



UNIVERSITI PUTRA MALAYSIA

***EFFECT OF FAT SOLUBLE ANTIOXIDANT IN VEGETABLE OILS ON
ACRYLAMIDE FORMATION IN FRENCH FRIES AND CHEMICAL
MODEL SYSTEM***

SITI ASIAH KAMARUDIN

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By

SITI ASIAH KAMARUDIN

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

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DEDICATION

*This thesis is dedicated with deepest love
to my beloved parents, Kamarudin Esa and Maziah Mohd.*



Abstract of thesis presented to Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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Acrylamide, a carcinogen is usually generated in carbohydrate rich heated foods. Among the parameters affecting the concentration of acrylamide in foods, the effect of fat soluble antioxidants has not yet been elucidated satisfactorily. The objective of this study was first to evaluate the effect of fat soluble antioxidants in frying oil on the formation of acrylamide in French fries. Three vegetable oils, having different fat soluble antioxidant content, were selected, and par-fried potato strips were fried in these oils, monitoring the concentration of acrylamide in French fries at different times (frying temperature at 180 °C) and during 10 consecutive frying sessions. The second objective was to evaluate the inhibitory activity of fat soluble antioxidants against the formation of acrylamide in chemical model system. Two chemical model reactions were performed. One was using different oil blends of red palm oil and another was using different vegetable oils. Different oil blends of red palm oil were prepared by blending 10%, 20% and 30% of red palm oil (industrial grade) with canola oil, respectively. Three different vegetable oils were used, namely commercial red palm oil (Carotino), yellow palm oil and corn oil. Vitamin E content in different oil blends of red palm oil and different vegetable oils were determined. Fat soluble antioxidant in vegetable oils affects the formation of acrylamide in French fries, especially when prolonged frying time was used under consecutive frying sessions. Acrylamide concentration in French fries decreased with increasing number of frying and significantly dropped to the lowest level at 524 µg/kg after 10th frying using red palm oil. However, no significant effect of different frying conditions on the formation of acrylamide in French fries for all types of oil was observed. Antioxidant in vegetable oils also affects the formation of acrylamide in chemical model system. Acrylamide concentration significantly increased as percentage of red palm oil increased from 10% to 20%, but later significantly decreased as percentage of red palm oil increased to 30% in oil blends. The lowest acrylamide

concentration was found in chemical model system using yellow palm oil. The role of yellow palm oil in reducing acrylamide formation is more obvious in chemical model system compared to food system. Therefore, the usage of yellow palm oil in addition to red palm oil can be proposed as a good mitigation strategy to reduce acrylamide formation.



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

**KESAN-KESAN ANTIOKSIDAN LARUT MINYAK DI DALAM
MINYAK SAYURAN DALAM PEMBENTUKAN AKRILAMIDA DI
DALAM KENTANG GORENG DAN SISTEM MODEL KIMIA**

Oleh

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Akrilamida, karsinogen biasanya dihasilkan dalam makanan yang kaya dengan karbohidrat. Antara parameter yang mempengaruhi kepekatan akrilamida dalam makanan, kesan antioksidan larut lemak belum dapat dijelaskan dengan memuaskan. Objektif pertama kajian ini adalah untuk menilai kesan antioksidan larut lemak dalam minyak goreng pada pembentukan acrylamide dalam kentang goreng. Tiga minyak sayuran, yang mengandungi kandungan antioksidan larut lemak yang berbeza, telah dipilih, dan kentang digoreng dalam minyak ini, untuk memantau kepekatan akrilamida dalam kentang goreng pada masa yang berlainan (suhu menggoreng 180 ° C) dan selama 10 kali berturut-turut sesi menggoreng. Objektif kedua adalah untuk menilai aktiviti antioksidan larut lemak terhadap pembentukan akrilamida dalam sistem model kimia. Dua model kimia telah dibuat. Satu menggunakan campuran minyak sawit yang berbeza dan satu lagi menggunakan minyak sayuran yang berlainan. Gabungan minyak sawit merah yang berbeza telah disediakan dengan campuran 10%, 20% dan 30% minyak kelapa sawit (gred perindustrian) dengan minyak canola. Tiga minyak sayuran yang berbeza digunakan, iaitu minyak sawit komersial (Carotino), minyak kelapa sawit dan minyak jagung. Kandungan vitamin E dalam campuran minyak yang berbeza minyak sawit merah dan minyak sayuran yang berbeza ditentukan. Antioksidan larut lemak dalam minyak sayuran menjejaskan pembentukan akrilamida dalam kentang goreng, terutamanya apabila masa penggorengan yang lama digunakan di bawah sesi penggorengan berturut-turut. Kepekatan akrilamida dalam kentang goreng berkurangan dengan peningkatan jumlah penggorengan dan menurun dengan ketara paling rendah pada 524 µg/kg selepas 10 sesi menggoreng menggunakan minyak sawit merah. Walau bagaimanapun, tiada kesan yang signifikan terhadap keadaan menggoreng yang berbeza pada pembentukan akrilamida dalam kentang goreng untuk semua jenis minyak diperhatikan. Antioksidan dalam minyak sayuran juga mempengaruhi pembentukan akrilamida

dalam sistem model kimia. Kepekatan akrilamida meningkat dengan ketara memandangkan peratusan minyak sawit merah meningkat dari 10% hingga 20%, tetapi kemudian menurun dengan ketara apabila peratusan minyak sawit merah meningkat kepada 30% dalam campuran minyak. Kepekatan akrilamida terendah didapati dalam sistem model kimia menggunakan minyak kelapa sawit. Peranan minyak kelapa sawit dalam mengurangkan pembentukan akrilamida lebih jelas dalam sistem model kimia berbanding dengan sistem makanan. Oleh itu, penggunaan minyak kelapa sawit sebagai tambahan kepada minyak sawit merah boleh dicadangkan sebagai strategi pengurangan yang baik untuk mengurangkan pembentukan akrilamida.



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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

μL	microlitre
μm	micrometer
AOCS	American Oil Chemists' Society
FAME	Fatty acid methylesters
g/kg	gram/kilogram
I_2	iodin
LC-MS/MS	Liquid Chromatography tandem
Mass Spectrometer mg/mL	milligram/mililitre
mL	mililitre
mM	milimole
MRM	multiple reaction monitored
$\text{M}\Omega\text{-cm}$	electrical resistivity
ng/g	nanogram/gram
ng/mL	nanogram/mililitre
ppb	part per bilion
RPO	Red Palm Oil
UHPLC	Ultra High Performance Liquid Chromatography

CHAPTER 1

INTRODUCTION

1.1 Background of study

Cooking and processing of high carbohydrate foods at high temperatures have been shown to produce various kinds of toxicants. Acrylamide is usually formed in many plant-based, high carbohydrate foods when they are heated (Tareke et al., 2002). Acrylamide has been a public health concern, having been classified as a “probable human carcinogen” by International Agency on Research on Cancer (IARC, 1994). On April 24, 2002, the Swedish National Food Agency presented data that, in part, showed high concentrations of acrylamide in certain fried, baked, and deep-fried foods, and later in coffee (Freisling et al., 2013). The highest concentrations have been identified in potato based products such as French fries (Claeys et al., 2010). The presence of acrylamide in common heated foods has been considered as an important food-related crisis by international authorities. Raw or unheated foods did not exhibit any acrylamide formation (Granda & Moreira, 2005). Mottram et al. (2002) indicated that acrylamide formation increases with temperature from about 120°C to 170°C and then decreases. While data reported by Becalski et al. (2004) indicated the effect of sugars and asparagine on the concentration of acrylamide in French fries is positive and significant.

1.2 Problem statements

Studies about the effects of the fat soluble antioxidant on acrylamide formation were scarce. In addition, the research to date has tended to focus on water soluble antioxidant in oil, rather than fat soluble. Napolitano et al. (2008) reported that water soluble antioxidant such as virgin olive oil phenolic compounds, having the highest concentration of ortho-diphenolic compounds, is able to efficiently inhibit acrylamide formation in crisps from mild to moderate frying conditions. Water soluble vitamins are good inhibitors of acrylamide formation. Nicotinic acid and pyridoxal inhibited acrylamide formation in fried potato strips by 51% and 34%, respectively (Zeng et al., 2009). For instance, a weak reduction effect on the acrylamide formation was found via the addition of ascorbic acid in a potato-based model. Furthermore, nearly 50% reduction of acrylamide occurred after the addition of a flavonoid spice mix (Zhang, 2007b). Nonetheless, Tareke (2003) reported that the addition of certain antioxidants (butylated hydroxytoluene, sesamol, and vitamin E) prior to cooking enhanced acrylamide formation. The author attributed the phenomenon observed to the protective effects of the above vitamins on acrylamide from being degraded in free radical-initiated reactions. Further, Napolitano et al. (2008) suggested that vegetable oils from different sources have been studied in acrylamide formation but their antioxidant properties have not been considered. However, to the best author’s knowledge, no studies have been conducted to evaluate the effect of fat soluble antioxidants in vegetable oil on the formation of acrylamide in French fries while the fat soluble antioxidant

effect from different blends of red palm oil in chemical model system is a new research area.

1.3 Significant of study

As mentioned, Napolitano et al. (2008) suggested that vegetable oils from different sources have been studied in acrylamide formation but their antioxidant properties have not been considered. Therefore, in this study an attempt was made to provide more data to improve safety attributes of food during deep-fat frying. As vegetable oils has high concentration of fat soluble antioxidants, it is important to study its effect on the formation of acrylamide in French fries during deep-fat frying as well as in model system. The findings in this study should be of interest to the food processing industry, restaurateurs, and home-makers as deep-fat frying is commonly practice in different segments of business. The use of palm oil and its derivatives, including red palm oil, can be proposed as one of the mitigation strategies to reduce acrylamide formation in deep fried, carbohydrate rich foods.

1.4 Objectives

Therefore the thesis objectives are:

1. To evaluate the effect of fat soluble antioxidants in frying oil on the formation of acrylamide in French fries.
2. To evaluate the inhibitory activity of fat soluble antioxidants against the formation of acrylamide in Chemical Model System.

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