UNIVERSITI PUTRA MALAYSIA

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By

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Faculty : Engineering

Crude palm oil (CPO) is refined to quality edible palm oil by removing objectionable impurities such as free fatty acid (FFA), phospholipids, trace metals and colouring pigments which are detrimental to the flavour, odour, colour and stability of the oil. Conventional refining involves degumming, bleaching and deodorization steps. The energy-saving membrane technology is a physical separation process that can offer an alternative method to improve the conventional refining method by reducing energy cost and minimizing the waste disposal problem.

The objectives of this research study are to investigate the influence of membrane on the quality of CPO, to evaluate the operating conditions such as transmembrane pressure and feed flow, to study the performance of membrane with time, to establish the appropriate cleaning procedures for membrane, and to compare the quality of membrane-processed oil and conventional-processed oil as well as the storage stability of the oils.

CPO was filtered through microfiltration (MF) and ultrafiltration (UF) ceramic membranes. Two different pore sizes of MF membranes (0.2 μm and 0.45 μm) and two pore sizes of UF membranes (20 nm and 50 nm) were used in the study. Comparison study was conducted for CPO treated with 0.2 μm membrane. Ceramic MF membranes with pore sizes of 0.45 and 0.2 μm rejected about 14% and 56.8% of phosphorus, respectively. The 0.2 μm membrane removed more than 80% of the iron. Ceramic UF membranes with pore sizes of 50 and 20 nm rejected about 60% and 78.1% of phosphorus, respectively. The 20 nm membrane reduced about 60% of iron content. All membranes (MF and UF) showed no influence on carotene, FFA and fatty acid composition (FAC).

The MF membranes (0.2 and 0.45 μm) showed similar trend where the permeate flux for the membranes increased with average transmembrane pressure and feed flow until it reached a certain limit where the flux declined with increasing pressure and feed flow. Both membranes showed rapid flux decline during the initial stage, but stabilized for the period of 5 hr. Cleaning process was achieved by using Alconox detergent and acid/alkalis solutions.

The effect of pressure on flux for the 20 nm UF membrane showed similar trend with the MF membrane, but after 0.9 bar, the increased in flux was only slowed down rather than declining. The flux for the 50 nm UF membrane increased proportionally with pressure and no sign of flux decline was observed at 2.9 bar. The increase in flux at higher feed flow was only observed for the 20 nm membrane. Concentration polarization could have occurred for the 50 nm membrane where the flux declined at higher feed flow. Cleaning for the UF membrane was more difficult than the MF membranes. The cleaning process involved cleaning with Alconox detergent, acid/alkalis solutions and soaking with solvents (hexane and isopropanol).

Reduction of phosphorus for oil treated with 0.2 µm MF membrane was comparable with commercial bleached oil. FFA and carotene content were reduced after deodorization process. Carotene content and colour reading for membrane-processed oil was slightly higher than conventional-processed oil. The membrane process was unable to remove oxidation products as it was observed that the FFA and peroxide value were increased during the storage period.

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TEKNOLOGI MEMBRAN ALIRAN SILANG UNTUK PENGOLAHAN MINYAK SAWIT MENTAH

Oleh

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Ogos 2001

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Minyak sawit mentah ditapis menjadi minyak makan sawit dengan menyingkirkan bahan-bahan bendasing seperti asid lemak bebas, fosfolipid, logam surih dan pigmen berwarna yang boleh merosakkan rasa, bau, warna dan kestabilan minyak. Penapisan lazim melibatkan beberapa peringkat pemprosesan seperti penyah-gam, perlunturan dan penyah-bauan. Penjimatan tenaga teknologi membran adalah proses pemisahan fizikal yang boleh digunakan sebagai kaedah alternatif untuk memperbaiki kaedah penapisan lazim. Ianya dapat menurunkan kos tenaga dan mengurangkan masaalah sisa buangan.

Objektif kajian penyelidikan ini adalah untuk menyelidik pengaruh membran terhadap kualiti minyak sawit mentah, untuk menilai keadaan kendalian seperti tekanan udara dan kadar suapan, untuk mengkaji prestasi membran terhadap masa, untuk menetapkan cara cucian bagi membran, dan untuk membandingkan kualiti minyak yang telah diproses dari kaedah membran dan penapisan lazim disamping perbandingan terhadap kestabilan storan terhadap minyak.

Minyak sawit mentah telah ditapis menggunakan penapisan-mikro (MF) dan penapisan-ultra (UF). Dua saiz liang yang berlainan bagi MF (0.2 μm dan 0.45 μm) dan dua saiz bagi UF (20 nm dan 50 nm) telah digunakan untuk kajian. Kajian perbandingan telah dijalankan bagi minyak sawit mentah yang telah ditapis dengan 0.2 μm membran. MF membran seramik dengan saiz liang 0.45 dan 0.2 μm masing-masing menyingkirkan lebih kurang 14% dan 56.8% fosforus. Membran dengan saiz liang 0.2 μm menyingkirkan lebih dari 80% kandungan besi. UF membran seramik dengan saiz liang 50 dan 20 nm masing-masing menyingkirkan lebih kurang 60% dan 78.1% fosforus. Membran dengan saiz liang 20 nm mengurangkan lebih kurang 60% kandungan besi. Semua membran (MF dan UF) menunjukkan tiada pengaruh terhadap kandungan karoten, asid lemak bebas dan komposisi asid lemak.

Membran MF (0.2 dan 0.45 μm) menunjukkan aliran yang sama di mana fluks serapan bagi kedua-dua membran meningkat apabila tekanan udara dan kadar suapan ditingkatkan sehingga sampai ke satu peringkat di mana fluks mula menurun apabila tekanan udara dan kadar suapan meningkat. Bagi kajian terhadap masa, kedua-dua membran menunjukkan penurunan fluks yang laju di peringkat awal tetapi stabil sepanjang tempoh operasi selama 5 jam. Proses cucian dilaksanakan dengan menggunakan bahan cuci 'Alconox' dan larutan asid/alkali.

Kesan tekanan udara terhadap fluks bagi membran UF 20 nm menunjukkan aliran yang sama dengan membran MF pada peringkat awal operasi. Walaubagaimanpun, peningkatan fluks berlaku dengan perlahan setelah 0.9 bar. Fluks untuk membran UF 50 nm meningkat berkadaran dengan tekanan udara, dan tiada penurunan fluks pada 2.9 bar. Peningkatan fluks pada kadar suapan yang tinggi hanya didapati pada membran UF 20 nm. Kemungkinan pengutuban kepekatan telah berlaku terhadap membran 50 nm di mana fluks didapati menurun apabila kadar suapan dinaikkan. Cucian untuk membran UF adalah lebih rumit berbanding dengan membran MF. Process cucian melibatkan bahan cuci 'Alconox', larutan asid/alkali dan rendaman dengan pelarut (hexana dan isopropanol).

Pengurangan fosforus bagi minyak yang telah ditapis dengan proses membran (MF 0.2 μm) adalah setanding dengan minyak komersil yang terluntur. Asid lemak bebas dan kandungan karoten juga berkurangan setelah melalui proses penyah-bauan. Kandungan karoten dan bacaan warna bagi minyak yang telah diproses dengan membran didapati tinggi sedikit dari minyak hasil dari proses-lazim. Proses membran didapati kurang berupaya untuk menyingkirkan produk pengoksidaan setelah asid lemak bebas dan nilai peroksida menunjukkan peningkatan dalam tempoh simpanan.

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INTRODUCTION

Crude palm oil (CPO) is produced by extracting oil from fresh fruit bunches (FFB). The oil contains mainly triglycerides and some variables of impurities. Impurities which include phospholipids, free fatty acid (FFA), trace metals, oxidation products and sterols are detrimental to the oil's flavour, odour and colour. This undesired impurities needs to be removed or reduced as much as possible in order to be accepted as edible palm oil. However, some of the impurities such as tocopherol and tocotrienol, and carotene have nutritional values. Both tocopherol and tocotrienol function as natural antioxidants which help to protect the oil from oxidatation and as vitamin E (Goh et al., 1987). α- and β-carotene are precursors of vitamin A.

Two methods are available for the refining of CPO to produce refined, bleached and deodorized palm oil (RBDPO). They are chemical refining (neutralization with sodium hydroxide solution) and physical refining. Each method involves various stages of refining including degumming, bleaching and deodorizing. Each stage removes only one or two undesirable components. These steps require high capital cost equipment. In chemical refining, treatment with sodium hydroxide results in oil loss due to emulsification, oil occlusion in soapstock and saponification (Young, 1981). Large amount of water is required, thus generates high amount of contaminated wastewater from the plant. The physical refining, which is preferable than chemical refining involves pretreatment (degumming and bleaching) and distillation processes. High temperature, high vacuum and direct steam injection are used to decompose the carotenoids pigments in palm oil and distil the breakdown compounds, fatty acids and oxidation products from the oil (Young, 1981).

For both chemical and physical refining, degumming process involves the usage of phosphoric acid and bleaching process involves addition of bleaching earth. Any excess of phosphoric acid which is not removed in the subsequent bleaching step will cause darkening of RBDPO (Thiagarajan and Tang, 1991). The level of phosphorus in RBD oils affects the rise of FFA and the increase in colour during storage. High levels of phosphorus in RBD oils with phosphoric acid during degumming may account for the colour deterioration in some "good" oils during storage, and form colour fixation during deodorization. These processes are energy-intensive and also produce waste by-products like spent bleaching earth, which may cause environmental problems unless properly treated.

In general, conventional refining of CPO requires the usage of chemicals such as phosphoric acid and bleaching earth for the treatment of the crude oil. During the process, bleaching earth trap some oil. According to Aziz (2000), the amount of oil loss in the refining process will also correspondent with the amount of bleaching earth during the bleaching process. The conventional refining consumes large amount of energy to heat and cool the oil as well as to provide