UNIVERSITI PUTRA MALAYSIA

APPLICATION OF PALM OIL AND PALM KERNEL OIL IN PRODUCING NON-DAIRY WHIPPING CREAM

KAMBIZ SHAMSI

FSMB 2003 32

APPLICATION OF PALM OIL AND PALM KERNEL OIL IN PRODUCING NON-DAIRY WHIPPING CREAM

By

Kambiz Shamsi

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

April 2003

TO

Hamid, Paymon and Ramin for their pure friendship

Yasmin for her love and devotion

Ladi , Sami and Alireza for their help, understanding and support

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

APPLICATION OF PALM OIL AND PALM KERNEL OIL IN PRODUCING NON-DAIRY WHIPPING CREAM

By

KAMBIZ SHAMSI

April 2003

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

Faculty: Food Science and Biotechnology

Refined, bleached and deodorized palm kernel oil (RBDPKO) and refined, bleached and deodorized palm oil (RBDPO), sucrose, corn syrup solids, sodium caseinate, soybean lecithin, carboxymethylcellulose (CMC), monoacylglycerol and distilled water were blended and made into creams. The creams were measured in terms of fatty acid composition (FAC), stability, slip melting point (SMP), iodine value (IV), whipping test, overrun, viscosity and solid fat content (SFC). Differential scanning calorimetry (DSC) and X-ray diffractometry (XRD) were used to study the crystal structure of the creams. The results showed that the increase in unsaturated fatty acids (UFA), among which oleic acid was the most prominent, could produce a more stable foam in palm oil-based whipping cream. It was shown that increasing the IV had an increasing effect on the stability of foam in non-dairy whipping cream as well. This study showed the advantages of a palm oil-based whipping cream over commercial dairy whipping cream (DWC) particularly when the stability of the

foam is being considered and the product is destined to be consumed in hot weather. It was shown that the percentage of fat in whipping cream, whether dairy or non-dairy, was not the only determining factor for producing a stable foam, but the composition of the component fat must be taken into account as well. It was also found that the IV was highly correlated with overrun and SFC and the increase in the degree of unsaturation can lead to the raising of overrun. However, there was no correlation between IV and the trend of viscosity in the creams as viscosity is mostly under the influence of stabilisers and emulsifiers, rather than the degree of unsaturation in fatty acids (FA) Viscosity acted as an independent variable of SFC as well. The studies using DSC and XRD on palm oil-based whipping cream developed showed that all blends possessed a stable and shiny β' polymorph at 25°C, which stands RBDPO and RBDPKO in an advantage for application in a non-dairy whipping cream. Some eutectic effects were also observed in some blends, which could be attributed to complex combination of triacylglycerol (TAG) in RBDPO and RBDPKO. It was also found that addition of RBDPO and RBDPKO to DWC could increase its stability and consistency in hot weather.

PERPUSTAKAAN SULTAN ABDUL SAMAD
UNIVERSITI PUTRA MALAYSIA

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

PENGGUNAAN MINYAK SAWIT DAN ISIRONG MINYAK SAWIT DALAM PENGELUARAN KRIM PUTAR TANPA TENUSU

Oleh

KAMBIZ SHAMSI

April 2003

Pengerusi: **Profesor Dr. Yaakob Bin Che Man, Ph.D.**

Fakulti: **Sains Makanan dan Bioteknologi**

Isirong minyak sawit yang ditapis, dinyahwarna dan dinyahbau (RBDPKO) dan minyak sawit yang ditapis, dinyahwarna dan dinyahbau (RBDPO), sukrosa, pepejal sirap jagung, sodium kasinat, lesitin soya, karboksimetilselulose, monoasilgliserol dan air suling telah di campur untuk menjadi krim. Krim telah dinilai dari aspek komposisi asid lemak (FAC), kestabilan, titik slip lebur (SMP), nilai iodin (IV), ujian putaran, 'overrun', kelikatan dan kandungan lemak pepejal (SFC). Kalorimeter Pembezaan Imbasan (DSC) dan Difraktometri X-ray (XRD) telah digunakan untuk mengkaji struktur kristal di dalam krim. Keputusan menunjukkan peningkatan asid lemak tidak tepu, di mana asid oleik yang paling menonjol, boleh menghasilkan buih yang lebih stabil bagi krim putar berasaskan minyak sawit. Di dapati peningkatan nilai iodin akan meningkatkan kestabilan buih di dalam krim putar tanpa tenusu. Kajian ini mengenengahkan kebaikan krim putar berasaskan minyak sawit dibandingkan dengan krim putar tenusu komersial (DWC) terutama apabila mengambilkira kestabilan buih dan kesesuaian produk di dalam keadaan cuaca panas. Kajian ini juga menunjukkan peratus lemak

dalam krim putar, samada dari tenusu atau bukan tenusu, bukanlah faktor penentu untuk menghasilkan buih yang stabil, tetapi komposisi komponen lemak perlu juga di ambilkira. Di dapati IV amat berkait rapat dengan 'overrun' dan SFC, dan peningkatan darjah tidak tepu boleh menyebabkan 'overrun' berlaku. Walau bagaimanapun, didapati tiada hubungan di antara IV dan kelikatan dalam krim kerana kelikatan lebih dipengaruhi oleh penstabil dan pengemulsi berbanding dengan darjah tidak tepu di dalam asid lemak. Kelikatan bertindak sebagai pemboleh ubah bebas dalam SFC. Dalam kajian ini, aplikasi DSC dan XRD di dalam krim putar berasaskan minyak sawit yang dihasilkan, menunjukkan bahawa semua campuran mempunyai β' polimorf yang stabil dan bersinar pada 25^0C, dan ini membuktikan RBDPO dan RBDPKO mempunyai kelebihan untuk digunakan dalam krim putar tanpa tenusu. Beberapa kesan 'eutectic' telah diperhatikan dalam beberapa campuran, yang menyumbang kepada kombinasi kompleks triasilgliserol (TAG) di dalam RBDPO dan RBDPKO. Hasil menunjukkan bahawa penambahan RBDPO dan RBDPKO kepada DWC dapat meningkatkan kestabilan dan keseragamannya dalam cuaca panas.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude, appreciation and thanks to Professor Dr. Yaakob Bin Che Man for his kind supervision, assistance and encouragement during the preparation of this thesis. I also thank members of my supervisory committee, Professor Dr. Jinap Selamat and Dr. Mohd Suria Affandi Yusoff for their assistance.

I would like to acknowledge the financial support provided by the IRPA fund [01-02-04-0461] for this research awarded to Professor Dr. Yaakob Bin Che Man. My thanks also go to Malaysian Palm Oil Board for providing the facilities and equipments necessary for undertaking this study.

My special appreciation is also extended to my labmates whom I will never forget Dr. Tan Chin Ping, Gabby Setiowati, Dr. Mohammad Elwathig Saeed Mirghani, Wanna Ammawath, Chu Boon Seang and Mariam Binti Abdul Latif for their sincere friendship and assistance.

I wish also to express my sincere appreciation to all those who directly or indirectly have provided me with their kind assistance including the authorities and staff in the Faculty of Food Science and Biotechnology.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CMC	carboxymethylcellulose
DAG	diacylglycerol
DE	dextrose equivalent
DSC	differential scanning calorimetry
DWC	dairy whipping cream
FA	fatty acid
FAC	fatty acid composition
FAME	fatty acid methyl esters
GC	gas chromatography
GLC	gas liquid chromatography
HMG	high melting glyceride
IV	iodine value
MAG	monoacylglycerol
mL	millilitre
MPOB	Malaysian Palm Oil Board
MP	melting point
o/w	oil-in-water
PGMS	propylene glycol monoesters
PS	palm stearin
RBDPKO	refined, bleached and deodorized palm kernel oil
RBDPO	refined, bleached and deodorized palm oil
SFC	solid fat content
SMP	slip melting point
SV	saponification value
SFA	saturated fatty acid
TAG	triacylglycerol
UHT	ultra high treatment
UFA	unsaturated fatty acids
w/o	water-in-oil
XRD	x-ray diffraction

CHAPTER I

INTRODUCTION

Dairy products and derivatives have found a wide range of consumption and a high demand in all countries due to their vast application in various products. In confectionery, bakery, pharmaceutical and some other non-dairy industries, there is an increasing demand for at least one of the milk components like caseinate, milk powder, etc. In developed countries the access to ruminants milk is much easier than developing countries. Furthermore, countries located in the tropical regions, due to the high ambient temperature have limitations in using milk products because of the sensitivity of milk to high temperature. Milk fat is made up of hundreds of FAs, which makes it difficult to handle and to use it tailor-sized (Magidman, 1962). For this reason, tropical countries prefer to use the substitutes and imitations for milk products.

In some other countries, like those in Southeast Asia including Malaysia, the access to the rich sources of palm oil has converted this region to the largest exporter of palm oil and related products in the world, and millions of tons of palm oil are exported annually from Malaysia to many countries. Today, only the imported cosmetic and nutritional products in Malaysia can be considered as products with no palm oil in content. Palm kernel oil, which is a product of the nut in the palm fruit, has also a wide use mostly in combination with palm oil. Therefore, a huge number of researches have been carried out in this country to fulfil the application of palm and palm kernel oil in a wide range of products and many research centres are involved in developing the new applications for palm oil and its products.

Non-dairy whipping cream is among those products, which has attracted the attention of many researchers either Malaysian or non-Malaysian and many studies have been undertaken to facilitate the application of a vegetable fat like palm oil or its fractions for the production of whipping cream. However, the studies undertaken so far on dairy or non-dairy whipping cream are mostly dealing with the effect of stabilisers and emulsifiers on the structure of cream, and very few studies have fundamentally focused on the effect of FAs on the physical characteristics of whipping cream either dairy or non-dairy. Furthermore, most researchers have focused on dairy creams since it is widely consumed in the developed countries.

Nesaretnam *et al.* (1993) studied the application of hydrogenation of palm kernel oil (HPKO) and palm stearin (PS) in whipping cream. Accordingly, the addition of PS to HPKO in the ratio of PS:HPKO 34:66 was judged to be the most promising blend in terms of its whipping performance and stability. The interesterification helped to eliminate increase in solid fat content at the highest temperatures.

Liew (1999) carried out a study to develop a non-dairy whipping cream formula by using interesterified palm oil products. In his study, a formula was developed for non-dairy whipping cream by the application of different percentages of stabilisers and emulsifiers. Liu (1998) developed a non-dairy whipping cream using palm kernel oil, palm kernel olein and palm stearin. She concluded that it is possible to develop non-dairy whipping cream by using resources from palm oil.

Smith *et al*. (2000) studied the microstructure and rheological properties of whipped cream as affected by heat treatment and addition of stabilisers. They found that unstabilised foams did not exhibit significant differences in rheological measurements when freshly whipped or after 24 hours of refrigerated storage regardless of heat treatment.

In another study, Bruhn and Bruhn (1988) made some observations on the whipping characteristics of cream. They concluded that the ultra heat treatment (UHT) creams took about 40% longer to whip than raw and pasteurised creams. Heavy creams according to them whipped in about 20% less time and to a lower overrun than regular whipping creams. Rousseau (2000) as in this study investigated the fat crystals and its effect on the emulsion stability and found that crystals had a determining impact on the structure and emulsion stability.

Stanely *et al.* (1996) studied the texture-structure relationships in foamed dairy emulsions. They concluded that the favourable textural qualities of foamed dairy emulsions result from the successful incorporation of air bubbles surrounded by partially coalesced fat globules into a stable product. They made a comparison between ice cream and whipped cream in terms of the action of polysaccharides in stabilizing dairy emulsions. In a similar study, Noda and Shiinoki (1986) investigated the mechanism of the formation of a rigid foam structure during whipping the cream and found the relationship between the rheological properties and microstructure of whipped creams. They concluded that the whipped cream is a mixed matrix of a soft oil-in-water (o/w) structure and a stiffer water-in-oil (w/o) structure.

However, in none of the above studies, the fatty acids (FA) in whipping creams and their impact on physical characteristics of whipping cream was fundamentally studied although fats and oils make a great portion of whipping creams either dairy or non-dairy.

The first objective of this study was to produce a substitute for a dairy whipping cream, which can be whipped easily and effectively. To develop a practical formula for the fat phase of a palm oil-based whipping cream and to produce a more stable froth in cream after whipping was the second objective in this study. The third objective focused on determining the composition of the FAs in a palm oil-based whipping cream and the impact on its physical characteristics namely stability, viscosity, overrun, etc. Increasing the stability of the foam in dairy whipping cream by the addition of RBDPO and RBDPKO was the last objective in this study.

CHAPTER II

LITERATURE REVIEW

Malaysian Palm Oil

Palm oil is the second largest source (19.35 million metric tons in 1999) of edible oil after soybean oil in the world (USDA, 2000). The commercial oil palm, *Elaeis guineensis,* which is cultivated in Malaysia, is known as *tenera* originated from West Africa (Yap *et al.,* 1991) and belongs to *Cocoidea* of *Palmae.* Although it was introduced into Malaysia in 1870 as an ornamental plant, the first commercial planting of oil palm seriously took place in 1917 (Pantzaris and Elias, 1987).

Palm oil has a long history of food use, with archaeological evidence going back to 5000 years ago (Bariso, 1996). However, improved varieties have been widely planted in the wet tropics in Africa, Latin America and South-east Asia. Concurrently, Malaysia is the largest producer (Table 1) and exporter of palm oil in the world (Table 2) with 3,449,012 million hectares of plantation area (Table 3). Other major producers and exporters of palm oil are Indonesia, Nigeria and Papua New Guinea. In Malaysia, within 18 years, from 1981 to 1999, area under oil palm plantation has increased almost 300%. During the past 40 years, palm oil has emerged from relative obscurity to become no. 1 in the world imports/exports among edible oils and no. 2 in total production (Table 2).

Table 1: World Major Producers of Palm Oil, 1996 – 2001 ('000 tonnes)

Country	1996	1997	1998	1999	2000	2001
Malaysia	8,386	9,069	8,320	10,554	10,700	11,660
Indonesia	4,899	5,385	5,006	6,060	6,650	7,400
Nigeria	670	680	690	720	740	750
Colombia	410	441	500	424	516	540
Ivory Coast	280	240	275	282	290	275
Thailand	375	390	355	410	435	535
Papua New Guinea	272	275	215	270	285	308
Equador	188	203	200	220	243	255
Costa Rica	109	109	103	105	115	123
Honduras	76	77	74	75	80	94
Brazil	80	80	89	90	95	110
Venezuela	45	46	48	46	80	84
Guatemala	36	50	51	53	58	70

Source: OIL WORLD ANNUAL (1996-2001).

Table 2: World Major Exporters of Palm Oil, 1995 – 2001 ('000 tonnes)

Country	1995	1996	1997	1998	1999	2000	2001
Malaysia	6,513	7,212	7,490	7,425	8,802	9,620	10,580
Indonesia	1,856	1,851	2,982	2,082	3,183	3,360	4,320
Papua NG	220	267	275	213	264	267	294.2
Ivory Coast	120	99	73	83	75	107	84
Colombia	21	29	61	67	101	110	99.7
Singapore	399	289	298	241	270	270	240
H. Kong	275	305	173	103	94	108	230

Source: OIL WORLD ANNUAL (1995-2001).