QUALITY AND STABILITY OF CANOLA AND SUNFLOWER OILS BLENDED WITH PALM OLEIN DURING FRYING AND MICROWAVE HEATING

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To

My beloved parents

Muhammad Nourah Bamalli and Sa'adatu Bamalli

My dearest husband

Dr. Nouruddeen Bashir Umar

For your unwavering love, sacrifices, encouragement and best wishes

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ABSTRACT

The aim of this study was to evaluate the changes in quality and oxidative degradation of canola oil (CO) and sunflower oil (SFO) and their blends with comparatively low priced palm olein (PO) during frying and microwave heating. The oil blends were prepared by blending PO with CO and SFO in the volume ratios of 20:80 (PC1 and PSF1) and 40:60 (PC2 and PSF2). Refractive indices of the samples increased insignificantly as the heating time performed by the oils increased. The amounts of free fatty acids were found to be higher in PO and in blends compared to the substrate oils. Peroxide values during frying or microwave heating of all the samples were increased until a maximum is reached and then decreased until the end of the heating. Other quality indices such as *p*-anisidine value, polymer content, viscosity, specific extinctions, food oil sensor and color unit values increased significantly in most of the samples as heating time progressed with increase in the blends being lower than those of the substrate oils. The amount of total polar compound in all the oil samples increased significantly with the time increment. During frying and heating, progressive decreases in iodine value and oxidative stability index were detected. However, PO addition to CO or SFO decelerated the formation of primary and secondary oxidative products and polymeric compounds during heating. In Gas Liquid Chromatography (GLC) analysis, the percentage of linoleic and linolenic acids tended to decrease, whereas the percentage of palmitic, stearic and oleic acids increased in most of the samples during frying and microwave heating. The decreased amounts in $C_{18:2}/C_{16:0}$ ratios from the initial values were observed for PO, CO and SFO in frying and microwave heating; being higher than those of their blends. In differential scanning calorimetry (DSC) analysis, addition of PO altered the shapes of endo- or exotherm peaks of CO and SFO. In this study, most of the degradation indicators suggested that the degradation was the fastest in CO or SFO as compared to their blends. Overall, it can be concluded that addition of PO to CO or SFO slowed down the oxidative degradation rate of the substrate oils. Blend PC2 and PSF2 showed slightly better frying performance compared to PC1 and PSF1.

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji perubahan dari segi kualiti dan degradasi oksidatif minyak canola (CO) dan minyak bunga matahari (SFO) dan percampurannya dengan olein minyak sawit yang berharga murah (PO) semasa menggoreng dan di panaskan dalam ketuhar gelombang mikro. Minyak ini di hasilkan dengan mencampurkan PO dengan CO dan SFO dalam nisbah isipadu 20:80 (PCI dan PSF1) dan, 40:60 (PC2 dan PSF2. Indeks biasan daripada sampel menunjukan peningkatan ketara apabila suhu pemanasan minyak meningkat. Jumlah asid lemak didapati tinggi didalam PO dan campurannya jika di bandingkan dengan minyak substrat. Nilai peroksida semasa menggoreng atau pemanasan dalam gelombang mikro untuk kesemua sampel meningkat sehingga nilai maksimum di capai dan kemudian menurun sehingga ke akhir pemanasan. Indeks kualiti lain seperti nilai *p*-Anisidina, kandungan polimer, kelikatan, keluputan spesifik, nilai sensor minyak makanan dan unit berwarna bertambah dengan ketara dalam kebanyakan sampel apabila suhu pemanasan progresif meningkat dengan peningkatan campuran yang lebih rendah daripada minyak substrat. Jumlah sebatian terkutub (TPC) dalam semua sampel minyak meningkat dengan ketara dengan peningkatan masa. Semasa menggoreng dan pemanasan, penurunan progresif bagi nilai iodin dan indeks kestabilan oksidatif telah dikesan. Walaubagaimanapun, pertambahan PO kepada CO atau SFO melambatkan pembentukan produk oksidatif utama dan sekunder dan gabungan polimerik semasa pemanasan. Dari analisa gas cecair kromatografi (GLC), peratus asid linoleik dan linolenik semakin menurun, manakala peratus asid palmitik,stearik dan oleik bertambah dalam kebanyakan sampel semasa menggoreng dan pemanasan gelombang mikro. Jumlah nisbah $C_{18:2}/C_{16:0}$ berkurang dari nilai permulaan, masing masing didapati untuk PO, CO dan SFO dalam gorengan dan pemanasan gelombangmikro; didapati lebih tinggi daripada campurannya. Dalam pengimbasan pembezaan kalorimetri (DSC), tambahan PO mengubah bentuk puncak endo dan eksoterma CO dan SFO. Dalam kajian ini, kebanyakan penunjuk degradasi mencadangkan degradasi terpantas adalah dalam CO atau SFO jika di bandingkan dengan campurannya. Secara keseluruhan kajian ini menunjukkan bahawa pertambahan PO kepada CO atau SFO melambatkan kadar degradasi oksidatif oleh minyak substrat. Campuran PC2 dan PSF2 menunjukkan sedikit kemajuan minyak goreng berbanding PC1 dan PSF1.

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LIST OF ABBREVIATIONS AND SYMBOLS

^0C	-	Degree Celsius
^0F	-	Degree Fahrenheit
ADC	-	Sunflower Oil
ANOVA	-	Analysis of Variance
cm	-	centimetre
CO	-	Canola Oil
cP	-	centipoise
DSC	-	Differential Scanning Calorimeter
g	-	grams
GLC	-	Gas Liquid Chromatography
h	-	Hour
HDL-C	-	High Density Lipoprotein- Cholesterol
kg	-	kilogramme
LDL-C	-	Low Density Lipoprotein- Cholesterol
Lp	-	Lipo- protein
min	-	minutes
ml	-	millilitre
mm	-	millimetre
MUFA	-	Monounsaturated Fatty Acid
nm	-	nanometer
PC1	-	Palm Olein: Canola Blend (20:80)
PC2	-	Palm Olein: Canola Blend (40:60)
PO	-	Palm Olien
PSF1	-	Palm Olein: Sunflower Oil (20:80)
PSF2	-	Palm Olein: Sunflower Oil (40:60)
PUFA	-	Polyunsaturated Fatty Acid
TFA	-	Total Fatty Acid

USFA	-	Unsaturated Fatty Acid
v/v	-	volume/ volume
μg	-	micrograms

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CHAPTER 1

INTRODUCTION

1.1 Background

Edible oils are used in cooking, baking and frying of foods. Consumption of edible oils has grown with the increase in the world population. The increase of health awareness and consciousness among consumers made the food industry more discriminating in the type of oil they use for food applications. Most native oils and fats have limited application in their unmodified forms, imposed by their tri-glyceride and fatty acids composition. By changing the natural physical and chemical characteristics of a fat or oil, it offers greater functionality for a large number of product formulations. Fats and oils can be modified though blending, fractionation, hydrogenation or combination of these processes (Petrauskaite *et al.*, 1998). Blending has long been used to modify oils and fats to improve their functionalities and thus optimizes their application in food products. It modifies the physicochemical properties of the oils, but without changing their chemical composition (Chu and Kung, 1997). Blending is also an economical way of producing health edible oils. Blending polyunsaturated oil with more saturated or monounsaturated oils, is an option to adjust fatty acid levels to optimal level (Nor Aini *et al.*, 1996).

Deep- fat frying is one of the oldest and most popular methods of preparation of food. Deep-fat frying is a process of immersing foods into hot edible oil or fat at temperature above boiling point of water. The oil is mostly heated to a temperature between 170 to 190°C which leads to heat and material transfer from the oil to the food, resulting in cooking of the food; however, some of the oil is absorbed by the fried foods, and hence become a source of flavor, smell, taste and nutrition. Furthermore, undesirable off- flavor occur if deteriorated oil is used or if the oil is used over a longer period of time, as a result of the heat treatment a lot of deteriorative chemical processes take place, resulting in different changes of the oil. In this process, not only undesirable components are formed, but also compounds with adverse nutritional effects and potential hazards to humans health (Billek, 1985; Billek, 1992). Moreover, these changes may result in a decrease of quality and stability of the fried product. During frying, a number of reactions occur in the frying oil causing oxidative and hydrolytic degradation and polymerization of the oil. The main causes of oil degradation are oxidation, thermal treatment, and oil food interaction at high temperature (Gary *et al.*, 1997).The quality of the oil used in deep-fat frying contributes to the quality of the fried food. The oil or fat used in the frying operation becomes part of the food we eat and is, of course, the major factor in the quality and nutritional value of the food we eat. In addition, highly oxidized oils may also produce polycyclic aromatic hydrocarbons that are known as carcinogens (Sebedio *et al.*, 1990; Romero *et al.*, 1998).On the other hand, microwave heating is a widespread procedure for food preparation and manufacturing, commonly employed in both domestic and catering operations for its high speed and convenience, as compared to conventional heating treatments (Burfoot *et al*., 1990). Heating of food by microwave outcomes from the molecular friction of electric dipoles, under an oscillating electric field of specific frequency (Mudgett, 1989).Advantages of microwave heating include savings in time and energy and easy to use. These advantages make it one of the most attractive cooking methods.

Palm olein is a highly monounsaturated oil, which is rich in oleic and is currently said to be oxidative stable acids (Nor Aini *et al*., 1993). Besides being marked as liquid oil, palm olein can be promoted for blending with other edible oils (Lin, 2002). It is being used increasingly in frying operations, and because of its inherent excellent frying properties, improve the frying quality of other vegetable oils when it is blended with them (Kun, 1990).Canola oil is the best source of omega 3 fatty acids which helps to reduce cholesterol in the blood stream. It contains the lowest concentration of saturated fatty acids (7%) among vegetable oils (Ackman, 1990). Canola oil, because of its high content of PUFA it is considered superior to many vegetable oils, but inferior in terms of thermal stability at high temperatures (Malcolmson *et al*., 1994). Sunflower oil is one of the healthiest and popular oil in the world. It is also excellent household oil, great for both frying and baking. It is a rich source of vitamin E and has a high level of linoleic acid (Huang *et al*., 1981; Beddows, 2000).

In view of the foregoing it has become paramount to undertake the necessary measurements by a combination of the most effective analytical and instrumental analysis to evaluate the quality and stability of canola and sunflower oils and their blends with palm olein during frying and microwave heating.

1.2 Problem Statement

Most healthy vegetable oils like canola oil, sesame oil, sunflower oil, corn oil etc. are expensive and cannot be reuse for so many number of frying due to the formation of oxidation and polymerization products after subjecting to high temperature and air, which makes it difficult for the food processing companies, restaurant and the consumers to purchase. In fact, the applications of canola and sunflower oils in house hold and in food industry are limited due to their high cost. Today, palm oil and its products, mainly palm olein, belong to the most important oils used for the preparation of fried food. The reason is that the oil is relatively cheap, it is available in huge amounts, it has a high oxidative stability and results in high-quality and tasty foods. However, the price is an important modulatory factor on the market, because for the production of fried food the oil is the most expensive part. Addition of oxidation-stable palm olein to canola and sunflower oils may affect the oxidative stability of canola and sunflower oils during frying or microwave heating. So, blending is the perfect way of obtaining qualitative and stable oils. Blending canola and sunflower oil with palm olein may lead to nutritious, qualitative and stable oils. Furthermore, blending canola and sunflower oil with palm olein will reduce the cost of purchase of the vegetable oils.

Secondly, the food industry and public health authorities are worried and concerned in relation to potential health hazards generated by the consumption of oxidized products, which most often contain lipid polymers resulting from oils used repeatedly in frying processes. The stability of the oil is also very important, because stability to oxidation during a prolonged exposure to high temperature is one of the main characteristics that industrial and domestic frying oils should possess, as its physical, chemical and nutritional properties may undergo significant modification during thermo-oxidation. From a practical point of view, commercial and industrial frying oil operators have no idea on when to discard frying oils. They want to know when the frying oils should be discarded, in other words when the frying oil needs to be dumped. Unfortunately, there is no simple answer to such question. A specific method may be ideal for one operation but useless in another. The end point of frying oil is therefore, dependent on mainly analytical measurements, good judgment and knowledge of the particular frying operation and the type of frying oils. This research work may help in consumer awareness on when to discard the oils after several uses and also help in buying the healthy oil from the market. On the other hand, amongst the various cooking techniques, microwave oven heating is a more recent development than other traditional cooking techniques. Due to its advantages (time and energy savings), this technique has become one of the most attractive cooking methods. This justifies its increasing use for studying the heating behavior of various foodstuffs.

Therefore, proper blending of canola and sunflower oils with palm olein in the optimal proportion may results in production of oil blends with improved stability, nutritional value and flavor characteristics.

1.3 Objectives of study

- To evaluate the changes in quality and thermooxidative degradation of highly unsaturated canola and sunflower oils and their blends with palm olein during frying of potato pieces and microwave heating.

- To produce blended oils that are less costly with good stability which can withstand domestic cooking and commercial frying or microwave heating operations.

1.4 Scopes of Study

To achieve the objectives of this research work, the following scopes were identified:

- To evaluate the impacts of addition of palm olein at different concentrations on the frying performance of canola oil and sunflower oil.

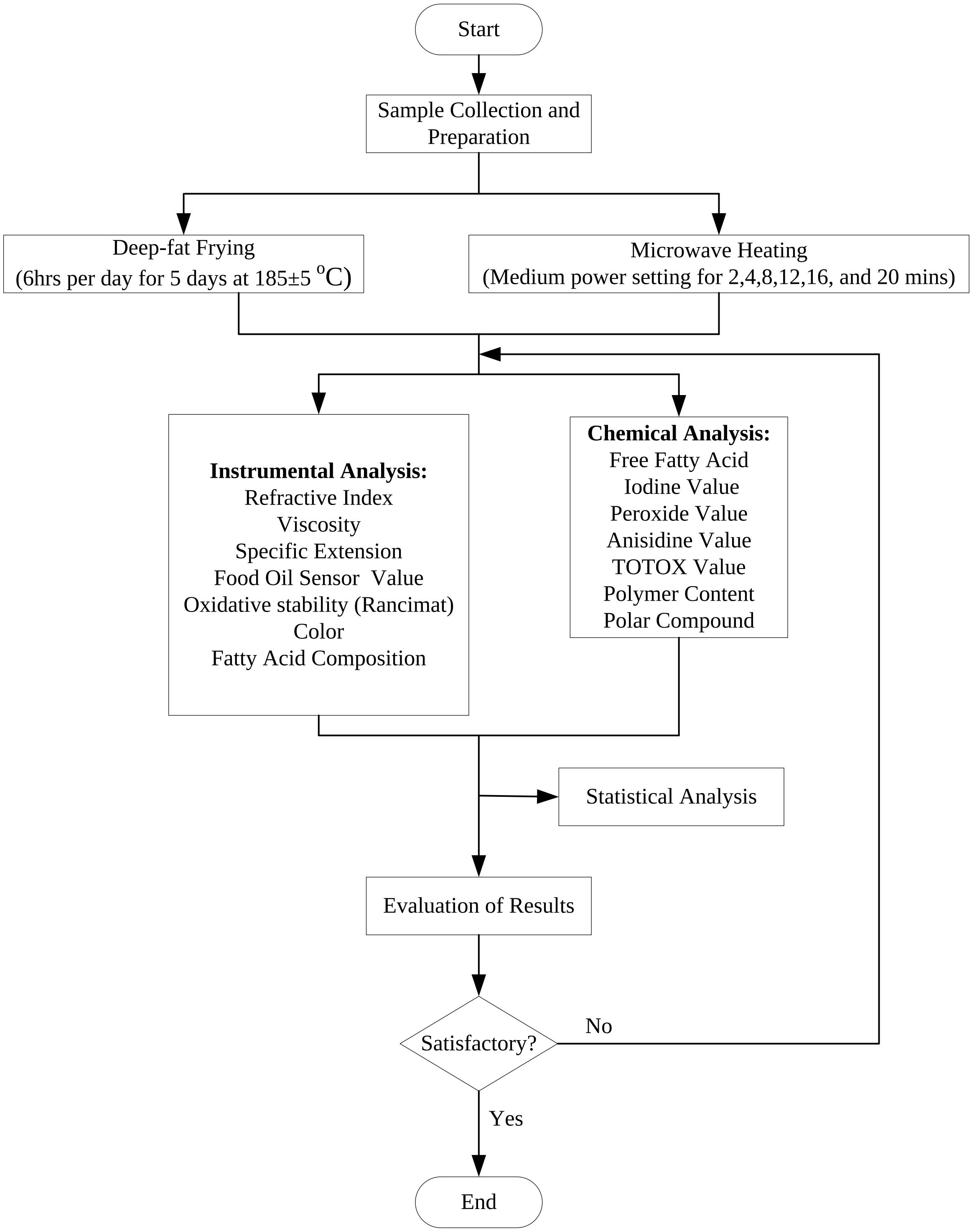
- To determine how microwave heating may affect the quality and stability of canola and sunflower oils and their blends with palm olein.

- To attempt to link the oil's deterioration to fatty acid composition during frying or microwave heating.

1.5 Significance of Study

The quality and stability of oils is very important to the human diet, to avoid consumption of unnecessary fats which can affect their body system and health. Moreover, the advantage of using blend as a means of modifying oils is that it is easier to use and less costly. Blending also serves to improve and enhance the nutritional and functional qualities of the oils, by combining the good attributes of the two blended oils into one. This research work may serve as a milestone towards development of effective frying operations and may increase consumer awareness toward nutritional values and health effects. This research can results in oil blends which could meet nutritional needs with improved stability for domestic and industrial deep fat frying. This study will also help to understand on how heat treatments by microwave oven may affect the oxidative degradation of canola and sunflower oils and their blends with palm olein.

1.6 Work Flow Chart



1.7 Thesis Outlines

The thesis is organized as follows:

In chapter 2, a brief description on palm olein, canola and sunflower oils was mentioned. The theory and application of heat transfer during deep-fat frying and the mechanism of microwave heating are also presented in this chapter. Moreover, previous studies on deep-fat frying and microwave heating of canola and sunflower oils and their blends with palm olein are reviewed. The effect of oil quality during frying and the method on how to improve the quality of the oils are highlighted.

In chapter 3, the experimental setups and procedures for frying and microwave heating employed in this study are described. The methodologies of each and every experiment considered in this study, are described in detailed.

Chapter 4 presents the results and discussion of deep-fat frying of the samples obtained from both instrumental and analytical methods.

Chapter 5 presents the results and discussion of microwave heating of the samples obtained from both instrumental and analytical methods.

Finally, chapter 6 is the concluding chapter. This chapter summarizes and concludes the research that has been carried out in this study. Future works are also suggested at the end of this chapter.

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