UNIVERSITI PUTRA MALAYSIA

FRACTIONATION OF PALM KERNEL OIL BY SHORT PATH DISTILLATION

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

FRACTIONATION OF PALM KERNEL OIL BY SHORT PATH DISTILLATION

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Chair : Professor Thomas Choong Shean Yaw, PhD

Faculty : Engineering

Fractionation of palm kernel oil (PKO) by short path distillation (SPD) was studied. The distillation was carried out at two feed flow rates (135 and 195 g/hr) and six temperatures, T_{Dis} (200, 210, 220, 230, 240 and 250°C). Other distillation parameters including vacuum pressure (0.001 mbar), blade rotation speed (400 rpm) and temperature of the feed material (60°C) were kept constant. Samples were collected at each experiment and analysed for product yield and physico-chemical properties including fatty acid composition (FAC), triacylglycerol (TAG) composition, slip melting point (SMP), thermal analysis by differential scanning calorimetry (DSC) and solid fat content (SFC). Crystallisation behaviour of PKO and the fractionated products were also studied by measurement of isothermal crystallisation at four temperatures, T_{Cr} (0, 5, 10 and 15°C). Crystallisation kinetics was examined by fitting the isothermal crystallisation data into the Avrami model.

Fractionation of PKO by SPD resulted in an enrichment of short-chain fatty acids as well as low and some medium molecular weight TAGs in distillates. The distillates were found to have higher SMP, SFC and crystallised in sharper peaks. Melting endotherm of distillates was almost similar to that of PKO but a slight shift to lower temperatures was observed. Long-chain fatty acids and high molecular weight TAGs were concentrated in residues. The residues were lower in SMP, SFC and had broader crystallisation and melting peaks.

Studies on the crystallisation behaviour by the Avrami model suggested that PKO crystallised in a plate-like crystal growth (n=2) from an instantaneous nuclei at lower crystallisation temperatures, T_{Cr} (0 and 5°C). At higher crystallisation temperatures, T_{Cr} (10 and 15°C), a plate-like (n=3) or spherulitic crystal growth (n=4) from sporadic nuclei was proposed. Fractionation of PKO altered the crystallisation behaviour of the resulted fractions. Distillates were expected to crystallise in a plate-like crystal growth (n=2) from instantaneous nuclei at lower T_{Cr}. Higher T_{Cr} resulted in distillates to possibly crystallised in a rod- (n=2) and plate-like crystal growth (n=3) from sporadic nuclei. Residues were observed to possibly crystallised in a plate-like crystal growth (n=2) from an instantaneous nuclei at lower T_{Cr}. At higher T_{Cr}, it was suggested that residues crystallised in a spherulitic crystal growth (n=4) from a sporadic nuclei.

PKO fractions derived by SPD were comparable to products obtained by conventional dry fractionation process. The FAC of distillates resembled closely to palm kernel stearin (PKS) and interestingly, coconut oil. Solid fat content was,

however, lower than PKS. Residues were found comparable in FAC to that of palm kernel olein (PKOo).

The study showed that SPD produced fractions with unique physico-chemical properties. In the crystallisation studies, the Avrami model was found to be a useful tool to predict the crystallisation behaviour of oil fractions obtained by SPD. Subsequently possible applications of the new fractions obtained could be explored.

Abstrak tesis yang dikemukakan kepada Senat Univeristi Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMERINGKATAN MINYAK ISIRONG SAWIT SECARA PENYULINGAN JARAK DEKAT

Oleh

MUHAMAD RODDY BIN RAMLI

Februari 2013

Pengerusi : Profesor Thomas Choong Shean Yaw, PhD

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Pemeringkatan minyak isirong sawit (MIrS) secara penyulingan jarak dekat (PJD) telah dikaji. Penyulingan telah dijalankan pada dua kadar suapan (135 dan 195 g/j) dan enam suhu (200, 210, 220, 230, 240 dan 250°C). Pembolehubah penyulingan yang lain seperti tekanan hampagas (0.001 mbar), laju bilah (400 rpm) dan suhu bahan mentah (60°C) ditetapkan malar. Sampel diambil di setiap ujikaji dan dianalisa untuk hasil produk penyulingan serta ciri-ciri fizikal dan kimia seperti komposisi asid lemak (KAL), komposisi triasilgliserol (TAG), takat lebur gelinciran (TLG), analisa terma melalui kalorimetri pembezaan imbasan (KPI) dan kandungan lemak pejal (KLP). Sifat pengkristalan MIrS dan produk pemeringkatan juga dikaji secara pengkristalan isoterma pada empat suhu, T_{Cr} (0, 5, 10 dan 15°C). Kinetik pengkristalan telah diselidik dengan memuatkan data pengkristalan isoterma ke dalam model Avrami.

Pemeringkatan MIrS secara PJD menjurus kepada pengkayaan asid lemak rantaian pendek serta TAG dengan berat molekul yang rendah dan sesetengah TAG dengan berat molekul sederhana di dalam hasil tersuling (*distillate*). Hasil tersuling menunjukkan TLG dan KLP yang tinggi dan menghablur dengan lebih turus. Endoterma peleburan hasil tersuling adalah hampir sama dengan MIrS tetapi peralihan ke suhu yang lebih rendah telah diperhatikan. Asid lemak rantaian panjang dan TAG bermolekul tinggi tertumpu di dalam sisa tersuling (*residue*). Sisa tersuling mempunyai TLG dan KLP yang lebih rendah serta menghablur dan melebur secara melebar.

Kajian terhadap sifat pengkristalan dengan menggunakan model Avrami mencadangkan bahawa pembentukan kristal MIrS adalah secara pembesaran kepingan (dua dimensi) (n=2) daripada nuklei berseketikaan pada suhu pengkristalan rendah, T_{Cr} (0 dan 5°C). Pada suhu pengkristalan tinggi, T_{Cr} (10 dan 15°C), pengkristalan dengan pembesaran kristal secara kepingan (n=3) atau pembesaran secara sferulit (n=4) daripada nuklei setempat telah dicadangkan. Pemeringkatan MIrS telah mengubah sifat pengkristalan pecahan-pecahan minyak yang terhasil. Hasil tersuling dianggarkan membentuk kristal dengan pembesaran secara kepingan (n=2) daripada nuklei setempat pada T_{Cr} rendah. T_{Cr} tinggi pula menjurus kepada kemungkinan bahawa hasil tersuling membentuk kristal dengan pembesaran kristal secara rod (n=2) atau kepingan (n=3) daripada nuklei setempat. Sisa tersuling pula didapati berkemungkinan membentuk kristal dengan pembesaran kristal secara kepingan (n=2) daripada nuklei berseketikaan pada tahap T_{Cr} rendah. Pada T_{Cr} tinggi, dicadangkan bahawa sisa tersuling membentuk kristal dengan pembesaran secara sferulit (n=4) daripada nuklei setempat.

Pecahan MIrS yang terhasil daripada PJD boleh dibandingkan dengan produk yang diperolehi daripada kaedah konvensional iaitu proses pemeringkatan kering. Komposisi asid lemak (KAL) hasil tersuling menyerupai KAL Stearin Isirong Sawit (SIrS) dan yang lebih menarik adalah minyak kelapa. Kandungan lemak pejal (KLP) hasil tersuling, walaubagaimanapun, lebih rendah daripada SIrS. Sisa tersuling pula mempunyai KAL yang hampir sama dengan Olein Isirong Sawit (OIrS).

Pembelajaran ini menunjukkan bahawa PJD menghasilkan pecahan dengan ciri-ciri yang unik. Di dalam kajian pengkristalan, didapati model Avrami amat berguna untuk menganggar sifat pengkristalan pecahan minyak yang terhasil daripada PJD. Seterusnya sebarang kegunaan yang berkemungkinan daripada pecahan baru yang terhasil boleh diterokai.

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I certify that a Thesis Examination Committee has met on 25 February 2013 to conduct the final examination of Muhamad Roddy Bin Ramli on his thesis entitled "Fractionation of Palm Kernel Oil by Short Path Distillation" in accordance with the Universities and Universities Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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MUHAMAD RODDY BIN RAMLI

Date: 25 February 2013

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