UNIVERSITI PUTRA MALAYSIA

CRYSTALLIZATION BEHAVIOR OF PALM OIL BLENDS AND PALM OIL-BASED FLUID SHORTENINGS

MISKANDAR MAT SAHRI

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CRYSTALLIZATION BEHAVIOR OF PALM OIL BLENDS AND PALM OIL-BASED FLUID SHORTENINGS

By

MISKANDAR MAT SAHRI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia
In Fulfilment of the Requirements for the Degree of Doctor of Philosophy

December 2006

DEDICATION

Especially dedicated to my beloved wife Hajjah Hanirah Hassan
and children
Hajar Marhamah, Muhammad Hanif, Hayati Munirah, Hanis Muslimah,
Muhammad Halim and Muhammad Azim ……

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Doctor of Philosophy

CRYSTALLIZATION BEHAVIOR OF PALM OIL BLENDS AND PALM OIL-BASED FLUID SHORTENINGS

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December 2006

Chairman: Professor Yaakob Bin Che Man, PhD

Faculty: Food Science and Technology

This thesis covers the establishment of palm oil-based fluid shortening production by investigating the static and dynamic crystallization behaviors of palm oil blends with and without emulsifier at various temperature treatments. Solid fat content (SFC), crystal size and distribution, fatty acid content (FAC) and triacylglycerol (TAG) composition of the palm oil blends were determined and analyzed using ANOVA at 95% confidence level. Palm oil-based fluid shortening formulation, emulsifier and stirring speed were optimized using response surface methodology (RSM) based on the storage study that included SFC, viscosity, pourability and crystal size and distribution.

Crystal development of the blends as a function of time had developed crystallization curves that demonstrated distinct steps corresponding to crystallization stages due to the occurrence of mixed crystallization. Slow crystallization without emulsifier was influenced by the total saturated FAC, with significant ($P<0.05$) changes in SFC, crystal distribution and viscosity. Lecithin at 0.03% was generally a crystal promoter; however, at 0.06 and 0.09% it acted as a crystal inhibitor. STS was generally a crystal inhibitor at 0.03, 0.06 and 0.09%. Temperature cycling processes at Cycle 3 had caused the blends with slip melting points (SMP) of 26.5 - 33.5°C to crystallize forming uniform crystal aggregates. Crystal size of blends with emulsifier was significantly increased as the temperature cycling was reduced and the emulsifier content was increased. However, blends with 0.03 and 0.06% lecithin and 0.09% STS had low viscosities. Blends of SMP 21.6 - 26.5°C with 0.09% STS and 0.03% lecithin formed crystal aggregates ranging from 10 – 40 μm and produced low SFCs. The model developed by RSM comprising of 20 - 23% palm oil, 77 - 80% palm olein, 0.02-0.06% lecithin and crystallized at stirring speed of 150 – 300 RPM had established palm oil-based fluid shortenings stable at storage of 25 – 30ºC for three weeks. It is concluded that the size of the crystal aggregates and their distribution in the bulk, were important factors contributing to palm oil-based fluid shortening to flow.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falasafah

SIFAT PENGHABLURAN ADUNAN MINYAK SAWIT DAN LELEMAK CECAIR BERASASKAN MINYAK SAWIT

Oleh

MISKANDAR MAT SAHRI

Disember 2006

Pengerusi: Profesor Yaakob Bin Che Man, PhD

Fakulti: Sains dan Teknologi Makanan

Tesis ini melaporkan kajian yang dijalankan untuk menghasilkan lelemak cecair berasaskan sawit yang merangkumi hasil kajian penghabluran dinamik dan statik adunan minyak sawit dengan bahan tambah pengemulsi atau tanpa pengemulsi dengan perlakuan pada pelbagai suhu. Kandungan lemak pepejal (SFC), saiz dan penyerakan hablur, kandungan asid lemak (FAC) dan komposisi triasilgliserol (TAG) adunan minyak sawit telah dianalisis menggunakan ANOVA pada tahap keyakinan 95%. Formulasi lelemak cecair berasaskan minyak sawit, bahan pengemulsi dan kelajuan adukan telah dioptimakan menggunakan 'response surface methodology (RSM)' berasaskan kajian penstoran yang melibatkan SFC, kelikatan, kebolehtuangan dan saiz dan penyerakan hablur.

Keluk pembinaan hablur adunan minyak sawit melawan fungsi masa jelas menghasilkan keluk bertangga yang berkaitan dengan tahap-tahap penghabluran yang terhasil daripada penghabluran berbaur. Penghabluran secara perlahan-lahan tanpa bahan pengemulsi dipengaruhi oleh jumlah asid lemak tepu dengan perubahan ketara ($P<0.05\%$) dalam SFC, penyerakan hablur dan kelikatannya. Lesitin pada 0.03% telah merangsang pembinaan hablur, walau bagaimanapun pada 0.06 dan 0.09% ia menghalang penghabluran. STS pula pada umumnya adalah penghalang penghabluran pada 0.03, 0.06 dan 0.09%. Proses kitaran suhu pada Kitaran 3 telah menyebabkan adunan yang mempunyai julat takat lebur 26.5 - 33.5ºC menghablur dan membentuk agregat-agregat hablur yang seragam. Peningkatan saiz hablur pada adunan-adunan yang ditambah bahan pengemulsi adalah ketara apabila suhu kitaran direndahkan manakala kandungan bahan pengemulsi ditingkatkan. Walaupun demikian, adunan-adunan yang mengandungi 0.03 dan 0.06% lesitin dan 0.09% STS mempunyai kelikatan yang rendah. Adunan dengan SMP 21.6 - 26.5ºC ditambah 0.09% STS atau 0.03% lesitin membentuk agregat-agregat hablur bersaiz dalam julat 10 – 40 μm dan menghasilkan SFC yang rendah. Model yang terhasil melalui RSM yang mengandungi 20 – 23% minyak sawit, 80 – 77% minyak olein sawit, 0.02 – 0.06% lesitin dan kelajuan putaran adukan dalam julat 150 - 300 pus/min telah menghasilkan lelemak cecair berasaskan minyak sawit yang stabil pada julat suhu penyimpanan 25 – 30ºC selama tiga minggu. Sebagai kesimpulan, saiz agregat hablur dan penyerakannya di dalam pukalan, merupakan faktor terpenting yang mempengaruhi kebolehtuangan lelemak cecair.

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Last but not least, I would like to express my heartiest appreciation to my beloved wife Hanirah Hassan and children for their moral support, encouragement, patience and understanding throughout my studies.

I certify that an Examination Committee met on 18th December 2006 to conduct the final examination of Miskandar Mat Sahri on his Doctor of Philosophy thesis entitled "Crystallization Behavior of Palm Oil Blends and Palm Oil-Based Fluid Shortenings" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UPM or other institutions.

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MISKANDAR MAT SAHRI

Date:

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