Simulation process unit bleaching in cooking oil plant using super pro designer version 10.0

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Abstract. The bleaching process is one of the processes in the manufacture of cooking oil that serves to absorb the gum, moisture content and color in crude palm oil. Role of color in the marketing of cooking oil is very important, because, in general consumers tend to use the color parameters as the quality of cooking oil. The use of programs to facilitate the design of a process such as Super Pro Designer, Aspen, and Hysys is a way to increase the profitability of an industry. This study aims to provide information that Super Pro Designer applications can simulate the bleaching process contained in the cooking oil plant. Method used was simulated data obtained from the plant using Super Pro Designer Version 10.0. The result showed that at feed flow rate of 86,000 kg/hour the temperature of 100 °C was obtained as output of plate heat exchanger.

1. Introduction
Crude palm oil contains triglycerides as the main constituent and non-triglyceride components in a small fraction [1][2]. In an attempt to obtain consumable oil, the non-triglyceride component must be separated or reduced to an acceptable level by purification process. One of the several stages of oil palm refining process is the process of bleaching [3]. Bleaching process is performed with the aim of physically separating the impurities from crude palm oil in the form of gum remnants, soap residues, metals, oxidation products, and pigments such as chlorophyll [4].

The purpose of bleaching process by using bleaching agent is to separate the dyestuffs and organic substances. The process can cause the crude palm oil (CPO) become dark (reddish brown), the substance is absorbed by the color adsorbent, then the color of CPO becomes clearer. Role of color in the marketing of cooking oil is very important, consumers tend to use the color parameter as an indication of the quality of a cooking oil. If the color of cooking oil deviates from the normal color, then the consumers will not purchase the cooking oil, although in fact the quality is good [5].

This bleaching process involves a variety of equipment and chemicals. To analyze the process design of a cooking oil plant in order to produce maximum yield and minimal energy consumption, a process simulation was needed. In this simulation, the Super Pro Designer program was used. Super Pro Designer is the best choice for any chemical, biochemical and environmental engineer. Super Pro Designer can be used and performed for environmental consulting companies, food and beverage and water treatment companies too. This program is capable of managing batch processes or continuous processes and providing databases for chemicals, tools and economic figures [6]. Use of Super Pro Designer is very useful to facilitate a plant. Super Pro Designer is very advantageous for the bleaching unit process in the cooking oil plant to produce high product conversion. This program can facilitate changes in a production in a plant [7].
2. Methodology
In this research Super Pro Designer version 10.0 was used with several stages such as:
- Data retrieval operations
  Data retrieval operations are intended to include all the data needed to perform simulations. The data was taken from the cooking oil plant, which includes
- Properties of feed and products
- Operation condition
- Limitation of the equipment
- Flowsheet
- Validation of simulation results with design data obtained
- Calculate the yield obtained
- Perform the simulation

3. Results and discussions

3.1. Main flowsheet bleaching process
The equipment in the bleaching process used in this process were heat exchanger, dryer tank, mixer and bleacher tank. Crude palm oil (CPO) as feed was flown to the bleaching unit with variations flow rates 90,000; 96,000; 100,000 and 120,000 kg/hour. The main flowsheet is presented in Figure 1.

![Figure 1. Flowsheet of bleaching unit at cooking oil plant.](image)

3.2. Heat exchanger
At this stage, crude palm oil is heated up until the range of 100 - 110 °C using a heat exchanger type plate heat exchanger as shown in Figure 2. The purpose of this stage is to evaporate the water content in crude palm oil. Hot fluid used in this process was the heat of refinery bleaching degumming palm oil (RBDPO) product.
After heating process using heat exchanger, next stage was to reduce moisture content from crude palm oil by heating up to 110 °C. This stage aims to reduce the water content by using the boiling point difference, so that only water was vaporized in this dryer. The flowsheet of dryer tank is presented in Figure 3.

3.4. **Mixer**
Process of removing the gums which existed in crude palm oil was performed in this stage by adding H₃PO₄ 85% with a 0.05% flowrate of crude palm oil flowrate. Dynamic mixer was used to mix the solution until it was completely uniform. The flowsheet of mixer is presented in Figure 4.
3.5. **Bleacher tank**

The last stage of the bleaching process was the bleacher tank, where crude palm oil was mixed with bleaching earth or bleaching agent that serves to absorb the gums and 85% $H_3PO_4$ contained in crude palm oil. At this stage, steam was used to ease the absorption bleaching agent process and useful for removing residual moisture content in the mixture. The flowsheet of bleaching process in bleaching tank is presented in Figure 4. While the result of bleaching process unit in cooking oil plant is presented in Table 1.

![Figure 5. Bleacher tank.](image)

**Table 1.** Result of bleaching process unit in cooking oil plant.

| Flow rate (kg/hr) | PHE Temp. (ºC) | Flow Rate (kg/day) | BE Conc. (%) | H$_3$PO$_4$ Conc. (%) | DBPO Flow Rate (kg/day) | Yield (%) |
|------------------|----------------|-------------------|--------------|------------------------|-------------------------|-----------|
| 86,000           | 100            | 86,000            | 0.6          | 0.055                  | 83,558.075              | 97.45     |
| 90,000           | 97.7           | 90,000            | 0.6          | 0.055                  | 87,706.125              | 97.45     |
| 96,000           | 94.4           | 96,000            | 0.6          | 0.055                  | 93,553.200              | 97.45     |
| 100,000          | 92.4           | 100,000           | 0.6          | 0.055                  | 97,451.250              | 97.45     |

Table 1 shows the effect of flow rate of crude palm oil feed with the change of output temperature at plate heat exchanger equipment and the amount of yield produced from the bleaching unit. In the conversion of crude palm oil into cooking oil, heating process is conducted using a plate heat exchanger. Plate heat exchanger serves to heat the crude palm oil until 100 ºC, then it can be vaporized in the dryer tank.

![Figure 6. Relationship of feed flow rate to output temperature of plate heat exchanger.](image)
Figure 6 shows the temperature changes to the feed flowrate obtained. It is shown that the heavier the crude palm oil feed rate in the plate heat exchanger, smaller the obtained temperature. To evaporate the water, the temperature should reach 100 - 110 °C, then water can evaporate perfectly and low-quality products can be avoided. Based on Fig. 6, at feed flow rate of 86,000 kg/hour, temperature of bleaching unit was 100 °C. Subsequently, in the process of making cooking oil, maximum results can be conducted at the flow rate of 86,000 kg/hour.

4. Conclusions
Super Pro Designer is an application which enable to simplify and to get benefit in designing a bleaching process in a cooking oil plant.

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References
[1] Maulina S, Irvan, Trisakti B and Daimon H 2018 Rasayan J. Chem, 11 (3) 1151-1158
[2] Octiva CS, Irvan, Sarah M, Trisakti B and Daimon H 2018 Rasayan J. Chem, 11 (2) 791-797
[3] Irvan, Trisakti B, Maulina S, Sidabutar R, Iriany and Takriff MS 2018 Journal of Engineering Science and Technology 13 (10) 3058 – 3070
[4] Haryono, Ali M, Wahyuni 2012 Jurnal Berkala Ilmiah Teknik Kimia I (1) pp 2-20
[5] Yusnimaar, Purwaningsih IS, Sunarno 2008 Seminar Nasional Teknik Kimia ISSN:1907-0500.
[6] Intelligenc, Inc 2007 SuperPro Designer v.7.0 COM Help.
[7] Woinaroschyi A, Taras S 2009 Rev. Chim. 60 979-983.