Identification and Quantification of Free Fatty Acid Content and Stripping Efficiency In Oil Palm Fruit

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***Abstract*— The aim of this research is to identify and quantify free fatty acid content and stripping efficiency in oil palm fruit at low level at low microwave power level. A high free fatty acid content gives low quality production of oil palm fruit. A long duration storage also affect the content free fatty acid simultaneously the stripping efficiency of oil palm fruit. The parameter that have been used are the stripping efficiency content, the free fatty acid in palm oil fruit and the quality oil produce. The limitation is the equipment used which is microwave compared to the specific machine or equipment as the oil palm industry since industries produce a large scale compare to the research studies. The parameters used by using ratio 1:0, 1:0.5 and 1:1 palm fruit to water. Findings shows that a high power resources of microwave gave higher stripping efficiency to the palm fruit and the addition of water effect the stripping efficiency decreases. Free fatty acid content obtained between 0.49-0.55 based on % of palmitic acid. Conclude that heating required to ensure a good stripping efficiency. However, the process of stripping should be proceed immediately to avoid the free fatty acid content of palm fruit increases.**

Keywords*— quatification, stripping, efficiency, free fatty acid, palm fruit.

I. INTRODUCTION

Palm oil fruit probably widely use in the world which is basically comes from the tropical rain forest region of West Africa. It is well known as commercialize and adaptable as it is nutritious vegetable oil, trans-fat free and very rich with vitamins and antioxidants. This oil palm fruit produced by clustered bunch of fruit and have an oval drupe shape (Christine *et.* al., 2013). This plant probably grows wild and produce more oil per land area than the other plant such as soya, rapeseed and sunflower crops. Normally, the plant will produce fruits after 30 months of plantation and will grow up to sixty feet. It contributes a lot in food industrial as a cooking oil, margarine and pizza, chocolate and ice cream as it hides as vegetable oils.

Palm oil fruit also known as versatile and uniqueness due to ability produce two type of oil which is crude palm oil and palm kernel oil. Crude palm oil probably a natural semi-solid oil and produced from fleshy mesocarp while the kernel oil from the seed. The versatility in food application have been increased by separated into liquid olein and solid stearin. Olein mostly applied in as a cooking oil while stearin used in food processing. Palm kernel oil really important raw material for oleo chemical industry and make specialty fats for various food products. This two types of oil probably have different composition which palm oil mainly contain palmitic acid and oleic acid while palm kernel oil is lauric acid.

Oil palm fruit have been extracted by using palm oil milling process. This process used a high pressure steam to sterilize the fresh fruit bunch as this is the first step to extract the oil palm fruit. The objectives for this sterilization process is to inactivate the oil splitting enzyme, soothe the palm fruit and stimulate the detachment of the fruitlet. The fresh mesocarp will extracted crude palm oil while the palm kernel produce the palm kernel oil. The process of sterilization, threshing, digestion, clarification, purification, drying and storage probably include in the oil milling process. All the equipment is require to play a good role in order to get a good oil quality and oil extraction rate.

Palm oil is a consumable oil which produce by the reddish pulp of the fruit of palm oil. The uses of palm oil probably widely used, commercialize and an adaptable plant which it can be used as cooking oil, soaps, manufacturing cosmetics and lubricants. The weight of palm oil fruit usually between 10kg-40kg based on their size and age which have an oval drupe shape. As it is a commercialize plant, it really give huge profit since it can produce more oil per land area than the other plant. However, it is compulsory to emphasize the quality of the palm oil produced and improving the efficiency of oil extraction. (Ojoma *et.* al., 2010)

Palm oil probably will undergoes few process to get a good quality and FFA content. A low FFA content is probably good quality but it probably exaggerated if there is no heating process taken. A bad quality of oil also might due to the damage of fruits which have been contaminate by microorganism, rapid hydrolysis of lipase enzyme and increasing of free fatty acid content. The storage time also the main problem of bad quality of oil. A long period of storage time of fruit will enhance the lipase enzyme activity. Thus, the FFA content increase which cause bad stripping efficiency due to the microbial contamination occur during storage.

A factor of free fatty acid content, stripping efficiency, carotene content, moisture content and period of storage is really main factor to get a good quality of oil. As the oil palm fruit really widely used in this new era especially in food manufacturing the process of oil palm fruit is really have to be so firm and in control as there is limitation of free fatty acid content that have been assigned by the regulations. Hence, the essential problem to be conduct are to quantify the free fatty acid content of palm oil fruits and identify stripping efficiency in oil palm fruits.

Thus, this paper reported about the identify and quantify the free fatty acid content and also the stripping efficiency in oil pam fruit for small and medium-scale processing aimed at solving the problems and difficulties in order to get the best product.

II. METHODOLOGY

A. Materials

The fresh fruit bunch of oil palm fruit have been used which is collected from Kapar, Selangor. The palm fruit have been cut into spikelets and store in the freezer immediately. (Refer Figure1) The chemical used for this experiment is Chemical Lab Grade Sigma Aldrid.

Figure 1: Fresh spikelet from fresh fruit bunch

B. Stripping efficiency

The spikelet of palm fruit have been weighted until 250g each in order to start the sterilization process for different parameter. A microwave of household have been used to sterilize the fruit. The palm fruit have been placed at the center of the microwave and expose to the different parameter which are 100kW, 300kW and 400kW. (Refer Figure 2). Each power that been test with different ratio of water to palm fruit which is 1:0, 1:0.5 and also 1:1. The value ratio of water for 0.5 and 1 is 100ml and 200ml respectively. The water vapor and caramel aroma changes have been recorded during the exposure time 1 to 4min. This statement have been supported by (Chow & Ma, 2007). Stripping has been test by using pushing method. Pushing method is a ways that need to push each of the palm fruit slightly to ensure that it will strip from the spikelet. The data have been taken after every two minutes until the last fruit have been stripped. The stripping efficiency have been determined by calculating the fruit loose form the bunch divided the fruit loose from the bunch plus the fruit remain to the bunch after stripping and multiply by 100.
(Sukaribin & Khalid , 2009)

$$Stripping\ efficiency = \frac{fruit\ loose}{fruit\ loose + fruit\ remain} \times 100$$

(Equation 1)

Figure 2: Sterilization process

C. Oil quality or extraction

1. Drying process
   The stripping fruit that have been rip have been undergoes a drying process to eliminate the water content in the fruit. The oil palm fruit have been peeled and the nut have been removed from the mesocarp. The drying process have been took 24h at the temperature of 103°C.
2. Soxhlet extraction and Rotary Evaporator.
   Oil has been extract by using the soxchlet extractor. The drying oil palm fruit have been measured until 20g to insert in the thimble and undergoes the extraction oil process. A 200ml of 98% methanol have been used to extract the oil for 6 hours until the yellow color disappeared. Solvent have been removed by using the rotary evaporator which is model Laborata 4000 of Heidolp Rotary Evaporator. This rotary will be rotate the flask and evaporation will happen in order to extract the solvent to round bottom flask. The evaporator operated at the 18 bar and 50°C at 60rpm. The same method have been repeated for all the parameters. The extracted oil have been measured in order to get the weight of oil.
3. Free Fatty Acid
   Free fatty acid content was measured by using titration method as written in the MPOB Test Method with some modification. (Loh *et* al., 2006) 2g of oil has been measured in a clean beaker and mixed with 50ml of isopropyl alcohol. A 3 drops of phenolhptalein has been added and the solution was neutralized by titration of 0.01M NaOH. The volume of sodium hydroxide has been taken and the percentage of free fatty acid have been calculated by using equation below:

$$\%FFA = \frac{25.6 \times V \times N}{w} \qquad \text{(Equation 2)}$$

The V represents the volume of NaOH titrated, N is the mole of NaOH while the w represents weight of oil palm fruit. (Maya & Mohd, 2013)

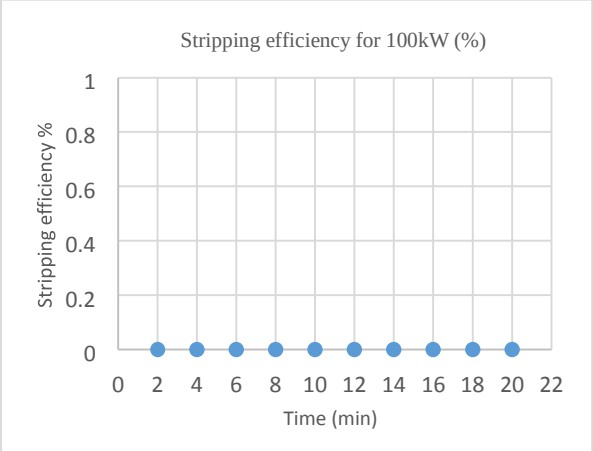
III. RESULTS AND DISCUSSION

A. Preliminary test with 100kW.

Figure 3: Sterilize palm fruit at 100kW

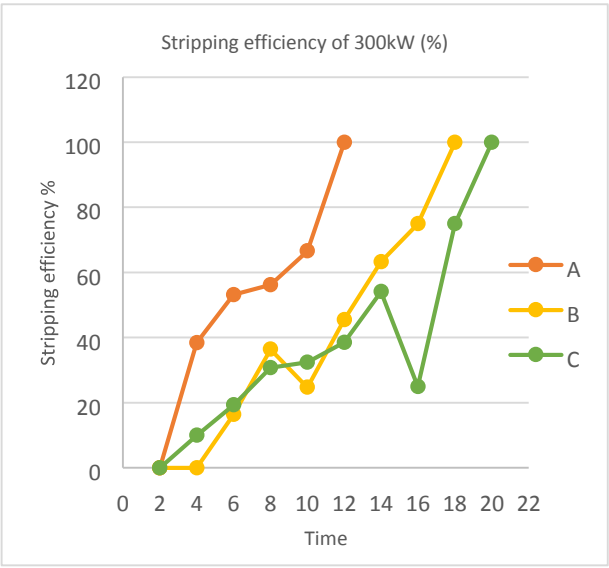
The parameter of power for palm fruit has been started with 100kW. As stripping is the first step of the experiment, the oil palm fruit has been test by sterilization of microwave. During sterilization, microwave heating the fruit which is energy generated by the electrical power microwave and absorbed by the palm fruit. Figure 3 shows that the palm fruit had undergoes changed color after 20minutes sterilization process. Graph 1 shows that there is no any changes stripping happens during the process. As time increasing, there is no fruit that have been strip but the color of fresh fruit bunch changes from the orangish to the brownish which is the color give it sign of burn. It can be concluded that low power giving a result of low efficiency. The fruit become dried and cannot be strip even the

time increasing. Hence, the process sterilization ratio of 1:0.5 and 1:1 for 100kW discontinued.



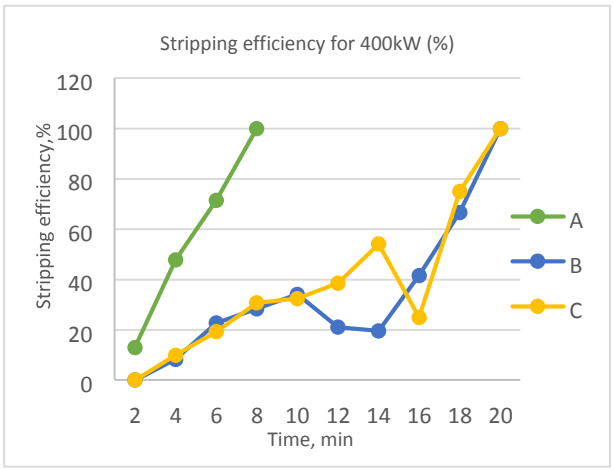
Graph 1: Stripping efficiency fir 100kW

The sterilization process continued with another parameter of 300kW and 400kW. Graph 2 and Graph3 shows that the label of A, B and C represents the ratio of the 1:0, 1:0.5 and 1:1. As mentioned earlier, it is the ratio of fruit to the water which are 100ml and 200ml for 0.5 and 1, respectively. Graph 2 shows that the ratio of 1:0 which does not have any addition of water stripped quickly compare to the others. All the fruits in an A end the stripped in 12 minutes while the B and C end their stripping process in 20 minutes. It is also shows that when the water using increase, the stripping efficiency of fruit decreases. Graph 3 also shows that the ratio in A recorded the highest efficiency which is without addition of water in 8 minutes while B and C are in 20 minutes.



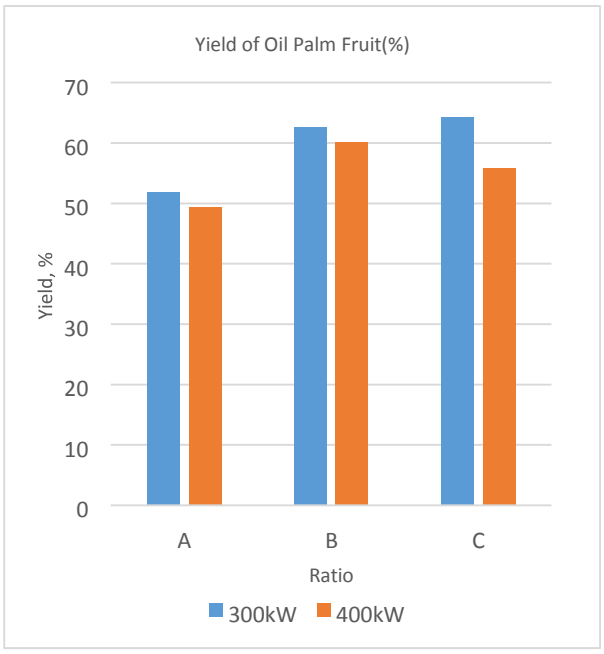
Graph 2: Stripping efficiency for 300kW

By comparing graph 2 and 3, it shows that when the power level increases, the stripping efficiency recorded increases quickly with shorter heating period. Stripping efficiency of 400kW recorded in 8 minutes compared to the 300kW with 12 minutes. It can be explain that heating is required in order to get a better efficiency. The micro power level also should be increases to ensure that the stripping efficiency can be done in a shorter period (Nazzarulhisham & Kaida , 2009). The greater energy generated from the microwave power will be absorbed by the palm fruit which it can help the fruit strip easily and recorded a higher stripping efficiency. According to the (Umudee *et*. al., 2013), spikelet fruit has a larger tendency or has highly dielectric constant that indicated for microwave absorption capability of empty spikelet which caused energy loss and long operating time is necessary. For spikelet microwave heating, the fruit thus embedded in a spikelet which has highly dielectric constant that indicated to microwave absorption capability of empty spikelet, caused of energy loss, long operating time is necessary.



Graph 3: Stripping efficiency for 400kW

Figure 4 shows that the yield oil that produce from the rotary evaporator process. As mentioned earlier, the A, B and C represents the ratio that have been used in the experiment. The highest yield recorded is from C which is 64.36% while the lowest 51.76% for power of 100kW with the ratio of an A. The trends of oil yield for 300kW shows increasing linearly. It have been recorded that the highest oil yield for 400kW was at ratio of B with 60.09% while the lowest at 49.39%. Findings shows that the yield produced related to the soxchlet evaporator process which the water supply play a role in reflux and condensation upon completion in 6 hours



Graph 4: Yield of Oil Palm Fruit

Table 1: Free fatty acid content

Power (kW)	Ratio	Volume NaOH (ml)	FFA (% based on palimitic acid)
300	1	40.9	0.52352
	1.05	38.9	0.49792
	1.1	37.5	0.48
400	1	36	0.4608
	1.05	41.1	0.52608
	1.1	43.6	0.55808
A2	-	0.2	0.00256
B2	-	0.3	0.00384

Based on Table 1, A2 and B2 have been test to be the benchmark for the Volume NaOH obtained which is from cooking oil and residual of cooking oil respectively. The table shows that the volume NaOH recorded 0.2ml and 0.3ml. Based on the free fatty acid which based on % palmitic acid, the A1 and B2 shows that the free fatty acid content are 0.00256 and 0.00384. As the titration process happened, the color changed for the solution are purple. This benchmark of oil are ready made from the market which have been produce by industries with a firm processes. Upon the completion of free fatty acid content, the volume NaOH have been taken which acts as neutralized the isopropyl alcohol and oil by addition of 3 drops of phenolphthalein. The volume of NaOH have been taken once the solution changed the color into pinkish salmon.

The highest of free fatty acid recorded was 0.52% for 300kW at the ratio of 1:0 while for 400kW the free fatty acid recorded was 0.55 at ratio 1:1. According to (Fatin *et*. al., 2014) the longer storage time of the chopped fruits, the higher the FFA release rate. This is due to the lipolytic enzyme released from the broken fruit's cell at the mesocarp. The rapid acceleration of the lipolytic enzyme simultaneously builds up the FFA content. The increment of moisture content also gained microbial activity hence affecting the FFA content during storage. The higher the moisture content, the higher the FFA content.

In addition, some of the outer layer slightly damaged and the mesocarp tends to absorb the moisture from the atmosphere especially once the fruit was chopped and (Ekwenye & U., 2006) researched that it gave an increment of moisture content in the palm oil. It also can be stated that a long of duration heating has damaged fruits mesocarp to be bruised which causes the moisture adsorption, hydrolysis reaction will be occurring and FFA increased when the storage of heated fruit not conveniently.

IV. Conclusion

The findings shows that low power of microwave resources will give low efficiency to the palm fruit. Heating is important in order to get a high stripping efficiency and the absorption of heat to the palm fruit will able the palm fruit strip easily. As the time stripping increase, the color of palm fruit changed. The highest ratio of fruit to water shows that addition of water or moisture made the stripping process slowly. As the benchmark of free fatty acid content have been set, it shows that the acceptable free fatty acid content should be in 0.0025 or 0.00384 which is % based on palmitic acid. The free fatty acid content for 300kW and 400kW shows that the value obtained by observe the changes of color of solution to pink. The free fatty acid content are high which is can be conclude that due to the period of storage of palm fruit.

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