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PERFORMANCE OF LIPASE-TRANSESTERIFIED FRYING SHORTENING FOR FRYING OF BANANA CHIPS

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PERFORMANCE OF LIPASE-TRANSESTERIFIED FRYING SHORTENING FOR FRYING OF BANANA CHIPS

By

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PERFORMANCE OF LIPASE-TRANSESTERIFIED FRYING SHORTENING FOR FRYING OF BANANA CHIPS

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November 2000

Chairman : Professor Hasanah Mohd. Ghazali, Ph.D.

Faculty : Food Science and Biotechnology

Palm stearin (POs), the solid fraction of palm oil is a useful hard stock that can substitute the hydrogenated oils, which contain *trans* fatty acids, in the production of plastic frying shortening. This study was initiated to produce a zero-*trans* plastic frying shortening through enzymatic transesterification of POs and palm kernel olein (PKOo) blend.

In the first part of this study, commercial plastic frying shortenings (domestic and imported) in Malaysia were characterised in order to obtain their physical properties which are related to their functionality. The domestic samples were found to have their plastic range at higher temperatures (21°C to 27°C) than the imported ones (15°C to 27°C). They were also more β-tending and generally had a higher slip melting point (SMP, ranging from 44.0°C to 49.7°C) than the imported samples (42.3°C to 43.0°C). Based on the physical properties of the commercial samples, an experimental plastic frying shortening was formulated from POs and PKOo at a ratio of 1:1 (by weight) through enzymatic transesterification, using Lipozyme IM60 lipase (*Rhizomucor miehei*). Transesterification had successfully changed the triacylglycerol composition of the

blend, and consequently altered its physical properties. The SMP of the transesterified POs/PKOo blend was reduced and had a lower solid fat content at all temperatures investigated compared to the control. The transesterified blend was also found to have similar or better product characteristics compared to the domestic samples. The SMP of the transesterified blend fell within the range of the commercial samples' and it had a wider plastic range or better workability compared to the commercial shortenings investigated.

However, transesterification had reduced the antioxidant activity that was naturally present in POs and PKOo. The transesterified blend was more susceptible to oxidation during deep fat frying and storage compared to its control. The banana chips fried with the transesterified blend also showed similar results. Nevertheless, the transesterified blend was still quite stable compared to a selected commercial frying shortening (Sample D) since it had a significantly ($P < 0.05$) lower iodine value (IV = 31.6 g of I_2/100 g of oil) compared to the commercial shortening (IV = 89.4 g of I_2/100g of oil).

The results in this study had provided a better understanding on the functionality of the plastic frying shortening and also serves as a guideline in producing a similar product in the industries.

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

PRESTASI LELEMAK PENGGORENG TERTRANSESTERIFIKASI-LIPASE UNTUK PENGGORENGAN CIP PISANG

Oleh

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November 2000

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Lemak stearin kelapa sawit (POs) yang merupakan pecahan pepejal minyak kelapa sawit adalah lemak keras yang berguna. Ia boleh menggantikan minyak terhidrogen yang mengandungi asid lemak berbentuk *trans* dalam penghasilan lelemak penggoreng yang bersifat plastik. Penyelidikan ini bertujuan untuk menghasilkan lelemak penggoreng tanpa *trans* melalui transesterifikasi POs dengan minyak olein isi rung kelapa sawit (PKOo).

Dalam bahagian pertama penyelidikan ini, lelemak penggoreng plastik komersial (tempatan dan import) di Malaysia dikaji untuk meneliti sifat-sifat fizikalnya yang berkaitan dengan tahap kecekapan penggunaannya. Sampel-sampel tempatan didapati mempunyai julat plastik pada suhu yang lebih tinggi (21°C hingga 27°C) daripada sampel-sampel import (15°C hingga 27°C). Sampel tempatan juga lebih cenderung untuk membentuk hablur β dan secara umumnya mempunyai takat lebur (SMP) yang lebih tinggi (44.0°C hingga 49.7°C) berbanding dengan sampel-sampel import (42.3°C hingga 43.0°C). Berdasarkan sifat-sifat fizikal sampel-sampel komersial itu, satu lelemak penggoreng telah dihasilkan daripada POs dan PKOo pada nisbah 1:1 (berat) melalui

transesterifikasi enzim dengan menggunakan lipase Lipozyme IM60 (*Rhizomucor miehei*). Transesterifikasi telah berjaya mengubah sifat-sifat fizikal campuran POs/PKOo itu. SMP campuran POs/PKOo tertransesterifikasi telah dikurangkan dan ia mempunyai kandungan lemak pejal yang lebih rendah pada semua suhu yang diuji berbanding kawalannya. Campuran lemak tertransesterifikasi itu juga didapati mempunyai sifat-sifat produk yang sama atau lebih baik berbanding dengan sampel-sampel komersial. SMP campuran tertransesterifikasi itu jatuh dalam julat SMP sampel-sampel komersial itu dan ia mempunyai julat plastik yang lebih besar berbanding dengan sampel-sampel komersial yang dikaji.

Walau bagaimanapun, transesterifikasi telah menurunkan aktiviti antioksidannya yang wujud secara semulajadi dalam POs dan PKOo. Campuran tertransesterifikasi itu lebih cenderung dioksidakan semasa penggorengan dan penyimpanan berbanding kawalan. Cip pisang yang digoreng dalam campuran itu juga didapati menunjukkan keadaan yang sama. Walau bagaimanapun, campuran tertransesterifikasi itu masih agak stabil berbanding sampel komersial kerana ia mempunyai nilai iodin (IV) yang rendah (IV = 31.6 g I_2/100 g minyak) berbanding sampel komersial (IV = 89.4 g I_2/100 g minyak).

Keputusan yang diperolehi dalam penyelidikan ini memberikan kefahaman yang lebih mendalam tentang kecekapan penggunaan lelemak penggoreng plastik dan boleh juga digunakan sebagai satu garis panduan untuk menghasilkan produk yang sama di dalam industri.

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Last but not least, I would like to take this opportunity to thank my family for their endless loves, cares and supports.

I certify that an Examination Committee met on 25th November 2000 to conduct the final examination of Chu Boon Seang on his Master of Science thesis entitled "Performance of Lipase-Transesterified Frying Shortening for Frying of Banana Chips" 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 follow:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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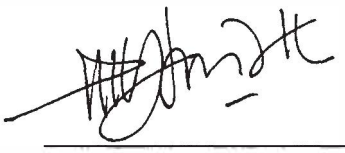
Date: 11 JAN 2001

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 concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.



Chu Boon Seang,
Candidate

Date: 6 December, 2000

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Varian
AOCS	American Oil Chemists' Society
AOM	Active Oxygen Method
AV	*p*-anisidine value
BHA	butylated hydroxyanisole
β	beta
β′	beta prime
c	*cis*
C6:0	caproic acid
C8:0	caprylic acid
C10:0	capric acid
C12:0	lauric acid
C14:0	myristic acid
C16:0	palmitic acid
C16:1	palmitoleic acid
C18:0	stearic acid
C18:1	oleic acid
C18:2	linoleic acid
C18:3	linolenic acid
C20:0	eicosanoic acid
D	capric acid
DSC	differential scanning calorimetry
$E^{1\%}_{1cm}$	Specific extinction

FA	fatty acid(s)
FFA	free fatty acid(s)
FOS	food oil sensor
IV	iodine value
HMG	high melting glycerides
HPLC	high performance liquid chromatography
L	linoleic acid
La	lauric acid
Ln	linolenic acid
M	myristic acid
MPOB	Malaysian Palm Oil Board
NVDP	non-volatile decomposition products
O	oleic acid
Oc	caprylic acid
OOSI	Omnion oxidative stability instrument
P	palmitic acid
PKO	palm kernel oil
PKOo	palm kernel olein
PORIM	Palm Oil Research Institute of Malaysia
POs	palm stearin
PV	peroxide value
QDA	Quantitative Descriptive Analysis
r^2	correlation coefficient
S	stearic acid
SAS	Statistical Analysis System

SFC	solid fat content
SFI	solid fat index
SMP	slip melting point
sp.	species
t	*trans*
TBA	thiobarbituric acid value
TBARS	thiobarbituric acid responsive substances
TBHQ	tertiary butylhydroxyquinone
TEP	1,1,3,3-tetraethoxypropane
TG	triacylglycerol(s)
$[TGI_t]$	concentration of triacylglycerols that increase in value at reaction time, t
$[TGI_0]$	concentration of triacylglycerols that increase in value at the start of reaction
TPC	total polar compounds
VDP	volatile decomposition products
v/w	volume/volume
v/v	volume/weight
w/w	weight/weight
X	rate of transesterification

CHAPTER 1

INTRODUCTION

Although the term "shortenings" initially refers to naturally occurring solid fats like lard and butter in baked products, it has now become virtually synonymous with fats and oils including those designed for purposes other than baking (O'Brien, 1998). Shortenings are used in the preparation of many foods such as cooking, baking, frying and also as an ingredient in fillings, icings and many other food systems.

Frying shortenings exert a tenderising effect on crusts formed on the surfaces of fried foods, as well as contributing to flavour, crispiness and pleasant eating characteristics (O'Brien, 1998). Solid or plastic frying shortenings are normally formulated from hydrogenated fats (Scavone, 1995). Even though hydrogenation is a cheap process on an industrial scale, it produces *trans* fatty acid (FA) which was reported to cause several coronary heart problems such as thrombogenesis (Zock and Katan, 1992; Willett *et al.*, 1993; Ray and Bhattacharyya, 1996). As a result of public awareness on the effects of *trans* FA on health, interest has grown to produce zero-*trans* shortenings using transesterification (Bloomer *et al.*, 1990; Chang *et al.*, 1990; Zeitoun *et al.*, 1993; Ghazali *et al.*, 1995a, 1995b; List *et al.*, 1995; Lai *et al.*, 1998a, 1998b, 1998c, 1999).

Rearrangement of acyl groups among triacylglycerols (TG) during transesterification process changes the original TG profile of a fat or oil. This is followed

by changes in the physical properties of the fat or oil such as the slip melting point (SMP), solid fat content (SFC), polymorphic forms and also stability over heating and storage time (Bloomer *et al.*, 1990; Forssell *et al.*, 1992; Foglia *et al.*, 1993; List *et al.*, 1995; Lai *et al.*, 1998a, 1998b). Through transesterification, a desired new fat product can be produced by controlling the fat/oil type and their ratio. Much research has been done to obtain new fat products or improve the quality of existing fat products (Bloomer *et al.*, 1990; Linko *et al.*, 1994; List *et al.*, 1995; Lai *et al.*, 1998a, 1998b, 1998c, 1999).

Plastic frying shortenings are composed of a hard stock which is mixed in judicious proportions with a base stock or oil to give a desirable requirement for packing, handling and composition. Palm stearin (POs), with a SMP ranging between 44 and 56°C (Chong, 1994) is a good natural source of hard stock in producing shortenings (Berger, 1981; Kheiri, 1985; Tan, 1989). Palm kernel olein (PKOo) which is quite saturated (iodine value, IV about 24 g of I_2/100 g of oil) and appears as liquid oil at room temperature (SMP is 26°C), is a potential base stock for frying shortenings. PKOo as a lauric oil has a good withstand toward the rigours of high heat frying (Crosby, 1993). Incorporation of POs and PKOo may give a blend that is suitable for deep fat frying.

Deep fat frying is a universal and traditional method of cooking in households and in restaurants. Frying can generate desirable texture and flavour in foods (Wu and Nawar, 1986). The frying fat or oil act as a heat transferring medium at high frying temperatures (about 180°C). However, exposure to high temperatures and oxygen accelerates the hydrolysis and oxidation of the fat or oil and produces a range of volatile and non-volatile decomposition products such as free fatty acids (FFA), peroxides,

ketones, aldehydes, dimers, cyclic compounds, etc. (Fritsch, 1981; Melton *et al.*, 1994; Orthoefer *et al.*, 1996), and hence causes the fat or oil to become unstable, gives rancid off-flavour and becomes deteriorated in quality. A deteriorated frying medium not only reduces the organoleptic quality of the fried foods, but also causes growth retardation, damage to the liver, thymus and testes (Alexander *et al.*, 1987) and alteration of the production of vascular eicosanoids (Giani *et al.*, 1985). Therefore, inspection on the quality of the frying fats or oils during frying is very important.

The autoxidative stability of the fat/oil during storage time is also an important attribute that should be of concern. Autoxidation is a natural process that takes place between molecular atmospheric oxygen and the unsaturated FA. Autoxidation of the unsaturated FA occurs *via* a free radical chain mechanism. This reaction causes disagreeable alterations in the flavour of the fat/oil and may produce potentially toxic compounds (Tautorus and McCurdy, 1992).

In this study, the physical and chemical properties of some Malaysian commercial plastic frying shortenings were analysed. Based on the information collected, an experimental plastic frying shortening was produced from POs and PKOo through enzymatic transesterification. POs and PKOo were mixed in the ratio of 1:1 (by weight) and then transesterified using Lipozyme IM60 lipase (from *Rhizomucor miehei*) as the biocatalyst. The product was used as a deep fat frying medium for the production of banana crisps. The effect of the shortening on the quality of the banana crisps as well as the stability of the shortening during frying were objectively monitored and evaluated. Therefore, the objectives of this study were: