling box, 500g of fruits are selected, weighed, counted and recorded. The damaged fruits are replaced with non-bruised fruits with similar size and the sample is put into a polythene bag to proceed with depericarping. Depericarping is a process where mesocarp of the fruits is scraped off the nuts by using a sharp blade which is usually a penknife. Since the scraping process is done in a relatively fast manner, workers need to put on protective clothes on their hands and fingers to avoid unnecessary injuries. After scraping, the fruits are separated into mesocarp and nuts. The fresh nuts obtained are counted, weighed and recorded. After that, the nuts are put in a tray where they are dried in oven at 80ºC for 24 hours before they are cracked to separate the shells from the kernel components. The shells are discarded while the kernel weight is recorded to determine kernel to bunch.

As for the mesocarp, 100g of fresh mesocarp is put into an empty tray which is weighed previously and the total weight is also recorded. The tray is then labeled with its serial number and is dried in oven at 105ºC for 24 hours. It is then cooled in a desiccator. Subsequently the dry weight of the mesocarp can be obtained and recorded. This is followed by mincing the dried mesocarp with a blender. The minced mesocarp is then sieved to separate the larger particles which cannot be minced. About 5g of the minced mesocarp is put into a small extraction envelope which is made of filter paper and had pre-dried in oven for 2 hours. The envelope containing mesocarp is further dried in oven for another 2 hours before it is left to cool in the desiccator. Then the envelope is weighed and recorded. Finally, the last procedure which is oil extraction is being carried out. About 100 extraction envelopes are placed into the soxhlets containing 5 litres of n-hexane acting as the oil extracting agent that extracts oil from the mesocarp. After that, the envelopes are dried in air before they are put into oven again at 105ºC for 24 hours for further drying. The mesocarp is now turned into a non-oil solid called fibre and is cooled in the desiccator before it is weighed. The procedure of bunch analysis also was followed by Razali et al., (2009) for determining the relationship of the oil palm fruit color skin with its ripeness.

Determination of the Optimum Reaction Time of Esigel

To determine the reaction time of ethephon on the bunch, an experiment was conducted where 3ml of 2.5%, 5% and 10% concentration of Esigel were injected to 3 bunches each and the injected bunches were left to react with Esigel. Figure 1 show the different concentrations of Esigel used in this study. The time taken for the Esigel to loosen the fruitlets for each bunch was recorded in Table 3 and the means were calculated. It was assumed that the fruitlets are loose enough when they can be plucked off from the spikelets using merely fore-finger

Figure 1. Different concentrations of Esigel.

Design and Fabrication of Vibrational Fruit Detaching Machine

After the above experiments were done, the design of the machine was carried out. The machine was designed and sketched using Autodesk Inventor Professional 10 Educational Version. This software enables user to sketch out the machine parts by parts and assembly them. Besides, it allows the user to present his design through 3D animation, which helps the audience to visualize the parts of the machine and how they are being linked and work together. The design must take in considerations on the physical size of oil palm FFB and the ease in attaching and detaching of oil palm FFB on the vibrator. Figures 2 and 3 show the valve handle and the mainframe of the designed vibration machine for this project.

Main Frame

The main frame which is the main part to hold the palm bunch was constructed by welding three rectangular soft iron bars with 4.8cm x 4.8cm cross-sectional area. The length of the horizontal bar is 84cm, while the length of the 2 vertical bars is 90cm. A screw with sharp end was integrated into the middle of the frame vertically, which functions as the part to penetrate the bunch and hold it while it is being vibrated. The screw has a valve handle attached on top of it, which makes it more convenient for operator to rotate the screw up and down. It was thought of that, in future, the motor will be used to automatically screw the bunch to the machine. A stopper was inserted between the handle and the frame to lock the screw when the bunch is tightly held. The frame was built of soft iron and it was mounted onto a base with bolts and nuts. The minimum height from the base to the tips of the screw is approximately 25cm. This will give ample length of the screw to penetrate the FFB, to ensure stability, and at the same time leaving a clearance between the screw and the vibrating surface of the machine.

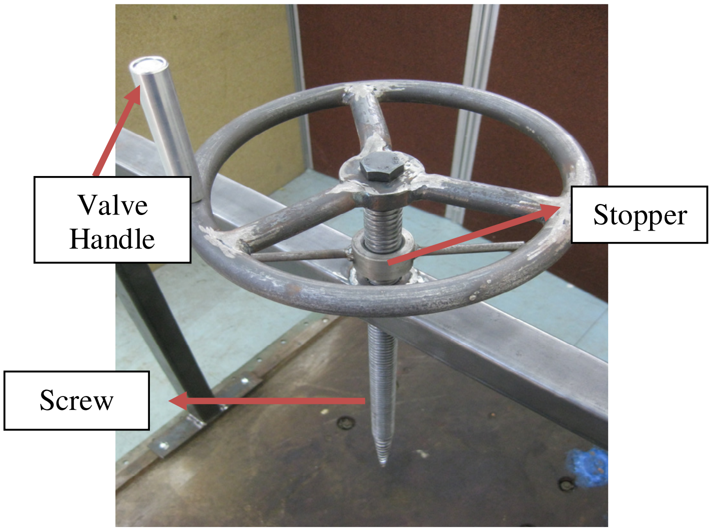

Figure 2. A valve handle was attached on top of the screw.

Basement

In this research, a readily available lab vibration machine was employed as the base of the fruit detaching machine. The vibration machine was found to be suitable as the vibration mode of the machine is of the oscillation type, which can provide continuous vertical strokes. In addition, the speed of this machine is adjustable, thus make it capable to generate vibration of different frequencies for the experiment purpose.

Mechanism of Vibration

From the gear of the vibration machine, there is a chain to transmit the output power with desired frequency to a pulley. The pulley which driven by a gear will reciprocate. Then the reciprocating motion is transformed into vertical stroke by the screw of the main frame. When the bunch which is held by the screw reciprocates with the frame, the vibration is transferred from the screw to the bunch to detach the fruitlets.

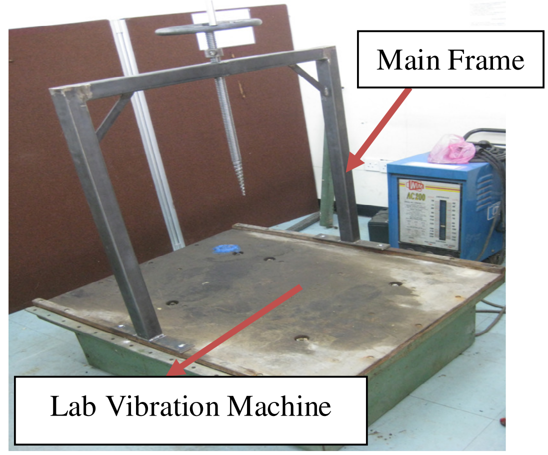

Figure 3. The main frame mounted on the vibration machine

Modification of the Machine

Upon the completion of the design, the machine was fabricated and tested. Mode of vibration of the machine was observed and studied before the oil palm fruit bunches treated with Esigel were detached their fruitlets using the vibrational fruit detaching machine. Modifications were performed on the machine as it was found to be inefficient. The vibration machine does not have a frequency meter, thus it cannot give the reading of the frequency which it is running at. In order to measure the frequency of the machine, a tally counter was attached at the bottom of the rotating surface of the machine to count the number of cycle every time it is hit by the base of the surface when the machine is vibrating. Figure 4 show the tally counter attached to the bottom of the machine for this study.

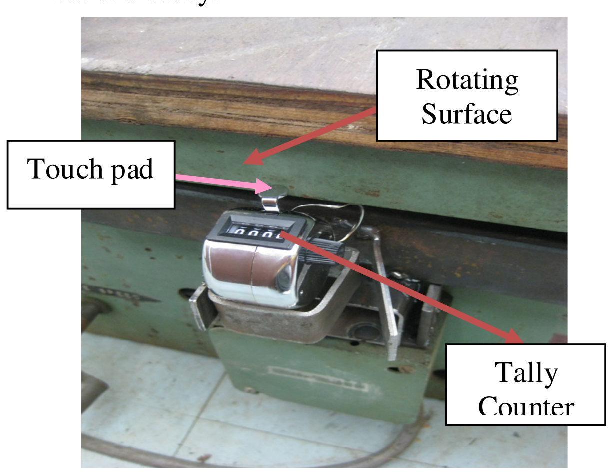

Figure 4. A tally counter attached to the bottom of the rotating surface of the machine.

Determination of the Optimum Frequency for Fruit Detachment

After the vibrational fruit detaching machine was confirmed its frequency can be measured, experiment to determine the optimum frequency to detach the fruitlets from the bunch using the machine was conducted. For this experiment, bunches were obtained from Taman Pertanian Universiti (TPU), UPM. 9 bunches were harvested from palm trees with average age of 4 years old.

After the harvested bunches were transported back to the lab, a hole was made in the middle of the chopped stalk for each bunch by using a hand drill. This was followed by injecting the Esigel into the hole with a syringe of 12ml. 10ml of Esigel of 10% concentration was injected into each of the bunch and they were left to react. Figures 5 and 6 show the image during process for injection of Esige1 concentration.

Figure 5. A hole drilled at the middle of the stalk using hand drill.

Figure 6. Esigel of 10% concentration injected into the hole.

After 24 hours, 3 bunches were selected for detaching their fruitlets using the fruit detaching machine. Each bunch was vibrated for 1 minute for 3 different frequencies which were 2.3Hz (140 cycle/60s), 3.3Hz (200 cycle/60s) and 4.3Hz (260 cycle/60s). The number of fruitlets detached from the bunch was recorded. The same procedure was repeated for another 3 bunches which were reacted with Esigel for 48 hours and also for another 3 bunches which were left to react with the hormone for 72 hours. The optimum frequency is the frequency that results the highest yield, i.e. most fruitlets are detached from the bunch. All the numbers of dropped fruitlets were recorded in Table 4, Table 5 and Table 6. Figure 7 shows the image during detachment process of oil palm using designed vibrational machine.

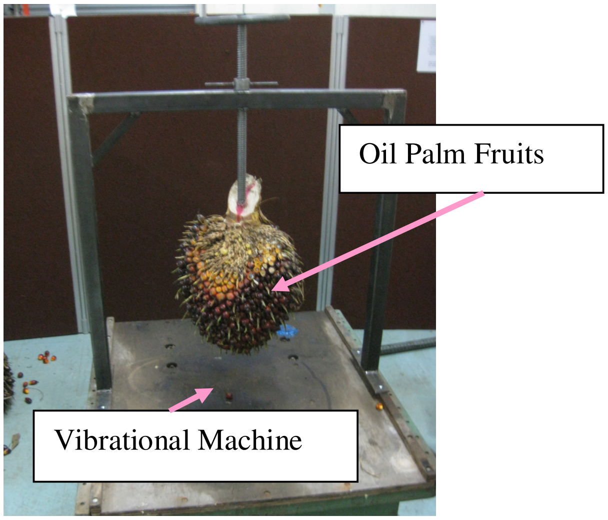

Figure 7. An oil palm bunch held by the vibrational fruit detaching machine.

RESULTS AND DISCUSSION

Ethephon's Effect on Fruit Components and Moisture Content

From Table 1, the result shows that the fruit components of fruitlets processed by Blaak's method and new method are not much different. This proves that ethephon has no effect on the fruit components of oil palm bunch.

Table 1. Fruit components of bunches processed with Blaak's method and new method.

Bunch	BWt (kg)	FWt (g)	FB (%)	pFB (%)	KF (%)	SF (%)	MF (%)	OD (%)	DWM (%)	OWM (%)	OB (%)
Common Blaak's Method											
1	13.0	10.7	66.6	0.0	4.1	5.3	90.7	76.4	59.5	45.5	27.5
2	12.0	14.4	71.1	16.9	5.8	8.5	85.8	78.3	65.8	51.5	31.3
3	9.5	8.9	43.5	0.0	5.8	5.4	88.8	76.4	64.0	48.9	18.9
4	14.2	10.9	49.4	0.0	7.0	9.0	84.0	74.2	59.1	43.9	18.2
5	11.0	20.7	50.7	0.0	5.9	23.8	70.3	78.8	60.6	47.8	17.0
6	15.2	10.0	63.7	0.0	4.3	6.7	89.0	73.8	64.2	47.4	26.9
Mean	**12.5**	**12.6**	**57.5**	**2.8**	**5.5**	**9.8**	**84.8**	**76.3**	**62.2**	**47.5**	**23.3**
New Method											
1	10.7	10.3	68.7	0.0	4.7	5.3	90.0	78.4	57.0	44.7	27.6
2	13.1	14.1	60.3	11.8	5.8	2.0	86.3	77.4	66.3	51.3	26.7
3	16.6	19.3	53.9	0.0	4.8	4.4	90.8	78.6	66.7	52.4	25.6
4	9.4	11.6	44.1	0.0	6.6	8.1	85.3	72.4	59.4	43.0	16.2
5	16.9	20.8	50.9	0.0	6.6	25.7	67.7	79.0	61.5	48.6	16.7
6	15.2	9.9	52.6	0.0	4.9	7.3	87.8	71.8	64.4	46.2	21.3
Mean	**13.7**	**14.3**	**55.1**	**2.0**	**5.6**	**8.8**	**84.7**	**76.3**	**62.6**	**47.7**	**22.4**

From the table 2, the result shows that the moisture contents of the ordinary bunches and bunches injected with Esigel are the same. This proves that ethephon has no effect on the moisture content of the oil palm bunches.

Table 2. Moisture contents of normal bunches and bunches injected with Esigel.

Normal Bunch				Bunch Injected with Esigel		
Bunch	Weight 1 (kg)	Weight 2 (kg)	Weight 2 – Weight 1 (kg)	Weight 1 (kg)	Weight 2 (kg)	Weight 2 – Weight 1 (kg)
1	13.1	13.0	0.1	10.9	10.7	0.2
2	12.4	12.0	0.4	13.4	13.1	0.3
3	9.9	9.5	0.4	17.1	16.6	0.5
4	14.5	14.2	0.3	9.6	9.4	0.2
5	11.5	11.0	0.5	11.1	10.9	0.2
Mean	**12.3**	**11.9**	**0.3**	**12.4**	**12.1**	**0.3**

Optimum Reaction Time of Esigel

Table 3 shows the reaction time of Esigel. From the results, it can be observed that the higher the concentration of Esigel is used, the faster it takes for the hormone to react with the bunch to loosen the fruitlets. As a result, Esigel of 10% concentration was chosen to be used for the experiment in determining the optimum frequency for fruit detachment.

Table 3. Reaction time for different concentrations of Esigel with oil palm bunches

Concentration of Esigel (%)	Reaction Time (hours)
2.5	16
5	12
10	8

Optimum Frequency for Fruit Detachment

Tables 4, 5 and 6 show the result of optimum frequency for the fruit detachment. From the results, the frequency of 3.3Hz yielded the highest number of dropped fruitlets. According to the tables 4,5 and 6, the data shows the longer the period of reaction of Esigel with the bunch, the more fruitlets can be detached from the bunch. This is proved by Table 6 which has the highest number of dropped fruitless for all the 3 frequencies tested. For all 3 days, the frequency of 3.3Hz yielded the most dropped fruitlets. Hence, 3.3 Hz is the optimum frequency for the vibrational oil palm fruit detaching machine to detach the fruitlets from the bunches injected with ethephon.

Table 4. Number of dropped fruitlets after bunch reacted with ethephon for one day.

	Number of dropped fruitlets		
Bunch	2.3Hz	3.3Hz	4.3Hz
1	11	20	16
2	10	18	14
3	13	19	17
Mean	11	19	16

Table 5. Number of dropped fruitlets after bunch reacted with ethephon for two days

	Number of dropped fruitlets		
Bunch	2.3Hz	3.3Hz	4.3Hz
1	15	23	18
2	13	25	19
3	14	21	16
Mean	14	23	18

Table 6. Number of dropped fruitlets after bunch reacted with ethephon for three days.

	Number of dropped fruitlets		
Bunch	2.3Hz	3.3Hz	4.3Hz
1	17	26	21
2	19	28	23
3	16	24	25
Mean	17	26	23

Even though the number of dropped fruitlets increases when the bunches are left to react with ethephone for a longer period, it should be noted that in the palm oil industry, the overnight bunches that being sent into palm oil mills are often being rejected as the oil extracted from overnight bunches are of lower qualities. Further research must be carried out to determine the FFA content between 1, 2 and 3 days old FFB after harvest.

Robust equation will be develop between relationships of digital value and the shape of FFB image with respect to the day estimation for harvesting and the oil content and to realize the development of portable real time maturity prediction device for harvesting (Mohd. Hudzari et al., 2011).

Designations Improvement for Vibration Machine

Even though the objectives of the project have been achieved, there are still lots of spaces for improvement and therefore below are a few suggestions for further study:

- Development of a better clamping device in order to facilitate vibrating operations, if it is to be commercialized.
- Development of a clamping device with automated drilling mechanism to ease the drilling process.
- Development of a trolley with jack, to carry the bunch to the shaker and also act as the dropped fruit collecting unit.
- Automation of the vibrational oil palm fruit detaching machine.
- Optimization of ethephon concentration and dosage on fruit detaching.

CONCLUSION

A vibrational oil palm fruit detaching machine was developed. It is able to hold the bunch at the hole made by hand drill at the middle of the stalk and detach the fruitlets from oil palm bunch which is treated with ethephon hormone beforehand by means of vibration. On top of that, the optimum frequency for the vibrational oil palm fruit detaching machine to detach the fruitlets from the bunch was determined to be 3.3Hz. Number of days of reaction of bunch with Esigel is insignificant as the optimum reaction time of bunch with Esigel was determined to be 16 hours at most. Moreover, overnight bunches are often being rejected by palm oil mills as the oil extracted from overnight bunches are of lower qualities. The use of ethephon hormone (Esigel) in this project has been justified that it has no effect on the fruit components and moisture content of the oil palm bunches, thus verifying the integrity of the project.

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