Abstract- The application enzymatic pre-treatment for processing of palm fruit mesocarp was investigated. The results of this project have shown that enzymatic treatment is a suitable method for extraction of oil from palm fruit mesocarp. Not only the enzyme concentration and enzymatic treatment time, but also the applied enzyme type (cellulose, pectinase, and mixture of enzymes) were important for oil extraction from palm mesocarp and decreasing the remaining pressed pulp. Increasing the cellulase enzyme concentration (treatment for 4h, 50 °C) from 0.05% to 0.15% (w/w fresh sample) decreased rapidly the remaining pressed pulp from about 18% to about 13%. In addition, was the oil yield of enzyme pretreated samples higher than untreated or thermal treated samples. Whereas the extracted oil for untreated samples was less than 75% was the extracted oil for cellulase enzyme treated sample distinct higher (88, 89, and 95 % for 0.05, 0.1 and 0.15% cellulase enzyme concentration respectively). Pectinase enzyme showed less effect on increasing the extracted oil compare to cellulase enzyme. Up to about 88% extracted oil was observed for sample treated with 0.15 % pectinase enzyme. In general were the values for free fatty acid and peroxide value of enzymatic treated samples in the range of acceptable value for crude palm oil.

Keywords- Palm Processing, Technical Enzymes, Oil Yield, Oil Quality.

I. INTRODUCTION

Palm oil has become the world’s leading vegetable oil in terms of consumption and production with 45.3 million tons (t) produced worldwide in 2009. The biggest producer, with a 47.6% share in production in 2009, was Indonesia, followed by Malaysia (38.8%) and Thailand (2.9%). Global production of palm oil and thus the plantation of oil palm have been increasing tremendously in the last decade with average annual growth rates of 9.7% between 1998 and 2008. Palm oil is versatile in its uses in the food and chemical industry and increasingly as a feedstock for biofuels, which is another reason for the rising popularity of palm oil. Other factors include the increasing demand for vegetable oils in general and the comparably low prices of palm oil.

Palm oil is extracted from highly perishable oil palm fruit through wet processing. The essential steps for conventional palm oil processing are 1) Harvesting [The fresh fruit bunches (FFB) of right maturity are harvested and transported without damage to the POM]; 2) Sterilization [The FFB are sterilized at 3 bars steam pressure for 60 minutes in a horizontal sterilizer]; 3) Stripping [Sterilized bunches are stripped in a rotary drum stripper to separate the fruits from the bunches]; 4) Digestion [The loose fruits are converted to semisolid pulp in the digester]; Pressing [The digested mash is subjected to mechanical pressing. While hydraulic press is employed in small mills (1 tone FFB/hr.), a continuous screw press is used in larger mills (5 tone and above)]; 5) Clarification [The oil: water mixture (emulsion) from the press is separated into oil and water in a clarifier]; 6) Purification [High speed centrifuge is used to remove the final solid impurities from the oil]; 7) Vacuum Drying [Moisture content of the oil finally removed by vacuum drying. Thus a high quality edible grade red palm oil is produced]; 8) Nut Recovery [Palm seeds are separated from the press cake in a seed recovery unit].

The conventional palm oil processing is very energy intensive industry because of sterilization and milling processes before pressing. The oil yield using conventional palm processing is low (17 to 18% compare to 24% oil content in palm bunch). In additions, this industry produce huge amount of waste water during clarification step containing high amount of organic substances that could negatively affect the environmental and need special treatment or complex biogas production. Disintegration of cellular material, a key step prior to juice winning operations such as extraction or pressing is often performed by an enzymatic maceration, a thermal treatment or a mechanical grinding. Aqueous enzymatic oil extraction from plant material can increase the oil yield in rapeseed, palm, canola, soybean, peanut and coconut oils. The enzyme system applied for extration of oil was relatively complex and consisted of tannase, Alkalase, pectinase and cellulase. The aims of this study is to increase the oil yield from palm mesocarp using application of technical enzymes cellulase, pectinase, hemicellulase and natural enzyme from waste of pineapple.

II. EXPERIMENTAL

A. Raw materials

Raw material: fresh palm fruit (with or without bunch) was applied for experiments. The fresh palm fruit was
cleaned, packed in plastic bag and stored in refrigerator (at about 4±2 °C) until use (about 2 weeks).

**B. Enzymatic treatment**
For enzymatic treatment the enzymes Cellulase (Novozyme, Denmark), Hemicellulase (LUKA, Germany), and Pectinase (Novozyme, Denmark) were applied. For treatment of palm using natural pineapple enzyme was the pine apple waste (skin and middle part of fruit) was grinded in household mixer (Mulinex), filtered through the 2 layer cheese cloth and mixed with palm mesocarp (1:1 wt:wt). 30 g of palm mesocarp mixed with 30 ml water containing 0.5 to 1.5 % enzyme or 30 g pineapple juice were grinded in house hold mixer ((Mulinex, Germany) and incubated in water bath for 4 and 8h. The enzymatic treatment carried out at 50 °C and adjusted pH of 4±0.2.

**C. Pressing**
For pressing of untreated, enzyme treated or with pine apple treated samples were pressed using a hydraulic press at max. 1000 psi for 5 min.

**D. Analytical methods**
Analytical methods: The oil content in fresh palm fruit as well as pressed pulp was measured using soxhelet method. The % oil content in sample was calculated using equation 1.

\[
\text{Oil content (\%)} = \frac{\text{Weight of extracted oil (g)}}{\text{Weight of sample (g)}} \times 100 \quad (1)
\]

The FFA amount in samples was determined using titration of oil with NaOH. The peroxide value is determined by measuring the amount of iodine which is formed by reaction of peroxides (formed in fat or oil) with iodide ion. The refractive index of palm oil was determined using a hand refractometer (ATAGO CO., LTD. Model R5000, Japan) at 50 °C. The color of extracted oil was measured using a UV-visible spectral photometer. The maximum absorption at 444 nm and 455 nm was considered as α- and β-carotene concentration respectively.

**III. RESULTS AND DISCUSSION**
As it shown in figure 1 increasing the concentration of cellulase enzyme increased the effectiveness of palm pressing. Whereas without adding enzyme the remaining pulp was about 30 % (on the basis of fresh palm)(Fig. 1), were the remaining pulp of enzyme treated palm distinct lower (19%, 16 % and 14 % for 0.05 to 1.5 % enzyme concentration respectively).

Comparison the effectiveness of different enzymes cellulase, hemicellulase and mixture of cellulase and hemicellulase at constant enzyme concentration (0.1% w/w) as well as applying of pine apple juice of plant source enzyme have indicated that the lowest pressed pulp could be observed for samples treated with cellulase enzyme followed by with pine apple juice treated samples (Fig. 2). The effectiveness of hemicellulase for decreasing of pressed pulp was lowest compare to cellulase and mixture of cellulase and hemicellulase.

![Fig. 1: Effect of cellulase enzyme concentration on the amount of pressed pulp of palm fruit (enzyme treatment time of 4h, at 50 °C)](image1)

![Fig. 2: Effect of different enzyme type on amount of pressed pulp of palm fruit](image2)

The results of % extracted oil (on the basis of total extractable oil from palm fruit) using technical enzymes have indicated that the cellulase enzyme can increase the extracted oil (Fig. 3). With increasing of cellulase enzyme concentration from 0.05 to 0.15% (w/w) increased the % extracted oil from ≈85% to 95% respectively and were distinct higher than the % extracted oil of sample without adding enzyme (≈82%).

This confirmed the great advantages of enzymatic pretreatment of palm fruit prior pressing using cellulase enzyme.
Enhanced Oil Extraction From Palm Fruit Mesocarp Using Technical Enzymes

As it shown in table 1 the enzymatic treatment of palm fruit mesocarp using cellulase and pectinase (pectinex) increased only slightly the peroxide value of extracted palm oil. In the case of pectinase enzyme, the peroxide value of extracted oil independent of enzyme concentration, whereas in the case of cellulase enzyme an slight decreasing of peroxide value with increasing of enzyme concentration was obvious. Apparently, due to higher oil yield with increasing the enzyme concentration the peroxide substance concentration on the basis of total weight of extracted oil will be decreased.

Table 1: Effect of cellulase enzyme pretreatment (8h at 50 °C) methods on peroxide value (meq/kg) of pressed crude palm oil

<table>
<thead>
<tr>
<th>Pretreatment methods</th>
<th>Average ± Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 % cellulase, 8h</td>
<td>7.33±1.26</td>
</tr>
<tr>
<td>0.1 % cellulase, 8h</td>
<td>5.83±0.55</td>
</tr>
<tr>
<td>0.15 % cellulase, 8h</td>
<td>4.79±0.75</td>
</tr>
<tr>
<td>No Enzyme, 8 h</td>
<td>4.49±0.01</td>
</tr>
</tbody>
</table>

The slightly higher free fatty acid (FFA) concentration of enzymatic pretreated palm oil compare to sample without enzyme treatment ( Table 2) is maybe because of enzymatic side activity of very low concentration of lipase (as impurity in technical cellulase enzyme) in technical enzyme. With increasing of Cellulase enzyme concentration decreased the FFA concentration negligible. This is maybe because of higher oil extraction at higher enzyme concentration that could have “dilution” effect of total FFA content in oil.

Table 2: Effect of enzymatic treatment using different enzyme (4h at 50 °C) on FFA of crude palm oil

<table>
<thead>
<tr>
<th>Pretreatment methods</th>
<th>FFA % Average ± Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1% Cellulase, 4h</td>
<td>1.118±0.015</td>
</tr>
<tr>
<td>0.1% Hemicellulase, 4h</td>
<td>1.069±0.008</td>
</tr>
<tr>
<td>0.1% Mix of Cellulase and Hemicellulase, 4h</td>
<td>1.125±0.008</td>
</tr>
<tr>
<td>50% pineapple+50 % palm, 4h</td>
<td>1.139±0.008</td>
</tr>
<tr>
<td>Untreated, 4h</td>
<td>1.118±0.015</td>
</tr>
</tbody>
</table>

CONCLUSION

The results of this project have shown that the enzymatic treatment is a suitable method for extraction of oil from palm fruit mesocarp. Not only the enzyme concentration, but also the applied enzyme type was important for cell digestion of palm fruit. Comparison between different enzymes added in palm fruit indicated that the cellulase is the most effective enzyme for cell digestion in palm fruit and increasing the % extracted oil followed by hemicellulase and mixture of cellulase and hemicellulase (Fig. 4). Interestingly, pretreatment of palm fruit using native enzyme from pineapple waste was effective to increase the %extracted oil up to 86% and was distinct higher than % extracted oil for sample without enzyme treatment (75%). This show that the agricultural waste could be applied as alternative enzyme source in palm oil processing. The fruit pine apple, Ananas comosus (L) Mert, is a rich source of a mixture of cysteine, the most abundant among them being bromelaine (EC 3.4.22.33), which hydrolytically cleaves the internal peptide bonds in proteins with relatively broad specificity. Reference have shown that using enzyme extracted from pineapple waste the oil yield of coconut meat increased rapidly. Whereas the oil yield from pressed untreated coconut meat was about 12%, increased the oil yield up to 20.5% after treatment of coconut meat with pine apple extract and the oil yield was nearly similar (21.19%) to enzyme treatment of sample using commercial cellulase and pectinase enzymes. The optimum temperature and pH for enzymatic activity of enzymes from pineapple was 60 °C and pH 5.5.
Enhanced Oil Extraction From Palm Fruit Mesocarp Using Technical Enzymes


mesocarp and decreasing the remaining pressed pulp. Increasing the Cellulase enzyme concentration (treatment for 4h, 50 °C) from 0.05% to 0.15% (w/w fresh sample) decreased rapidly the remaining press pulp from about 18 % to about 13%.

In contrast was the decreasing of press pulp weight using pectinase enzyme not significant. Interestingly was the enzyme from pine apple as agricultural waste material effective to decrease the weight of pressed pulp up to 15% and was much more effective compare to pectinase enzyme. The evaluation of extracted oil (on the basis of total extractable oil) have indicated that the Cellulase enzyme is very effective enzyme to increase the oil yield.

Whereas the extracted oil for untreated samples was less than 75%, was the extracted oil for samples treated with cellulase enzyme distinct higher (88, 89, and 95 % for 0.05, 0.1 and 0.15% cellulase enzyme concentration respectively). pectinase enzyme showed less effect on increasing the extracted oil compare to cellulase enzyme. Application of pineapple waste as enzyme source increased the extracted oil up to 86% and was distinct higher than extracted oil of untreated sample (75 % extracted oil).

The analysis of extracted oil has indicated that the free fatty acid as well as peroxide value of enzyme treated sample was slightly higher than thermal pretreated and untreated samples. In general were the values for free fatty acid and peroxide value of enzymatic treated samples in the range of acceptable value for crude palm oil reported in literature.

REFERENCES


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