UNIVERSITI PUTRA MALAYSIA

IMPROVEMENT OF PHYSICOCHEMICAL PROPERTIES OF RBD PALM OLEIN BLENDED WITH SOYBEAN OIL FOR DEEP-FAT FRYING

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BY

LIU JIA LONG

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Food Science and Biotechnology Universiti Putra Malaysia

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Dedicated to

My beloved wife and my daughter

for their love,

patience,

and understanding.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

RBDPOo	Refined, bleached and deodorised palm olein
RBDPOo70	Blend of RBDPOo/SBO=70/30
RBDPOo50	Blend of RBDPOo/SBO=50/50
RBDPOo30	Blend of RBDPOo/SBO=30/70
SBO	Soybean oil
SFC	Solid fat content
FAC	Fatty acid composition
PV	Peroxide value
AnV	Anisidine value
FFA	Free fatty acid
IV	Iodine value
VDP	Volatile decomposition product
NVDP	Non-volatile decomposition product
TBHQ	Tertiary butylhyoquinone
DSC	Differential scanning calorimetry
SMLR	Stepwise multiple linear regression

Abstract of the 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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September 1999

Chairman : Prof. Yaakob B. Che Man, Ph.D.

Faculty : Food Science and Biotechnology

The quality changes of refined, bleached and deodorised palm olein (RBDPOo), soybean oil (SBO) and their blends during intermittent deep-fat frying at 180±5°C for 5h per day for 5 consecutive days were studied. The shelf-life of potato chips used for frying was also investigated. The results showed that the physicochemical properties of SBO were improved by blending with RBDPOo in terms of resistance to oxidation, iodine value (IV), anisidine value (AnV), foaming tendency, % polar component and polymers content. However, SBO also contributed to RBDPOo with respect to colour, viscosity, free fatty acids (FFA) content and smoke point. Sensory evaluation showed that potato chips fried in both of RBDPOo and SBO were equally preferred by the panellists. Shelf-life stability of the fried potato chips indicated that chips fried in RBDPOo were better than that fried in SBO. The blends of RBDPOo : SBO were improved with increasing proportion of RBDPOo. The observation showed that there

were minimal effects on the rate of development of rancidity in the fried product beyond the fourth day of frying in all blends.

The changes of RBDPOo with added TBHQ and α-tocopherol during deep-fat frying were also studied. Addition of antioxidants resulted in improved oxidative stability. TBHQ was more effective in reducing the level of FFA, polar component and polymers and decreased the rates of change in IV and the ratio of C18:2/C16:0. α-tocopherol was more effective in reducing AnV and totox values. However, adding antioxidants caused darkening of oils and increased the formation of foam during deep-fat frying.

Differential scanning calorimetry (DSC) was also used to monitor IV, peroxide value (PV), AV and FFA of frying oils. The heating thermogram was from –50 to 80°C at a heating rate of 5°C/min, whereas, the cooling thermogram was at the same rate from 80 to –50°C. Stepwise multiple linear regression (SMLR) analysis showed that peak characteristics, namely peak temperature, enthalpy and peak height of heating and cooling thermograms can predict the parameters such as IV, PV, AV and FFA of the samples with the coefficient of determination (R^2) at least 0.9300. Thus, this study showed that DSC method can monitor these quality parameters of fried oils to replace wet chemical methods which involve a large number of toxic and environmental unfriendly solvents and reducing the labour cost as well.

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

PEMBAIKAN CIRI-CIRI FIZIKO-KIMIA MINYAK SAWIT OLEIN TULIN YANG DICAMPURKAN DENGAN KACANG SOYA UNTUK PENGGORENGAN

By

LIU JIA LONG

September 1999

Pengerusi : Prof. Yaakob B. Che Man, Ph.D.

Fakulti : Sains Makanan dan Bioteknologi

Perubahan-perubahan kualiti minyak sawit olein tulin (RBDPOo), minyak kacang soya (SBO) dan campuran kedua-dua jenis minyak ini telah dikaji semasa penggorengan pada suhu 180±5°C untuk 5 jam/hari selama 5 hari berturut-turut. Kajian hayat simpanan kerepek ubi kentang yang digunakan semasa penggorengan juga telah diselidiki. Keputusan-keputusan kajian menunjukkan bahawa ciri-ciri fizika-kimia SBO menjadi lebih baik apabila di campurkan dengan RBDPOo dari segi ketahanan terhadap pengoksidaan, nilai iodin, nilai anisidin, keupayaan pembentukan busa, % komponen polar, dan kandungan polimer. Walau bagaimanapun, SBO menyumbangkan ciri-ciri yang lebih baik kepada RBDPOo dari segi warna, kelikatan, kandungan asid lemak bebas dan titik asap. Penilaian deria menunjukkan bahawa panel-panel deria menyukai kerepek ubi kentang yang telah digoreng dalam kedua-dua RBDPOo dan SBO. Kajian hayat simpanan kerepek ubi kentang menunjukkan bahawa RBDPOo lebih baik dari segi jangka hayat simpanan produk jika dibandingkan dengan SBO. Campuran minyak

RBDPOo : SBO didapati lebih baik dari SBO dengan peningkatan bahagian RBDPOo. Pencerapan kajian menunjukkan bahawa kadar pembentukan ketengikan adalah minimal dalam produk yang telah digoreng sehingga hari penggorengan keempat.

Perubahan RBDPOo dengan penambahan TBHQ dan α-tokoferol semasa penggorengan telah dikaji. Penambahan antioksidan dapat memperbaiki kestabilan pengoksidaan minyak. TBHQ didapati lebih berkesan dalam mengurangkan kandungan asid lemak bebas, komponen polar dan polimer, mengurangkan kadar perubahan nilai iodin dan nisbah C18:2/C16:0. α-tokoferol didapati lebih berkesan bagi mengurangkan nilai anisidin dan totox. Walau bagaimanapun, penambahan antioksidan menyebabkan pemerangan minyak dan peningkatan busa semasa penggorengan.

Kalorimetri pembias kebedaan (DSC) juga telah digunakan untuk mengawal nilai iodin, peroksida, anisidin dan asid lemak dalam minyak yang telah digunakan untuk penggorengan. Termogram pemanasan dari –50 ke 80°C pada kadar pemanasan 5°C/min, manakala termogram penyejukan pada kadar penyejukan yang sama dari 80 ke –50°C telah diperolehi. Analisis stepwise multiple linear regression (SMLR) menunjukkan bahawa ciri-ciri puncak, umpamanya suhu puncak, entalpi, ketinggian puncak termogram-termogram pemanasan dan penyejukan boleh menganggarkan parameter sampel dengan koefisien penentuan (R^2) sekurang-kurangnya 0.9300. Dengan itu, kajian ini menunjukkan bahawa kaedah DSC boleh memantau ciri-ciri kualiti minyak pengorengan ini untuk menggantikan kaedah-kaedah kimia yang memerlukan penggunaan pelarut-pelarut beracun dan pencemar alam sekitar dan juga dapat mengurangkan kos buruh.

CHAPTER I

GENERAL INTRODUCTION

Deep-fat frying is one of the most used cooking methods for foods worldwide. The oil plays a critical role as a heat-transfer and impregnation medium and it is the crucial component of the frying process (Blumenthal and Stier, 1991). Upon repeated use at high temperatures, frying oils undergo several oxidative, polymerisation, and thermal degradation reactions leading to changes in their physical, chemical, nutritional, and sensory properties. In particular, health risks including heart disease, diabetes, cancer, and stroke are well established for high-fat diets (Hollingsworth, 1996), and there are some evidences that highly oxidised and abused oils may even have mutagenic properties (Clark and Serbia, 1991).

During frying, triacylglycerols which constitute 96-98% of the fresh oil, degrade to form volatile decomposition products (VDP) and non-volatile decomposition products (NVDP). VDP are constantly removed by the steam generated during frying, whereas NVDP are formed mainly by oxidation and/or thermal reactions of unsaturated fatty acids and consist mainly of polymers, dimers, and trimers. Chemical changes also result in physical alterations of the oil such as increase in viscosity, due to the presence of polymers, and colour darkening (Melton *et al.*, 1994).

Among the commonly used oils and fats, refined, bleached and deodorised palm oil (RBDPOo) and its fractions such as palm olein are of the most important and commonly used frying oils since they have no unpleasant odour and are highly resistant to oxidation (Pantzaris, 1988).

The majority of soybean oil is consumed as salad oil, shortening and margarine. Soybean oil is not really suitable for deep-fat frying as there is extensive oxidation or polymerisation. Another reason is that heat cause the development of fishy odours in the air which are quite objectionable (Theodore, 1970). Efforts to improve soybean oil and make it more resistant to oxidation have involved partial hydrogenation, adding antioxidants, blending with the other more stable oils and metal inactivators to reduce the linolenic acid content (Neff *et al*., 1994b).

Among all the methods, blending is by far the most economical process for modification. Antioxidants can also be used to avoid or retard oxidative rancidity in oils and fats. Antioxidants can scavenge the active forms of oxygen involved in the initiation step of oxidation. They can also break the oxidative chain reaction by reacting with the fatty acid peroxy radicals to form stable antioxidant-radicals which are either too unreactive for further reactions or form non-radical products (Valenzuela and Nieto, 1996).

To monitor the quality changes in frying oils a large number of methods are available now, either physicochemical or instrumental methods. Stevenson *et al*. (1984) listed more than 20 objective methods for measuring oil degradation during frying. Thermal analysis of frying oils may be of practical importance as a quality control and research tool. Differential scanning calorimetry (DSC) provides information on the excess specific heat over a wide range of temperatures. Any endothermic or exothermic event is registered as a peak in the chart, and its area is proportional to the enthalpy gained or lost, respectively (Gloria and Aguilera, 1998). Based on the number of works conducted on different oils, we postulated that it could also be applicable to measure some quality parameters of palm olein by using DSC. Therefore, the objectives of this study are as follows:

1. To determine the physicochemical characteristics of RBDPOo, SBO and their blends during deep-fat frying.

2. To determine the effects of TBHQ and α–tocopherol on physicochemical changes of RBDPOo during deep-fat frying.

3. To determine the effect of oil quality on shelf-life of potato chips after deep-fat frying.

4. To use DSC for monitoring some quality parameters of frying oils during deep-fat frying.

CHAPTER II

LITERATURE REVIEW

Palm Oil & Soybean Oil

History

The oil palm originated in West Africa and is now cultivated in other parts of Africa, Southeast Asia, Central and South America, preferring humid conditions within10^{o} of the equator. Palm oil derives from the pulp of the fruit of which it makes up *c* 56% and in the best cultivation 6 tonnes/ha are obtained per annum (Patterson, 1987).

The soybean originated in China more than 5000 years ago, cultivation has spread to many parts of the world. In the present century crushing to obtain oil developed gradually, the usual oil content of 20% (dry basis) is much below that of several other important oil seeds, but the balance is a very rich source of protein for human or animal nutrition (Patterson, 1987).

Going back more than two decades, we find that production of palm oil was static for many years. The dynamic growth of the industry did not begin until 1970, although preparation for it had already started in the 1950s. In fifteen years up to 1984 world production increased by as much as 325 percent, during the same period the production of its two keenest competitors soybean and rapeseed oil, rose by only 157 and 200 percent respectively (Mielke, 1987).

Production

The palm oil refining industry emerged as a significant industrial sector in Malaysia in the late seventies. The total approved capacity of operating refineries increased from 0.879 million tons of crude palm oil (CPO) feedstock in 1980 to 10.013 million tons in 1994. Consonant with the increase in refining and fractionation capacity, export of processed palm oil (refined and/or fractionated) products (including palm fatty acid distillate) increased from 0.215 million tons in 1975 to 2.074 million tons in 1980. The volume of processed palm oil increased further to 5.634 million tons in 1990, and 6.595 million tons in 1994. Processed palm oil exports grew at a compounded annual rate of 19.7% over the 20 years period (Gopal, 1996).

The production of palm oil and soybean oil achieved 15.17 and 20.298 million tons in 1995 respectively, and gradually increased to 17.518 and 20.81 million tons in 1997, respectively (Oil World, 1999). Now, Malaysia is the largest producer and exporter of palm oil and palm oil based products. Malaysia produced 9.068 million tons palm oil in 1997 and exported 7.49 million tons in 1997 whereas China is the