UNIVERSITI PUTRA MALAYSIA

EFFECT OF PROCESSING PARAMETERS ON THE PHYSICAL CHARACTERISTICS OF PALM OIL-BASED TABLE MARGARINE

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By

MISKANDAR MAT SAHRI

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

June 2002

DEDICATION

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

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Master of Science

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Chairman: Professor Yaakob Bin Che Man, Ph.D.

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The optimum processing conditions are as important as the product formulation in margarine production. However, the effects of the processing parameters, especially the emulsion temperature, flow rate, product temperature and pin-worker speed, have not yet been thoroughly investigated. This study, using a scraped-surface tube cooler pilot plant, investigated the effects of these parameters on a palm oil-based margarine during its processing and storage.

The processing conditions mainly affected the margarine through its consistency by influencing the solid fat content (SFC) and the crystal polymorph formed. At temperatures of 40°C, 45°C and 50°C, there was no SFC in the

emulsions, but 15.9%, 13.9% and 15.6% were formed in the tube cooler, respectively. The emulsion temperature had no significant effect on the product during storage, although some differences were observed during processing. A margarine with stable consistency and SFC, a moderately high softening point and in the β' polymorph was formed from the emulsion at 45°C. The margarine consistency was the highest at 15 kg/hr emulsion flow rate, and the lowest at 45 kg/hr. Margarine processed at tube cooler temperature 25°C produced an unusual hardening with formation of the β-crystal polymorph in the second week of storage. At 15°C and 20°C it remained in the β'-crystal form for four and three weeks, respectively. The SFCs developed in the tube cooler at the pin-worker speeds of 100 and 300 RPM were 9.12% and 10.11%, respectively. The higher speed retained the emulsion longer in the tube cooler, allowing more crystal formation. The SFCs after the pin-worker at 100 and 300 RPM were 9.01% and 8.72%, respectively. The higher speed severely destroyed the crystal structure, lowering the SFC. The consistency of the margarines at the pin-worker speeds of 100, 200 and 300 RPM were 214, 210.4 and 204 g/cm^2, respectively. They were already in a mixture of β' and β crystal forms in the first week after production.

The study suggests that margarine manufacturers using 100% palm oil should use an emulsion temperature of 45°C, emulsion flow rate at 100% of the plant capacity, pin-worker speed of 200 RPM and chilling temperature of the scraped surface tube cooler of 20°C.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

KESAN PARAMETER PEMPROSESAN TERHADAP SIFAT FIZIKAL MARJERIN BERASASKAN MINYAK SAWIT

Oleh

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Keberkesanan parameter pemerosesan dan pemilihan formulasi adalah sama pentingnya bagi penghasilan marjerin yang bermutu. Walau bagaimanapun, keberkesanan pemerosesan marjerin dari minyak sawit khususnya, pengemulsian, aliran emulsi, suhu tiub penyejukan dan kelajuan pin-pengaduk belum dikaji secara terperinci. Kajian ini yang menggunakan peralatan tersebut telah mengenalpasti kesan aruhnya terhadap produk semasa pemerosesan dan penstoran.

Kaedah pemerosesan mempangaruhi kekonsistenan marjerin dengan mengubah kandungan pepejal lemak (KPL) dan hablur polimorfnya. Suhu

pengemulsian tiada kesan ketara terhadap produk semasa penstoran, walaupun perubahan produk dapat dikesan semasa pemerosesan. Pada suhu pengemulsian 40, 45 dan 50°C, KPL tidak dapat dikesan pada suhu-suhu tersebut, tetapi KPL masing-masing meningkat ke 15.9%, 13.9% dan 15.6% di dalam tiub penyejukan. Marjerin terbaik yang dihasilkan telah diemulsikan pada suhu 45°C, mempunyai kekonsistenan dan nilai pelembutan yang sederhana dan berada pada hablur jenis β'. Pada kelajuan aliran emulsi 15kg/j marjerin yang dihasilkan adalah tinggi kekonsistenannya, berbanding 45kg/j yang rendah. Marjerin yang diproses pada suhu tiub penyejukan 25°C mengalami kekerasan luar biasa seawal minggu kedua dengan pembentukan hablur β. Walau bagaimanapun pada suhu pemerosesan 20 dan 15°C, kekonsistenan dan nilai pelembutan marjerin adalah seragam, manakala hablur adalah dalam β' sehingga minggu ketiga dan keempat. KPL yang terbentuk di dalam tiub penyejukan oleh kelajuan pin-pengaduk 100 RPM ialah 9.12% manakala oleh kelajuan 300 RPM ialah 10.11%, menunjukkan bahawa kelajuan pin pengaduk telah memperlahankan aliran produk di dalam tiub penyejukan dan meningkatkan penghabluran. KPL selepas melalui pin pengaduk pula adalah 8.72% pada kelajuan 300 RPM dan 9.01% pada 100 RPM, menunjukkan bahawa pemusnahan ikatan hablur telah berlaku semasa pengadukan. Semasa penstoran, kekonsistenan marjerin daripada kelajuan pin pengadukan 100 RPM ialah 214 g/cm^2, 300 RPM ialah 210.4 g/cm^2 dan 200 RPM ialah 204 g/cm^2 , manakala hablur yang terbentuk ialah campuran diantara β' dan β pada seawal minggu pertama

Kajian yang dijalankan telah mendapati bahawa bagi penghasilan marjerin yang terbaik daripda minyak sawit 100% pengilang seharusnya menggunakan suhu pengemulsian 45°C, kelajuan emulsi pada kadar 100% kapasiti mesin, suhu tiub penyejukan 20°C dan kelajuan pin pengaduk 200 RPM.

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I certify that an Examination Committee met on 11th June 2002 to conduct the final examination of Miskandar Mat Sahri on his Master of Science thesis entitled "Effect of Processing Parameters on the Physical Characteristics of Palm Oil-Based Table Margarine" 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 has been accepted as fulfilment of the requirements for the degree of Master of Science

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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.

Miskandar Mat Sahri

Date: 23 Julai, 2002

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LIST OF ABBREVIATION

Abbreviation

AOCS	American oil chemists' society
C	Caproic acid
CAN	Canola
CB	Cocoa butter oil
CNO	Coconut oil
CSO	Cottonseed oil
E	Elaidic acid
FAC	Fatty acid composition
GNO	Ground nut oil
Ln	Linoleic acid
L	Lauric acid
LAR	Lard
LL	Linolenic acid
M	Myristic acid
MDP	Mettler dropping point
MF	Milk fat
MPOB	Malaysian Palm Oil Board
MSP	Mettler softening point
MZO	Corn oil/ maize oil

NMR	Nuclear magnetic resonance
O	Oleic acid
OL	Olive oil
P	Palmitic acid
PKO	Palm kernel oil
PKOo	Palm kernel olein
PO	Palm oil
Poo	Palm olein
Pos	Palm Stearin
RBD	Refined bleached and deodorized
RBO	Rice bran oil
RPM	Rotation per minute
SAF	Safflower oil
SBO	Soybean oil
SES	Sesame oil
SFC	Solid fat content
SFO	Sunflower oil
SMP	Slip melting point
St	Stearic acid
TAG	Triacylglycerol
TAL	Tallow

CHAPTER I

GENERAL INTRODUCTION

The properties of a margarine can be varied for its intended use. The layman differentiates between margarines by simple sensory evaluation and common adjectives to describe the product are *soft*, *smooth*, *hard*, *brittle*, *yellowish*, *whitish*, *salty*, *oily* and *buttery*. Manufacturers also consider the properties of their margarine when packaging them for both storage and their intended use – in packets, tubs, tins and cartons - depending on whether they are for households, industrial use, institutional catering or repacking. The range of products can be grouped by their properties - baking index, creaming index, yield value, hardness index, texture and polymorphic crystal structure - for ease of use (Podmore, 1994; Haighton, 1965; deMan *et al*., 1989a; Greenwell,1981).. However, to conform to the requirements on the properties of their products, manufacturers have to select the correct types of oils and fats for their formulations, as well as the processing conditions and temperature for storage.

Price, characteristics and availability are some of the factors considered when selecting oils for margarine production. Soybean oil, sunflower oil, palm oil, canola, coconut oil and palm kernel oil are some of the most commonly used oils (Moore, 1971). Soybean oil is mainly produced in the U.S.A., sunflower oil in Europe, palm oil and palm kernel oil in Malaysia and canola in Canada. In 2000, Malaysia produced

12 million tonnes of palm oil and exported 9.08 million tonnes (Mohd Nasir and Hasiah, 2001).

The use of palm oil can be traced back some 5,000 years (Berger, 1994). However, its substantive use and trade started only in 1960. Since then it has been gaining market share year by year (Berger, 1994; Mohd Nasir and Hasiah, 2001). Considerable research has been done on palm oil, especially in nutrition, food products, processing, oleochemicals and animal feed. It is increasingly being used mixed with the more liquid oils because of the desirable crystallization properties it imparts to margarines and shortenings. This is in stark contrast to the early days when palm oil was perceived as an inferior oil for margarine (Madsen, 1971). Indeed, unbeknown to many, several palm products, like palm olein and palm stearin, have crept into various foods.

However, palm oil is not without its problems. Its slow crystallization makes it rather difficult to use in products like shortening and margarine (Gutcho, 1979; Duns, 1985) despite some good properties imparted. And despite the considerable work done, the problem has not yet been sufficiently addressed for the oil to compete and substitute fully for the hydrogenated liquid oils often used in margarines and shortenings. Further, very little is being done on the characteristics of the oil in influencing the margarine qualities. For example, in processing, deMan and deMan (1994) stated that formulations with the same solid fat content (SFC) need not necessarily produce margarines of the same quality. The product end point and

processing technique are still considered an art and kept secret by most companies although, doubtless, all will be known in time (Bernadini, 1983).

A proper guide on the effects of processing conditions and formulations on the product quality will be immensely useful to the industry and will broaden its scope for innovation. The ready availability of palm oil in the market will make the products made from it less expensive and more competitive with no quality problem such as oiling off, greasiness and sandiness.

The study was undertaken to determine the effects of various processing conditions on the physical properties of palm oil-based table margarine. The conditions investigated were:

I. Emulsion temperature;

II. Emulsion flow-rate;

III. Tube cooler temperature; and

IV. Pin-worker speed.

Special emphasis was placed on the development of crystal structure in processing and during storage.