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DEVELOPMENT OF PINK GUAVA SEED OIL-PALM STEARINE BLEND AS LARD SUBSTITUTE

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By

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

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Chairman : Mohammed Nazrim Marikkar, PhD
Institute : Halal Products Research

Guava (*Psidium guajava* L.) belonging to the family Myrtaceae is grown widely in the tropical regions of Asia, Africa, and America. In Malaysia, pink guava fruits are used mainly for production of juices meant for export market. After production of juice, guava seeds are discarded without any productive use. The possibility of using guava seed for oil recovery, however, still remains unexplored in Malaysia. Therefore, the aim of this study was to extract and characterise pink guava seed oil and use it in combination with palm stearin to formulate lard alternative fat substitutes to be applied in products. Hence, the blends can be permissible to be used as a replacement for lard by Muslims, Jews and vegetarians. In this study, oils of pink and white guava seeds were extracted and analysed. The oil recoveries of pink guava (PGO) and white guava (WGO) seeds were 8.44% and 6.85%, respectively. The color of WGO was light yellow while that of PGO was dark yellow. The iodine value for PGO and WGO were 123.78 and 125.73, respectively. The blends were prepared by mixing pink guava seed oil with palm stearin (PGO/PS) in different ratios: PGO-1, 40:60; PGO-2, 45:55; PGO-3, 50:50; PGO-4; 55:45. The blends and lard were compared in terms of their basic physicochemical parameters, fatty acid and triacylglycerol (TAG) compositions, melting, solidification and polymorphic properties. The slip melting points (SMP) of the fat blends were found to range from 43.63 to 50.30ºC. Among the four blends, PGO-1 and PGO-2 showed better compatibility to lard at most temperature. According to x-ray diffraction analysis, the diffractogram of all blends display beta and beta prime polymorphic forms which is the same as lard. The potential of the modified blends to be as lard alternative were proposed in the range of 40% to 55% with the addition of PGO. Then, the four blends were applied in the cookies as shortening to compare their performance with lard in the end products. The rheology for PGO-2 and lard looked closer to each other based on tan δ value which were 0.54 (PGO-2) and 0.53 (lard). For the test hardness, PGO-2 gave the nearest value to the lard which was 13.43N and 14.48N respectively. Thickness and width were taken to measure the dimension of cookies where PGO-2 had almost the same value with 13.68mm (PGO-2) and 13.94mm (lard) for the thickness and 66.37mm (PGO-2) and 66.54mm (lard) for the width.

Appearance were tested by observing the surface island on the top of cookies where PGO-1 and PGO-2 showed less cracking which were similar to lard surface. Among the four cookies, PGO-2 showed the similarities to lard at most test. Therefore, blend of PGO-2 could be a potential blend to lard substitute.

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

PENGHASILAN CAMPURAN MINYAK BIJI JAMBU BATU MERAH JAMBU-STEARIN PALMA SEBAGAI PENGGANTI LEMAK BABI

Oleh

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Jambu (*Psidium guajava* L.) kepunyaan keluarga Myrtaceae dibiakkan dengan meluas di kawasan Asia tropika, Afrika , dan Amerika. Di Malaysia, buah jambu batu merah jambu digunakan dalam menghasilkan jus untuk tujuan pengeksportan. Selepas penghasilan jus, biji-biji buah jambu batu merah jambu dibuang tanpa sebarang kegunaan yang produktif. Malaysia adalah satu-satunya negara yang mengeksport jus jambu batu merah jambu mungkin menghadapimasalah pelupusan, jika benih dibuang tanpa sebarang kegunaan. Kini, pengeluaran tanaman juga bergantung kepada kualiti biji yang ditanam. Kemungkinan untuk penggunaan biji jambu batu merah jambu untuk penghasilan miinyak bagaimanapun masih kurang dijelajahi di Malaysia. Jadi, tujuan penyelidikan ini adalah untuk mengekstrak dan mengenalpasti karakter minyak biji jambu batu merah jambu dan menggunakannya dalam campuran stearin palma dengan pencampuran fisikal untuk memformulakan penggantian lemak babi bagi diaplikasikan di dalam produk akhir. Oleh itu, campuran tersebut halal digunakan sebagai pengganti lemak babi di kalangan orang Islam, Kristian dan penggemar sayuran. Dalam penyelidikan ini, jambu batu merah jambu dan jambu batu putih diekstrak dan dianalisis. Penghasilan minyak untuk jambu batu merah jambu (PGO) adalah 8.44% manakal jambu batu putih (WGO) pula adalah 6.85%. Kedua-dua jenis jambu batu tersebut adalah berwarna kuning tetapi WGO adalah lebih kuning daripada PGO. Nilai iodin untuk PGO dan WGO adalah123.78 and 125.73 masing-masing. Empat campuran disediakan dengan mencmapurkan minyak jambu batu merah jambu dengan stearin palma (PGO/PS) mengikut nisbah yang berbeza: PGO-1, 40:60; PGO-2, 45:55; PGO-3, 50:50; PGO-4; 55:45. Campuran tersebut dan lemak babi dibandingkan dari segi parameter asas fisiko kimia, asid lemak, kandungan tri-asil gliserol, peleburan, pemejalan dan ciri-ciri polimorf. Takat lebur (SMP) lemak campuran tersebut didapati dari kadar 43.63 ke 50.30^{o}C. Antara empat campuran tersebut, PGO-1 dan PGO-2 menunjukkan keserasian dengan lemak babi pada semua suhu. Menurut analisi pembelauan sinar-X, difraktogram semua campuran mempamerkan bentuk beta dan beta asas polimorfik yang sama dengan lemak babi. Potensi campuran yang telah diubah ini sebagai pengganti lemak babi adalah dicadangkan dari kadar 40% ke 50% dengan

penambahan PGO. Kemudian, empat campuran ini diaplikasikan dalam biskut sebagai bahan lemak untuk dibandingkan persembahannya dengan lemak babi di dalam produk akhir. Reologi untuk PGO-2 dan lemak babi dilihat adalah hamper antara stu sama lain berdasarkan nilai tan δ dimana nilainya adalah 0.54 (PGO-2) and 0.53 (lemak). Bagi ujian kekerasan, PGO-2 memberikan nilai yang rapat dengan lemak babi iaitu 13.43N and 14.48N masing-masing. Ketebalan dan kelebaran diambil dengan mengukur dimensi biskut-biskut tersebut dimana PGO-2 mempunyai nilai yang paling hampir dengan lemak babi dengan nilai 13.68mm (PGO-2) and 13.94mm (lemak babi) untuk ketebalan dan 66.37mm (PGO-2) and 66.54mm (lemak babi) untuk kelebaran. Bentuk diuji dengan memerhati permukan pulau di atas biskut di mana PGO-1 dan PGO-2 menunjukkan kekurangan retak yang mana sama dengan lemak babi. Antara empat campuran tersebut, PGO-2 menunjukkan banyak persamaan dengan lemak babi untuk kebanyakkan ujian. Jadi, campuran PGO-2 boleh dijadikan potensi campuran untuk pengganti lemak babi.

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I certify that a Thesis Examination Committee has met on 5 September 2016 to conduct the final examination of Noor Raihana binti Abd. Rahman on her thesis entitled "Development of Pink Guava Seed Oil-Palm Stearine Blend as Lard Substitute" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
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%	percentage
g	Gram
mg	milligram
µg	microgram
µl	microlitre
ml	milliliter
Mm	milimeter
Cm	centimeter
Kg	kilogram
H	hour
Min	minute
Sec	second
°c	degree celsius
Hz	hertz
B	beta
β'	beta prime
A	alpha
Å	angstrom
M	molar
N	newton
G’	storage modulus
G”	loss
Kpa	kilopascal
Δ	tan

w/v	weight per volume
w/w	weight per weight
°c/min	degree celsius per minute
ml/min	mililiter per minute
ANOVA	one-way analysis of variance
AOCS	americal oil chemists' society
B	blue
DSC	differential scanning calorimetry
FAME	fatty acid methyl ester
FID	flame ionization detector
GC	gas chromatography
HPLC	high performance liquid chromatography
IV	iodine value
L	linoliec
Ln	linolenic
LD	lard
M	myristic
MUFA	monounsaturated fatty acid
O	oleic
P	palmitic
PORIM	palm oil research institute of malaysia
PGO	pink guava seeds oil
PUFA	polyunsaturated fatty acid
PS	palm stearin
R	red
RI	refractive index

SFA	saturated fatty acid
SFC	solid fat content
SFO	safflower oil
SG	specific gravity
SMP	slip melting point
St	stearin
SSS	trisaturated triacylglycerol
T	thickness
TAG	tri-acylglycerol
US	United States
USS	mono-unsaturated triacylglycerol
UUS	diunsaturated triacylglycerol
W	width
WGO	white guava seeds oil
Y	yellow
XRD	x-ray diffraction

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Fats and oils have been perceived for a long time as essential nutrients of human diet as well as concentrated sources of energy. They act as carriers of fat-soluble vitamins in the human diet. Besides these, they also play an important role in the transport of substances that determine the growth and development of body muscles as well as the brain (FAO, 1994). In nature, oils and fats exist in many different forms in a variety of sources. They are extracted from plant seeds, and fruits, and body parts of animals such as cow, goat and swine. Honeydew melon (Yanty *et al.*, 2008), rambutan (Manaf *et al*., 2013), guava (Prasad & Azeemoddin, 1994; Singh, 2011), pumpkin (Alfawaz, 2004; Nawirska-Olszańska *et al.*, 2013) and papaya (Malacrida *et al*., 2011) seeds are some of the plant sources having oils in their fruit seeds. Fruits of avocado (Yanty *et al*., 2012), olive (Moghaddam *et al*., 2012; Gutfinger, 1981) and palm (Tarmizi *et al*., 2008; Zhang *et al*., 2013) are also known to provide oils and fats for daily needs. Land and marine animals are other sources of oils and fats, which are exploited for human consumption. Fish oils which are extracted from the marine animals such as shark, cod, etc are used as supplements to reduce inflammation in body (Kris-Etherton *et al*., 2002). Lard and tallow are examples of fats extracted from animals namely, pig and cow respectively (Taylor *et al*., 2002).

In bakery products, shortening and margarine are always used in order to make the perfect baking creation. Both have different properties that affect their end products. Shortening works best for some types of baking due to the zero water content that toughens a product. On the other hand, margarine contain water that may produce different but still acceptable texture (Waterlow, 2008). Shortening refers to the ability of a fat to be lubricant, weaken or shorten the structure of food components so that they function in a characteristics way to provide desirable textural properties to food products. The process of shortening involves several stages, which include melting and pre-cooling stage until complete crystallization (Sciarini *et al.*, 2013). Shortenings are commonly applied in baked products to produce the sensation of hardness and toughness during chewed (Chrysam, 1985). Besides this, they allow uniform heat transfer during cooking as well as aids in the formation of a moisture barrier during frying application (Ghotra *et al*., 2002).

Novel halal-based shortening can be produced through blending of unconventional oil sources. Seeds of guava (*Psidium guajava*), for instance, is a waste material generated in abundance on a daily basis throughout Malaysia. Around 100 tons of guava seeds are considered to be generated as decanter waste out of 10,000 tons of guava fruits (Chek Zaini *et al,* 2009). So far very little effort has been made to utilize it for productive uses (Chek Zaini *et al,* 2009). In fact, waste seed can be readily available from Sime Darby Beverages Sdn Bhd which possesses 500 pink guava

plantations in Sungei Wangi Estate in Sitiawan, Perak. Once the continuous supply of seed materials is ensured, it can be a potential source of oil. According to Prasad & Azeemoddin (1994), guava seed oil is reported to contain 10-17% oil. Hence, guava seed waste material can be efficiently used for oil recovery as well as for production of shortenings with the blended of palm stearin since blending is considered as the simplest modification process for fat and oil (Abdul Azis et al., 2011). Furthermore, blending of pink guava seed oil and palm stearin can be a new invention for shortening to substitute lard in product ingredients. However, there is hardly any past study on the utilization of guava seed oil for shortening production to the best of our knowledge.

1.2 About the Plant

1.2.1 Guava

Guava, a member of the Myrtaceae family, is a crop widely grown in the tropical countries of the Asia and Africa. A quite a number of varieties of guava with differences in the color of the pulp, such as white, pink, red, etc., are grown in these countries (Castro-vargas *et al.,* 2012). Guava in medium to large size with 100-250g and 5-10cm in diameter, is spherical, ovoid or pyriform in shape depends on the types (Singh, 2011). The most popular type of guava consumed by Malaysians is white guava while pink guava is grown for production of fruit juices (Figure 1). The content of vitamin C in guava has made it the richest source when compare to any other citrus fruit.

1.2.2 Guava: origin and application

Psidium guajava grows in the tropical and subtropical countries of the world include in India, Pakistan, Mexico, Brazil, Egypt, Thailand, Colombia, Indonesia, Venezuela, Sudan Bangladesh, Cuba, Vietnam,, the US, Malaysia, Puerto Rico and Australia (Singh, 2011) (Chen *et al*., 2015) (Uchôa-thomaz *et al*., 2014). It is a well-known and popular crops for its delicious fruit (Prasad & Azeemoddin, 1994). Apart from the delicious taste, guava pulp is also processed into products to be used in food and beauty care applications (Castro-vargas et al., 2012). Guava normally consumed freshly or in the processed form such as jellies, jams, nectar, puree, candy bars and juices provides a good source of dietary fiber as well as natural antioxidant compounds (Chang et al., 2013). According to previous study done by Singh (2011), guava has been used for traditional medicinal purposes against diarrhoea, gastroenteritis and colic pathogenic germs of intestine.

A **B**

Figure 1: (A) White guava and (B) Pink Guava

Figure 2: Pink guava seeds

1.2.3 Guava waste recovery in industry

The seeds of guava constitute about 6–12% by weight of the whole fruit (Nicanor *et al.*, 2000). Being round in shape and pale yellowish brown in color (Figure 2), the seeds are reported to contain about 16% oil, 7.6% protein, and 61.4% crude fiber (Prasad & Azeemoddin, 1994). Owing to this fact, guava seeds have the potential to become a source of oil that can be used in food products as well as supplement in dietary health. Zaini and co-workers (Che Zaini *et al.*, 2009) made an attempt to utilize guava seed waste for formulation of fiber-enriched biscuits. The oil extracted from guava seeds (Figure 3) are reported to possess phenolic compounds that display antioxidant properties such as radical scavenging activity (Mohamed *et al.*, 2011). According to the fatty acid compositional analysis (Table 1), total unsaturated and saturated fatty acids in guava seeds oil were 87.3 and 11.8%, respectively. The major fatty acids of guava seed were linoleic acid (76.4%) followed by oleic (10.8%), palmitic (6.6%), and stearic acids (4.6%). According to Prasad and Azeemoddin (1994), it is more or less similar to the fatty acid composition of safflower oil and can become a potential substitute for it.

Worldwide, millions of tons of waste from agro-industrial activities are generated. Some of it is used as animal feed or in other fields; however, most of it is still discarded without treatment causing damage to the environment. The waste disposal has become an environmental problem for fruit processing industries. In addition, the destination of this waste, as currently practiced, causes economic deficit in the supply chain since a substantial part is rich in bioactive compounds, but some of them are capable of preventing the oxidative damage caused by free radicals (Melo *et al.*, 2011; Omena *et al.*, 2012; Uchôa-thomaz *et al.*, 2014). Since this kind of waste is characterized as potential pollutant source, alternative for reducing its amount are of great importance. Therefore, there have been efforts to develop new food products and the extraction of several compounds from these products to increase the options for reuse and recovery waste.

1.3 Problem Statement

There are evidences in the past studies to show that lard and hydrogenated lard were employed for the production of shortening intended for uses in food applications. DeMan (1992) stated that lard has been a major source of shortening in North America and Western European countries for a long time. According to Che Man *et al*. (2005), there are some countries that choose to produce shortening from the blend of vegetable fat and lard. Lard shortening was heavily used in the food products such as bread, biscuits, crackers, cakes, cookies and so on. The main reason for this was said to be its superior performance characteristics during food processing. It is believed that lard has also got some special stickiness behavior, which helps to achieve a good binding property in minced-meat. As such, lard is the preferred fat in Europe for processing of minced meat. Because of this, there is a high concern among Muslim consumers nowadays on the Halal status of food products containing different ingredients. It is therefore, necessary to initiate various efforts to develop halal-based shortening as replacement for lard.

1.4 Objective of Study

1.4.1 General Objective

Development of Pink Guava Seed Oil-Palm Stearine Blend as a Lard Substitute

1.4.2 Specific Objectives

The present study is conducted with the following objectives:

1. To extract the seed oils of two Malaysian guava (*Psidium guajava*) varieties and characterize their physico-chemical properties
2. To prepare various blends of PGO and PS and compare their thermo-physical behavior with that of lard
3. To compare the dough and cookies properties made out of PGO-PS (Pink Guava (*Psidium guajava*) Seed Oil-Palm Stearin) shortening with those prepared using lard

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