UNIVERSITI PUTRA MALAYSIA

FORMULATION OF FAT SUBSTITUTE USING PLANT-BASED FATS SIMULATING THE PROPERTIES OF LARD

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IPPH 2015 7

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

October 2015

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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October 2015

Chairman : Mohammed Nazrim Marikkar, PhD
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Lard (LD) is a solid fat used as shortening in the manufacture of bread, cakes, cookies and other products due to its flavor and physical properties. However, the limitation of lard applications were concerned as the Muslims, Jews and vegetarians are not permissible to consume both pork and lard in any products. In addition, consumption of lard and other animal fats is not recommended since there is a growing negative perception about the implication of animal fats on human health. Therefore, lard alternative products are highly demanded from many Muslim majority countries to regularize food formulation according to the syariah compliance. If an alternative halal product is made available, it may serve as an import substitute as well as to satisfy the demand for alternative halal products. However, past studies on lard alternative fat substitute is very limited. Hence, a study was carried out to formulate lard alternative fat substitute by mixing various plant fats such as mee fat [*Madhuca longifolia* (MF)], palm stearin (PS), avocado fat (Avo), cocoa butter (CB), palm oil (PO) and soybean oil (SBO). At first, the binary (MF:PS), ternary (Avo:PS:CB) and quaternary (PO:PS:SBO:CB) (w/w) mixtures were formulated using the above mentioned fats at different ratios and their physico-chemical properties were compared to that of LD such as slip melting point (SMP), iodine value (IV), fatty acid (FA) composition using GC, triacylglycerol (TAG) composition using HPLC, thermal behavior using DSC and solid fat content (SFC) NMR. None of the plant based mixtures had a SMP and IV that were similar to that of lard. Even though there were diversity in fatty acids and triacylglycerol molecules, however, some of plant based mixtures showed similarity with some fatty acids and triacylglycerol molecules of LD. Binary (MF:PS) mixtures had higher saturated fatty acids (44.25-45.77%) and UStSt triacylglycerol contents (38.21-44.76%) compared to that of lard (37.38 and 26.60%, respectively). Meanwhile, the saturated fatty acid and UStSt triacylglycerol contents of ternary (Avo:PS:CB) (36.65-38.01% and 24.89-33.61%, respectively) and quaternary (PO:PS:SBO:CB) (34.44-36.79% and 22.47-24.86%, respectively) mixtures were almost similar to lard (37.38 and 26.60%, respectively). The cooling and heating profiles of plant based mixtures were differed from lard. However, the major melting peak of MF:PS (99:1), Avo:PS:CB (84:7:9) and all quaternary mixtures was found to be closest to that of lard at -3.59 °C. SFC profile compatibility of mixture was used as the main criteria to choose the best mixture under each set (binary, ternary and quaternary) as compared to that of lard. According to this,

the SFC of binary mixture of MF:PS (99:1), ternary mixture of Avo:PS:CB (84:7:9) and quaternary mixture of PO:PS:SBO:CB (38:5:52:5) were almost similar and the least difference to that of lard. In the next stage, these selected plant based mixtures and lard were subjected to shortening production. The formulated shortenings were compared to that of lard shortening in term of their hardness using a texture analyzer (TA), consistency using a cone penetrator, polymorphism using XRD and microstructure behavior using PLM. The hardness (26.19-28.35 g) and adhesiveness (82.46-137 g/s) of formulated plant based shortening were not significantly different ($p>0.05$) compared to that of lard shortening (26.67 g and 123.88 g/s, respectively). The formulated plant based shortenings and lard shortening were categorized as plastic fats based on their consistency value (319.20-326.26 g/cm2) and displayed a mixture of β' and β-form polymorphs of which the β'-form was found to be predominant. However, the polymorphism characteristic was not affected by crystallization behavior where the number and size of crystals in the formulated plant based shortenings were dissimilar to those of lard shortening. In the final stage, the functional properties of formulated plant based shortenings and lard shortening were compared in the production of cookie dough and cookie. The dough made with formulated plant based shortenings and LD shortening had a better consistency with increase of mixing time. However, dough made with binary (337 BU) and quaternary (300 BU) mixture shortenings had a closer consistency value at 15 min of the mixing time and there were also no significant differences ($p>0.05$) with dough made with LD shortening (333 BU). The dough made with formulated plant based shortenings and lard shortening had a maximum cookie spread at 3 min while baking in the oven. In the meantime, there was no significant difference ($p>0.05$) in elasticity of dough made with binary mixture shortening (65 BU) with dough made with LD shortening (63 BU). However, there were no significant differences ($p>0.05$) among cookies of different types of shortenings with regard to cookie hardness (1008.12-1015.75 g), diameter (72.33-72.95 mm), thickness (9.32-9.52 mm) and cookie spread ratio (7.65-7.8 mm). With regard to color, ANOVA results showed that there were no significant differences ($p>0.05$) in *L*, *a*, and *b* values of cookies made with binary (70.43, 8.12 and 19.55, respectively) and quaternary (69.23, 7.27 and 20.96, respectively) mixture shortenings and lard shortening (69.27. 7.03 and 18.79, respectively).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

FORMULASI LEMAK TUMBUHAN SEBAGAI PENGANTI BAGI MENYERUPAI CIRI-CIRI LEMAK BABI

Oleh

YANTY NOORZIANNA BINTI ABDUL MANAF

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Lemak babi merupakan salah satu lemak yang digunakan sebagai *shortening* bagi pembuatan roti, kek, biskut dan lain-lain lagi. Walau bagaimanapun, aplikasi lemak babi adalah terbatas yang mana orang-orang Islam, Yahudi dan pengamal vegetarian dilarang untuk menggunakan lemak haiwan tersebut. Tambahan pula, lemak babi tidak disyorkan memandangkan terdapat persepsi negatif mengenai implikasi lemak haiwan terhadap kesihatan manusia. Oleh itu, penganti lemak babi sangat diperlukan oleh negara-negara majoriti penduduknya Muslim di mana pengganti lemak babi ini dapat digunakan dalam pembuatan makanan mengikut hukum syarak. Sekiranya terdapat alternatif produk halal, maka permintaan terhadap produk tersebut dapat dipenuhi. Walau bagaimanapun, kajian mengenai alternatif lemak babi sangat terhad. Oleh itu, tujuan kajian ini adalah untuk memformulasikan alternatif kepada pengganti lemak babi dengan mencampurkan pelbagai lemak daripada sumber tumbuhan seperti lemak mee [*Madhuca longifolia* (MF)], stearin sawit (PS), lemak avokado (Avo), lemak koko (CB), minyak sawit (PO) and minyak soya (SBO). Pada permulaannya, lemak yang telah dinyatakan seperti di atas digunakan bagi menghasikan formulasi campuran binari (MF:PS), ternari (Avo:PS:CB) dan kuaternari (PO:PS:SBO:CB) pada nisbah yang berbeza dan membandingkannya dengan lemak babi dari segi ciri-ciri kimia-fizikal seperti titik lebur (SMP), nilai iodin (IV), komposisi asid lemak manggunakan GC, komposisi triasilgliserol menggunakan HPLC, sifat terma menggunakan DSC dan kandungan lemak pepejal menggunakan NMR. Tiada campuran lemak tumbuhan yang mempunyai SMP dan IV yang sama seperti lemak babi. Walaupun terdapat kepelbagaian asid lemak dan triasilgliserol, sesetengah asid lemak dan molekul triasilgliserol yang terdapat dalam campuran lemak tumbuhan adalah sama seperti lemak babi. Campuran binari mengandungi asid lemak tepu (44.25-45.77%) dan triasilgliserol UStSt (38.21-44.76%) yang lebih tinggi berbanding dengan lemak babi. Sementara itu, campuran ternari (Avo:PS:CB) (36.65-38.01% dan 24.89-33.61%, masing-masing) dan kuaternari (34.44-36.79% dan 22.47-24.86%, masing-masing) mengandungi asid lemak tepu dan triasilgliserol UStSt yang hampir sama dengan lemak babi (37.38 dan 26.60%, masing-masing). Profil penyejukan dan pemanasan bagi campuran lemak tumbuhan adalah berbeza dengan lemak babi. Walau bagaimanapun, lemak babi dan campuran MF:PS (99:1), Avo:PS:CB (84:7:9) dan semua campuran kuaternari mempunyai puncak pemanasan utama pada -3.59 °C.

Persamaan profil SFC digunakan sebagai kriteria utama untuk memilih campuran yang paling baik untuk setiap set (binari, ternari dan kuaternari) dalam menentukan persamaannya dengan lemak babi. Berdasarkan ciri-ciri ini, SFC campuran binari MF:PS (99:1), campuran ternari Avo:PS:CB (84:7:9) dan campuran kuaternari PO:PS:SBO:CB (38:5:52:5) menunjukkan persamaan yang paling ketara dengan lemak babi. Pada tahap seterusnya, campuran lemak tumbuhan yang telah dipilih dan lemak babi digunakan dalam penghasilan *shortening. Shortening* yang telah diformulasi akan dibandingkan dengan *shortening* lemak babi dari segi kekerasan menggunakan penganalisa tekstur (TA), konsistensi menggunakan penetrasi kon, polimorfik menggunakan XRD and sifat struktur mikro menggunakan PLM. Kekerasan (26.19-28.35 g) dan kelekatan (82.46-137 g/s) *shortening* berasaskan lemak tumbuhan tidak menunjukkan perbezaan ($p>0.05$) berbanding *shortening* lemak babi (26.67 g dan 123.88 g/s, masing-masing). *Shortening* berasasakan lemak tumbuhan dan *shortening* lemak babi dikategorikan sebagai lemak palstik berdasarkan nilai konsistensi (319.20-326.26 g/cm^2) dan terdiri daripada campuran β' and β- polimorfik di mana β' merupakan polimorfik utama. Walau bagaimanapun, ciri-ciri polimorfik tidak mempengaruhi sifat pengkristalan di mana bilangan dan saiz kristal adalah berbeza di antara *shortening* berasaskan lemak tumbuhan dan *shortening* lemak babi. Pada tahap terakhir, perbandingan antara *shortening* berasaskan lemak tumbuhan dan *shortening* lemak babi digunakan dalam penghasilan doh dan biskut. Konsistensi *shortening* berasaskan lemak tumbuhan dan *shortening* lemak babi adalah lebih stabil apabila diadun lebih lama. Walau bagaimanapun, tiada perbezaan secara signifikan ($p>0.05$) terhadap kosistensi doh yang dihasilkan daripada *shortening* campuran binari (337 BU), kuaternari (300 BU) dan lemak babi (333 BU) pada 15 minit pengadunan. Pengembangan biskut adalah maksimum pada 3 min sewaktu dibakar di dalam oven bagi doh yang dihasilkan daripada *shortening* berasaskan lemak tumbuhan dan *shortening* lemak babi. Pada masa yang sama, kekenyalan doh yang dihasilkan daripada *shortening* campuran binari (65 BU) dan *shortening* lemak babi (63 BU) tidak menunjukkan perbezaan secara signifikan ($p>0.05$). Walau bagaimanapun, biskut yang diperbuat daripada *shortening* yang berbeza tidak menunjukkan perbezaan secara signifikan ($p>0.05$) terhadap kekerasan (1008.12-1015.75 g), diameter (72.33-72.95 mm), ketebalan (9.32-9.52 mm) dan nisbah pengembangan biskut (7.65-7.8 mm). Dari segi warna, nilai ANOVA menunjukkan tiada perbezaan secara signifikan ($p>0.05$) bagi nilai *L*, *a*, dan *b* bagi biskut yang dihasilkan daripada s*hortening* campuran binari (70.43, 8.12 and 19.55, masing-masing), kuaternari (69.23, 7.27 and 20.96, masing-masing) dan lemak babi (69.27. 7.03 and 18.79, masing-masing).

ACKNOWLEDGEMENTS

Alhamdulilah thank you to Almighty God Allah for His mercies and blessings. I would like to express my most profound and sincere appreciation to my supervisor, Dr. Mohammed Nazrim Marikkar from the Department of Biohemistry, Faculty of Biotechnology and Biomolecular Sciences for his guidance, advice, encouragement and understanding. His cooperation and support are always highly appreciated. My appreciation also goes to my co-supervisors Dr. Miskandar bin Mat Sahri and Prof. Dr. Shuhaimi bin Mustafa for their encouragement, opinion, comments and valuable moral support.

A special thanks to Dr. Ir. Filip Van Bockstaele and Prof. Dr. Koen Dewettinck from Department of Food Quality and Food Safety, Ghent University, Belgiurm for giving me the opportunity to use their lab. I would also like to thank my colleagues and staffs from Halal Research Products Institute UPM, The Malaysian Agricultural Research and Development Institute (MARDI), Malaysian Palm Oil Board (MPOB) and University of Ghent, Belgium for their help throughout the course of this project.

I would like to take this opportunity to express my warmest gratitude to my parents, husband, son, sister, brother in law and niece for their encouragement, support and love.

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

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This is to confirm that:

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LIST OF ABBREVIATIONS

°C	Degree celcius
a	Redness
ANOVA	Analysis of variance
AOAC	Association of analytical communities
AOCS	American Oil Chemists' Society
Avo	Avocado fat
b	Yellowness
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	Arachidic acid
CB	Cocoa butter
CBE	Cocoa butter equivalents
CBS	Cocoa butter substitute
CHD	Coronary heart disease
cm	Centimeter
DSC	Differential scanning calorimetry
DSC	Differential scanning calorimeter
FAME	Fatty acid methyl ester
FAO	Food and Agricultural Organization
g	Gram
GLC	Gas liquid chromatography
g/s	Gram per second
g/cm^2	Gram per centimeter square
HPLC	High performance liquid chromatography
IV	Iodine value
L	Lightness
LD	Lard
LLL	Trilinoleoyl glycerol
LLLn	Dilinoleoyl-3-linoleneoyl glycerol
MF	Mee (Madhuca longifolia) fat
mL/min	Milliliter per minute
MLCT	Medium-and long-chain TAGs
mm	Milimeter
MPOB	Malaysian Palm Oil Board
MUFA	Monounsaturated fatty acid
OLL	1-oleoyl- dilinoleoyl glycerol
OOL	Dioleoyl-3-linoleoyl glycerol
OOO	Trioleoyl glycerol
PDAGS	Stearin fraction of palm-based diacylglycerol
PLL	1-palmitoyl-dilinoleoyl glycerol
PLM	Polarized light microscopy
PMF	Palm mid fraction

pNMR	Pulse nuclear magnetic resonance
PO	Palm oil
POL	Palmitoyl-oleoyl-linoleoyl glycerol
POO	1-palmitoyl-dioleoyl glycerol
PORAM	Palm Oil Refiners Association of Malaysia
PPL	Dipalmitoyl-3-linoleoyl glycerol
PPO	Dipalmitoyl-3-oleoyl glycerol
PPP	Tripalmitoyl glycerol
PPS	Dipalmitoyl-3-stearoyl glycerol
PS	Palm stearin
PUFA	Polyunsaturated fatty acid
RID	Refractive index detector
rpm	Revolution per minute
SBO	Soybean oil
SFA	Saturated fatty acid
SFC	Solid fat content
SHSs	Sunflower hard stearins
SMP	Slip melting point
SOO	1-stearoyl-dioleoyl glycerol
SOS	1,3-distearoyl glycerol
SPO	Stearoyl-palmitoyl-oleoyl glycerol
SSS	Tristearoyl glycerol
StStSt	Trisaturated
TAG	Triaclyglycerol
USA	United State of America
USFA	Unsaturated fatty acid
UStSt	Disaturated
UUSt	Diunsaturated
UUU	Triunsaturated
w/w	Weight per weight
WAXD	Wide angle X-ray diffraction
XRD	X-ray diffraction
α	Alpha
β	Beta
β'	Beta prime
µL	Microliter
µm	Micrometer

CHAPTER 1

INTRODUCTION

Animal fats are widely used as food ingredient for a long time. Apart from being used as a medium of deep frying and meat flavors, animal fats were also used as shortening in bakery products due to their availability and lower cost. Lard (LD) and tallow are well known animal fat with similar characteristics in terms of high saturated fatty acids (SFA). LD has been used in food applications in many countries in Europe (Antonietta *et al*., 2004), America (deMan *et al*., 1991) and in Asia such as China, Taiwan, Thailand, Cambodia and Vietnam (Omar *et al*., 2010; Hsu and Yu, 2002; Morell and Enig, 2000). The main reason for this trend relates to its flavor and superior performance characteristics during food processing.

Although the use of LD is already popular in the food culture of certain ethnic groups, the consumption of LD is prohibited for some communities based on religious believes. Particularly, Islamic and Orthodox Jewish religions command the prohibition of consumption of both pork and LD in any products (Regenstein *et al*., 2003; Montiel-Sosa *et al*., 2000; Rashood *et al*., 1996). Therefore, LD adulteration in food products is a concern for Muslim and Jewish people. Most of the manufacturers want to reduce production costs and to increase the amount of raw material because of high demand for some products which could be the main reason for adulteration. However, the fraudulent food claim, could lead to a loss of thousands even billions toward food industries, if they do not implement the right halal practices as being told by the advisory or authoritative bodies. In addition, if there is any contamination or non-halal substance detected in the product, it may be difficult to rebuild the trust and confidence among consumers. In this context, detection and estimation of LD adulteration in fats and oils has become an important aspect in food quality control due to growing public concern in many parts of the world. Therefore, the development of instrumental and analytical methods for halal authentication and detection was reported by several research groups (Rohman *et al*., 2011; Juliana *et al*., 2011; Mansor *et al*., 2011; Marina *et al*., 2010; Marikkar *et al*., 2005; Che Man *et al*., 2005).

In addition to religious prohibition, medical reports of unfavorable health effects of LD also prompted the general public to be more vigilant about pork and LD contamination in food products (Rashood *et al*., 1996). According to previous studies, pork fat or LD could contribute to heart disease, obesity, hypertension and colon cancer (Wang *et al*., 2013; Chicco *et al*., 2008; Sinkeldam *et al*., 1990; Rogers *et al*., 1986). Owing to this, there has been a growing trend to formulate fat substitutes for the replacement of LD in many products (Rodrigues-Capena *et al*., 2011; Degado-Pado *et al*., 2011; Ospina-E *et al*., 2010; Choi *et al*., 2010; Serivini *et al*., 2003; Muguerza *et al*., 2003). However, there is still much potential to further research and innovation, especially for formulating halal alternative fats for LD using locally available plant lipids.

If modifications to fats and oils from plant sources could be done to mimic the physical properties of LD, it would be worthwhile. Blending is the simplest way to modify the physical properties of fats where it could be a mixture of different oils and fats (Siddique *et al*., 2010; Miskandar *et al*., 2005). Blending is also generally preferred to other modification techniques because it is less costly and the desired consistency can be reached by choosing the right mixture ratios (Nusantoro *et al*., 2013). The fat substitute simulating the properties of LD could be done by mixing several fats and oils where the raw material should come from halal sources. Thus, plant lipids could be selected as the potential sources as they are usually not prohibited under halal laws.

In this study, fats and oils from plant sources such as oil palm (PO and PS), cocoa (CB), avocado (Avo), mee seed [*Madhuca longifolia* (MF)] and soybean (SBO) have been chosen for blending. PS and CB are categorized as hard fats. PO, Avo, and MF are categorized as semisolid fats while SBO is categorized as liquid oil. In order to obtain the simulating characteristics of LD, mixing of fats and oils from different plant sources can be achieved in the form of binary [mee fat:palm stearin (MF:PS)], ternary [avocado fat:palm stearin:cocoa butter (Avo:PS:CB)] and quaternary [palm oil:palm stearin:soybean oil:cocoa butter (PO:PS:SBO:CB)] mixtures at different ratios. The comparisons of physical properties of LD and the formulated plant based fat mixtures could be done by evaluating them with respect to slip melting point (SMP), iodine value (IV), solid fat content (SFC) and thermal properties. Besides these, the fatty acid (FA) and triacylglycerol (TAG) compositional analyses would also be carried out as they are key to understand the physical behavior of the formulated plant based fat substitutes. The selection of the most suitable mixture from each fat category namely binary, ternary and quaternary mixtures would be the preliminary step of the investigation. The selected plant based mixtures shall be processed into shortenings in the next step to cross-check their compatibility to LD shortening in terms of their physical characteristics, crystal behavior and polymorphism. In the final stage, the formulated plant based shortenings and LD shortening can be applied on to the preparation of cookies to find out their functional properties in actual product formulation.

1.1 Problem statements

i. Whether it is possible to formulate fat substitutes for lard using binary, ternary and quaternary mixtures of selected plant fats

ii. Whether the formulated plant-based fat substitutes for lard could really work as a fat ingredient in the preparation of good quality cookies

1.2 Hypothesis

It may be possible to formulate fat substitutes to simulate the properties of lard using binary, ternary and quaternary mixtures of selected plant fats.

1.3 Research objective

Hence, the overall objectives of this study were to formulate plant based fat substitutes in simulating the properties of LD as halal alternatives. The specific objectives of this research are:

i. To formulate binary, ternary and quaternary mixtures of selected plant fats

ii. To compare the composition and physico-chemical properties of the formulated mixtures with those LD

iii. To compare the functional properties of LD shortening with those of the formulated plant based shortenings

iv. To compare the cookie dough properties and cookie quality prepared from LD shortening with those using formulated plant based shortenings

REFERENCES

Abboud, A.M., Rubenthaler, G.L. and Hoseney, R.C. 1985. Effect of fat and sugar in sugar-snap cookies and evaluation of tests to measure cookie flour quality. *Cereal Chemistry* 62: 124–129.

Abeyesekera, M., and Hemapala, A. 1981. *Avocado oil*. Sri Lanka: Ceylon Institute of Scientific and Industrial Research.

Acevedo, N.C., Peyronel, F. and Marangoni, A.G. 2011. Nanoscale structure intercrystalline interactions in fat crystal networks. *Current Opinion in Colloid and Interface Science* 16: 374–383.

Aini, I.N. and Maimon, C.H.C. 1996. Characteristics of white pan bread as affected by tempering of the fat ingredient. *Cereal Chemistry* 73: 462–465.

Aini, I.N. and Miskandar, M.S. 2007. Utilization of palm oil and palm products in shortenings and margarines. *Fette, Seifen, Anstrichmittel* 109: 422–32.

Álvarez, D., Delles, R.M., Xiong, Y.L., Castillo, M., Payne, F. and Laencina, J. 2011. Influence of canola-olive oils, rice bran and walnut on functionality and emulsion stability of frankfurters. *LWT - Food Science and Technology* 44: 1435–1442.

Antonietta, P.M., Maria, M.V., Bersani, C., Beretta, G. and Mentasti, T. 2004. Characterisation of a lard cured with spices and aromatic herbs. *Meat Science* 67: 549–557.

Anwar, F., Hussain, A.I., Iqbal, S. and Bhanger, M.I. 2007. Enhancement of the oxidative stability of some vegetable oils by blending with *Moringa oleifera* oil. *Food Chemistry* 93: 1181–1191.

AOAC. 2007. *Official Methods of Analysis of AOAC International*. Washington: Association of Official Analytical Chemists.

AOCS. 1999. *Official Methods and Recommended Practices of the American Oil Chemists' Society*. Champaign: American Oil Chemists' Society.

AOCS. 2004. *Official Methods and Recommended Practices of the American Oil Chemists' Society*. Champaign: American Oil Chemists' Society.

AOCS. 2011. *Oil World Annual Report.* 2009. Retrieved 2 December 2015 from http://lipidlibrary.aocs.org/OilsFats.

Arifin, N., Cheong, L.Z., Koh, S.P., Long, K., Tan, C.P., Yusoff, M.S.A, Aini, I.N., Lo, S.K and Lai, O.M. 2011. Physicochemical properties and sensory attributes of

medium- and long-chain triacylglycerols (MLCT)-enriched bakery shortening. *Food and Bioprocess Technology* 4: 587–596.

Arifin, N., Koh, S.P., Long, K., Tan, C.P., Yusoff, M.S.A., Idris, N.A and Lai, O.M. 2010. Relationship between textural properties and sensory qualities of cookies made from medium- and long-chain triacylglycerol-enriched margarines. *Journal of Science of Food and Agriculture* 90: 943–948.

Athar, M. and Nasir, S.M. 2005. Taxonomic perspective of plant species yielding vegetable oils used in cosmetics and skin care products. *African Journal of Biotechnology* 4: 36–44.

Aziz, A.A., Mohamud, Y., Roselina, K., Boo, H. C., Nyuk, L.C. and Che Man, Y.B. 2011. Rheological, chemical and DSC thermal characteristics of different types of palm oil/palm stearin-based shortenings. *International Food Research Journal* 18: 189–200.

Azizi, S.N. and Najafzadeh, S. 2008. Fatty acids and volatile compounds in avocado cultivated in North of Iran. *World Applied Sciences Journal* 5: 1–4.

Baltsavias, A., Jurgens, A. and van Vliet, T. 1997. Rheological properties of short doughs at small deformation. *Journal of Cereal Science* 26: 289–300.

Basiron, Y. 1996. Palm oil. In *Bailey's Industrial Oil and Fat Products*, ed. Y.H. Hui, pp. 313–331. New York: John Wiley and Sons, Inc.

Basiron, Y. 2005. Palm oil. In *Bailey's Industrial Oil and Fat Products*, ed. F. Shahidi, pp. 253–257. New York: John Wiley and Sons, Inc.

Berger, K.G. 2005. *The Use of Palm Oil in Frying*. Malaysia: Malaysian Palm Oil Council.

Berry, S.E.E. 2009. Triacylglycerol structure and interesterification of palmitic and stearic acid-rich fats: an overview and implications for cardiovascular disease. *Nutrition Research Reviews* 22: 3–17.

Bessler, T. and Orthoefer, F. 1983. Providing lubricity in food fat systems. *Journal of the American Oil Chemists' Society* 60: 1765–1768.

Bochicchio, D., Faeti, V., Marchetto, G., Poletti, E., Maranesi, M., Mordenti, L. and Della Casa, G. 2005. Effect of feeding partially hydrogenated lard on *trans*-fatty acid content of muscle and backfat of heavy pigs. *Meat science* 71: 651–656.

Borwanker, R.P., Frye, L.A. Blaurock, A.E. and Sasevich, F.J. 1992. Rheological characterization of melting of margarines and table spreads. *Journal of Food Engineering* 16: 55–74.

Bootello, M., Hartel, R.W., Levin, M., Martínez-Blanes, J.M., Real, C., Garcés, R., Martínez-Force, E. and Salas, J.J. 2013. Studies of isothermal crystallisation

kinetics of sunflower hard stearin-based confectionery fats. *Food Chemistry* 139: 184–95.

Bracco, U., Dieffenbacher, A. and Kolarovic, L. 1981. Frying performance of palm oil liquid fractions. *Journal of the American Oil Chemists' Society* 58: 6–12.

Bragagnolo, N. and Rodriguez-Amaya, D.B. 2002. Simultaneous determination of total lipid, cholesterol and fatty acids in meat and backfat of suckling and adult pigs. *Food Chemistry* 79: 255–260.

Brown, A. 2007. *Understanding Food: Principles and Preparation*. Wadsworth: Cengage Learning.

Brunello, N., McGauley, S.E. and Marangoni, A. 2003. Mechanical properties of cocoa butter in relation to its crystallization behavior and microstructure. *Lebensmittel-Wissenschaft und -Technologie* 36: 525–532.

Campos, R. 2005. *Fat Crystal Networks*. New York: Marcel Dekker.

Campos, R. Narine, S.S. and Marangoni, A.G. 2002. Effect of cooling rate on the struscture and mechanical properties of milk fat and lard. *Food Research International* 35: 971–981.

Che Man, Y.B, Syahariza, Z.A., Mirghani, M.E.S., Jinap, S. and Bakar, J. 2005. Analysis of potential lard adulteration in chocolate and chocolate products using Fourier transform infrared spectroscopy. *Food Chemistry* 90: 815–819.

Che Man, Y.B., Shamsi, K., Yusoff, M.S.A. and Jinap, S. 2003. A study on the crystal structure of palm oil-based whipping cream. *Journal of the American Oil Chemists' Society* 80: 409–415.

Chicco, A.J., Sparagna, G.C., Mc Cune, S.A., Johnson, C.A., Murphy, R.C., Bolden, D.A., Rees, M.L., Gardner, R.T. and Moore, R.L. 2008. Linoleate-rich high-fat diet decreases mortality in hypertensive heart failure rats compared to lard-rich and low-fat diets. *Hypertension* 52: 549–555.

Choi, Y.S., Choi, J.H., Han, D.J., Kim, H.Y., Lee, M.A., Jeong, J.Y., Chung, H.J., Kim, C.J. 2010. Effects of replacing pork back fat with vegetable oils and rice bran fiber on the quality of reduced-fat frankfurters. *Meat Science* 84: 557–563.

Codex Alimentarius, 1999. *Codex Standard for Named Animal Fats*. Retrieved 15 December 2014 from http://www.fao.org/docrep/004/y2774e/y2774e05.htm.

Coleman, M.H., and Macrae, A.R., 1981. *U.S. Patent* 4,275,081.

Copeland, L., Blazek, J., Salman, H. and Tang, M.C. 2009. Form and functionality of starch. *Food Hydrocolloids* 23: 1527–1534.

Corke, H., De Leyn, I., Nip, W.K., Cross, N.A., and Hui, Y. 2006. *Bakery Products: Science and Technology*. Oxford: Blackwell Publishing.

D'Souza, L., deMan, L. and deMan, J.M. 1991. Chemical and physical properties of the high melting glyceride fractions of commercial margarine. *Journal of the American Oil Chemists' Society* 68: 153–162.

D'Souza, V., deMan, J.M. and deMan L. 1990. Short spacings and polymorphic forms of natural and commercial solid fats: A review. *Journal of the American Oil Chemists' Society* 67: 835–843.

Danthine, S., Gibon, V. and Deroanne, C. 2005. Physicochemical characteristics of ternary fat blends involving low-erucic rapeseed oil. *European Journal of Lipid Science and Technology* 107: 627–633.

De Graef, V., Vereecken, J., Smith, K.W., Bhaggan, K. and Dewettinck, K. 2012. Effect of TAG composition on the solid fat content profile, microstructure, and hardness of model fat blends with identical saturated fatty acid content. *European Journal of Food Science and Technology* 114: 592–601.

Deffense, E. 1985. Fractionation of Palm Oil. *Journal of the American Oil Chemists' Soc*iety 62: 376–385.

Delgado-Pado, G., Cofrades, S., Rodríguez-Salas, L. and Jiménez-Colmenero, F. 2011. A healthier oil combination and konjac gel as functional ingredients in low-fat pork liver pâté. *Meat Science* 88: 241–248.

deMan, J.M. 1998. Functionality of palm oil in foods. *Journal of Food Lipids* 5: 159–170.

deMan, J.M. 1999. *Principles of Food Chemistry*. New York: Springer Science+Business Media, Inc.

deMan, J.M. 2002. Texture of fats. In *Physical Properties of Lipids*, ed. G. Alejendro, A.G. Marangoni, and S.S. Narine, pp. 191–215. New York: Marcel Dekker, Inc.

deMan, J.M. and deMan, L. 2001. Polymorphism and texture of fats. In *Crystallization and Solidificaton Properties of Lipids*, ed. N. Widlak, R. Hartel, and S.S. Narine, pp. 225–235. Illinois: AOCS Press.

deMan, L., deMan, J.M. and Blackman, B. 1989. Polymorphic behavior of some fully hydrogenated oils and their mixtures with liquid Oils. *Journal of the American Oil Chemists' Society* 66: 1777–1780.

deMan, L., deMan, J.M. and Blackman, B. 1991. Physical and textural properties of some North American shortenings. *Journal of the American Oil Chemists' Society* 68: 63–69.

Dinç, S., Javidipour, I, Özbas, Ö,Ö and Tekin, A, 2014. Utilization of zero-trans non-interesterified and interesterified shortenings in cookie production. *Journal of Food Science and Technology* 51: 365–370.

Duff, H.G. 1991. Winterizing. In *Introduction to Fats and Oils Technology*, ed. P.J. Wan, pp. 105-113. Champaign, IL: AOCS Press.

Dutta, A., Baruah, K.K.Jr. and Anubha-Boruah, M. 1996. Effect of human chorionic gonadotropin. Serum thyroid hormones during pregnancy in nondescript treatment on goats of Assam. *Journal of Nuclear Agriculture and Biology* 25: 122–125.

Enser, M. Meat lipids. In *Developments in Oils and Fats*, ed. R.J. Hamilton, pp. 1–31. Glasgow, Scotland: Blackie Academic and Professional.

Fadzlillah, N.A., Che Man, Y.B., and Jamaludin, M.A. 2011. Proceeding from 2nd International Conference on Humanities, Historical and Social Sciences: *Halal Food Issues from Islamic and Modern Science Perspectives*. Singapore: IPEDR, IACSIT Press.

Farag, R.S., Farag, M.M. and Ali, R.F.M. 2008. Use of sunflower oil mixed with jojoba and paraffin oils in deep-fat frying process. *International Journal of Food Science and Technology* 59: 401–410.

Faur, L. 1996. Margarine technology. In *Oils and Fats Manual*, ed. A. Karleskind, pp. 951–962. Paris, France: Lovoisier Publishing.

Floter, E. 2009. The role of physical properties data in product development. *European Journal of Lipid Science and Technology* 111: 219–226.

Foubert, I., Peter, A., Vanrolleghem, and Dewettinck. K. 2003. A differential scanning calorimetry method to determine the isothermal crystallization kinetics of cocoa butter. *Thermochimica Acta* 400: 131–142.

Fustier, P., Castaigne, F., Turgeon, S.L. and Biliaderis, C.G. 2008. Flour constituent interactions and their influence on dough rheology and quality of semi-sweet biscuits: a mixture design approach with reconstituted blends of gluten, water-solubles and starch fractions. *Journal of Cereal Science* 48: 144–158.

Gabbott, P. 2004. *Hyper DSC, a Breakthrough Method for Materials Characterization*. Malaysia: Perkin Elmer.

Gabbott, P. 2008. A practical introduction to differential scanning calorimetry. In *Principles and Applications of Thermal Analysis*, pp. 1–49. Oxford: Blackwell Publishing Ltd.

Gamboa, O.W.D. and Gioielli, L.A. 2006. Crystallization behavior of structured lipids produced from palm kernel fat and fish oil. *Quimica Nova* 29: 646–653.

Ghotra, B. S., Dyal, S.D and. Narine, S.S 2002. Lipid shortening: a review. *Food Research International* 35: 1015–1048.

Gitlesen, T., Svensson, I., Aldercreutz, P., Mattiason, B. and Nilsson, J. 1995. High oleic acid rapeseed oil as starting material for the production of confectionary

fats via lipase-catalysed transesterification. *Industrial Crops Products* 4: 167–171.

Given, P.S. 1994. Influence of fat and oil–physicochemical properties on cookie and cracker manufacture. In *The Science of Cookie and Cracker Production*, ed. H. Faridi, New York, USA: Chapman and Hall.

Given, P.S.J. 1990. Influence of fat and oil physicochemical properties on the expression of functionality in baked goods. *Cereal Foods World* 35: 813.

Greenwell, B.A. 1981. Chilling and crystallization of shortenings and margarines. *Journal of the American Oil Chemists' Society* 58: 206–207.

Greethead, G.F. 1969. The role of fats in bakery products. *Food Technology in Australia* 21: 228–230.

Grundy, S.M. Influence of stearic acid on cholesterol metabolism relative to other long-chain fatty acids. 1994. *The American Journal of Clinical Nutrition* 60: 986–990.

Gryglewicz, S., Piechocki, W. and Gryglewicz, G. 2003. Preparation of polyol esters based on vegetable and animal fats. *Bioresource Technology* 87: 35–39.

Gunstone, F.D. 2006. Methods of analysis to determine the quality of oils. In *Modifying Lipids for Use in Food*, ed. K. Warner, pp. 115–127. Cambridge, UK: Woodhead Publishing Limited.

Gunstone, F.D. 2008. Research highlights: Lipid Technology. *Lipid Technology* 10: 67–69.

Gutierrez, R., Gonzalez, O. and Dobarganes, M.C. 1988. Analytical procedures for the evaluation of used frying fats. In *Frying Food: Principles, Changes, New Approaches*, ed. G. Varela, A.E. Bender, and I.D. Morton, pp. 141–154. London: VCH Publishers Ltd.

Haighton, A.J. 1959. The measurement of the hardness of margarine and fats with cone penetrometers. *Journal of the American Oil Chemists' Society* 36: 345–348.

Haighton, A.J. 1976 Blending, chilling and tempering of margarine and shortening. *Journal of the American Oil Chemists' Society* 53: 397–399.

Hartley, C.W.S., 1988. *The Oil Palm.* New York: Longman.

Haryati, T., Che Man, Y.B., Asbi, A., Ghazali, H.M. and Buana, L. 1997. Determination of iodine value of palm oil by differential scanning calorimetry. *Journal of the American Oil Chemists' Society* 74: 939–942.

Haumann, B.F. Stearic acid: a 'different' saturated fatty acid. 1998. *INFORM* 9: 202–208,

Henry, J. 2009. Processing, manufacturing, uses and labeling of fats in the food supply. *Annals of Nutrition and Metabolism* 55: 273–300.

Herrera, M.L. and Hartel, R.W. 2002. Effect of processing conditions on physical properties of a milk fat model system: Microstructure. *Journal of the American Oil Chemists' Society* 77: 1197–1204.

Hoerr, C.W. and Waugh, D.F. 1950. Some physical characteristics of rearranged lard. *Journal of the American Oil Chemists' Society* 32: 37–41.

Hoffman, G. 1989. *The Chemistry and Technology of Edible Oils and Fats and Their High Fat Products*. London: Academic Press.

Hoseney, R.C. 1994. *Principles of Cereal Science and Technology*. USA: AACC International.

Hoseney, R.C., Wade, P., and Finley, J.W. 1988. Soft wheat products. In *Wheat Chemistry and Technology*, ed. Y. Pomeranz, USA: AACC International.

Howe, G.R., Friedenreich, C.M., Jain, M. and Miller, A.B. 1991. A cohort study of fat intake and risk of breast cancer. *Journal of the National Cancer Institute* 83: 336–40.

Hsu, S.Y. and Yu, S.H. 2002. Comparisons on 11 plant oil fat substitutes for low-fat Kung-wans. *Journal of Food Engineering* 51: 215–220.

Hugo, A. and Roodt, E. 2007. Significance of porcine fat quality in teat technology: A review. *Food Reviews International* 23: 175–198.

Hui, Y.H. 1996. Shortening: Type and formulations. In *Edible Oil and Fat Products: Products and Application Technology. Bailey's Industrial Oil and Fat Products*, ed. Y. H. Hui, pp. 161–191. New York: John Wiley and Sons.

Idris, N.A., Berger, K.G. and Ong, A.S.H. 1989. Evaluation of shortenings based on various palm oil products. *Journal of the Food of Science and Agriculture* 46: 481–493.

Idris, N.A., Embong, M.S., Abdullah, A., and Hassan, A.H. 1991. Proceeding from PORIM International Conference: *Utilization of Palm Oil and Milk Fat in Shortening Formulation for Madeira Cake*. Kuala Lumpur: MPOB.

Jacob, J. and Leelavathi, K. 2007. Effect of fat-type on cookie dough and cookie quality. *Journal of Food Engineering* 79: 299−305.

Jakab, A., Heberger, K. and Forgaics, E. 2002. Comparative analysis of different plant oils by high-performance liquid chromatography–atmospheric pressure chemical ionization mass spectrometry. *Journal of Chromatography A* 976: 255–263.

Jayaweera, D.M.A. 1982. *Medicinal Plants Used in Ceylon*. Colombo: National Science Council of Sri Lanka.

Jeyarani, T. and Reddy, S.Y. 1999. Heat-resistant cocoa butter extenders from Mahua (*Madhuca latifolia*) and Kokum (*Garcinia indica*) fats. *Journal of the American Oil Chemist' Soc*iety 76: 1431–1436.

Jirasubnakorn, W., Bell, A.E., Gordon, M.H. and Smith K.W. 2007. Effects of variation in the palm stearin:palm olein ratio on the crystallization of a low-trans shortening. *Food Chemistry* 103: 477–485.

Juliana, M., Che Man, Y.B. and Hashim, D.M. 2011. Analysis of lard's aroma by an electronic nose for rapid halal authentication. *Journal of the American Oil Chemists' Society* 88: 75–82.

Kalnin, D., Garnaud, G., Amenitsch, H. and Ollivon, M. 2002. Monitoring fat crystallization in aerated food emulsions by combined DSC and time-resolved synchrotron X-ray diffraction. *Food Research International* 35: 927–934.

Kamel, B.S. 1992. Characteristics of bread and buns made with lard and vegetable oils of different iodine value. *Journal of the American Oil Chemists' Society* 69: 794–796.

Kanagaratnam, S., Hoque, M.E, Mat Sahri, M. and Spowage, A. 2013. Investigating the effect of deforming temperature on the oil-binding capacity of palm oil based shortening. *Journal of Food Engineering* 118: 90–99.

Kanagaratnam, S., Mat Sahri, M., Idris, N A, Tangavelu, T. and Ahmad, M.J. 1995. Palm-based trans-free roll-in margarine. *Palm Oil Development* 48: 7–12.

Karabulut, I., Turan, S. and Ergin, G. 2004. Effects of chemical interesterification on solid fat content and slip melting point of fat/oil blends. *European Food Research and Technology* 218: 224–229.

Keisersberger, E. 1989. *Themo Chimica Acta*. Amsterdam: Elsevier Science Publishers.

Kesteloot, H., Lesaffre, E. and Joossens, JV. 1991. Dairy fat, saturated animal fat, and cancer risk. *Preventive Medicine* 20: 226–236.

Kheiri, M.S.A. 1988. Hydrogenation. *PORIM Technology* 10: 1–50.

Kirkeby, P.G. 2011. Innovations in margarines, shortenings and spreads. *Lipid Technology* 4: 83–86.

Kitts, D. 1996. Toxicity and safety of fats and oils. In *Bailey's Industrial Oil and Fat Products*, ed. Y.H. Hui, pp. 215–280. New York: John Wiley and Sons.

Kok, L.L., Fehr, W.R. Hammond, E.G. and White, P.J. 1999. *Trans*-free margarine from highly saturated soybean oil. *Journal of the American Oil Chemist' Soc*iety 76: 1175–1181.

Kowalski, B. 1988. Determination of specific heats of some edible oils and fats by differential scanning calorimetry. *Journal of Thermal Analysis* 34: 1321–1326.

Kris-Etherton, P.M., Griel, A.E. and Psota, T.L. 2005. Dietary stearic acid and risk of cardiovascular disease: intake, sources, digestion, and absorption. *Lipids* 40: 1193–1200.

Kweon, M., Donelson, T., Slade, L. and Levine, H. 2010. Micro-sugar-snap and micro-wire-cut cookie baking with trans-fat and zero-trans-fat shortenings. *Cereal Chemistry* 87: 415–419.

Lai, O.M., Ghazali, H.M., Cho, F. and Chong, C.L. 2000. Physical and textural properties of an experimental table margarine prepared from lipase-catalyzed transesterified palm stearin:palm kernel olein mixture during storage. *Food Chemistry* 71: 173–179.

Lansani, A., Bondioli, P., Mariani, C., Folegatti, L., Venturini, S., Fedeli, E. and Barreteau, P.A. 1994. New short-path distillation system applied to the reduction of cholesterol in butter and lard. *Journal of the American Oil Chemist' Soc*iety 71: 609–614.

Latip, R.A., Lee, Y., Tang, T., Phuah, E., Tan, C. and Lai, O. 2013. Physicochemical properties and crystallisation behaviour of bakery shortening produced from stearin fraction of palm-based diacyglycerol blended with various vegetable oils. *Food Chemistry* 141: 3938–3946.

Lawson, H.W. 1985. *Standards of Fats and Oils*. New York: Springer.

Lawson, H.W. 1995. *Food Oils and Fats: Technology, Utilization and Nutrition.* New York: Chapman and Hall.

Lida, H.M.D.N. and Ali, A.R.M. 1998. Physicochemical characteristics of palm-based oil blends for the production of reduced fat spreads. *Journal of the American Oil Chemists' Society* 75: 1625–1631.

Lida, H.M.D.N., Sundram, K., Siew, W.L., Aminah, A. and Mamot, S. 2002. TAG composition and solid fat content of palm oil, sunflower oil, and palm kernel olein blends before and after chemical interesterification. *Journal of the American Oil Chemists' Society* 79: 1137–1144.

Lin, J., Zhang, S.M., Cook, N.C.R., Lee, I.M. and Buring, J.E. 2004. Dietary fat and fatty acids and risk of colorectal cancer in women. *American Journal of Epidemiology* 160: 1011–1022.

Lipp, M. and Anklam, E. 1998. Review of cocoa butter and alternative fats for use in chocolate-Part A. Compositional data. *Food Chemistry* 62: 73–97.

Lipp, M., Simoneau, C., Ulberth, F., Anklam, E., Crews, C., Brereton, P., de Greyt, W., Schwack, W. and Wiedmaier, C. 2001. Composition of genuine cocoa butter and cocoa butter equivalents. *Journal of Food Composition and Analysis* 14: 399–408.

List, G.R., Mounts, T.L., Orthoefer, F. and Neff, W.E. 1995. Margarine and shortening oils by interesterification of liquid and trisaturated triglycerides. *Journal of the American Oil Chemists' Society* 72: 379–382.

Liu, K.J., Chang H.M. and Liu K.M., 2007. Enzymatic synthesis of cocoa butter analog through interesterification of lard and triestearin in supercritical carbon dioxide by lipase. *Food Chemistry* 100: 1303–1311.

Liu, Y., Meng, Z., Shan, L., Jin, Q. and Wang, X. 2010. Preparation of specialty fats from beef tallow and canola oil by chemical interesterification: Physico-chemical properties and bread applications of the products. *European Food Research Technology* 230: 457–466.

Maache-Rezzoug, Z., Bouvier, J.M., Allaf, K. and Patras, C. 1998. Effect of principal ingredients on rheological behaviour of biscuit dough and on quality of biscuits. *Journal of Food Engineering* 35: 23−42.

Malécka, M. 2002. Antioxidant properties of the unsaponifiable isolated from tomato seeds oat grains and wheat germ oil. *Food Chem*istry 79: 327–330.

Manley, D. 2000. Short dough biscuits. In *Technology of Biscuits, Crackers and Cookies*, ed. D. Manley, pp. 274–284. Boca Raton, USA: CRC Press.

Mansor, T.S.T., Che Man, Y.B. and Rohman, A. 2011. Application of fast gas chromatography and Fourier transform infrared spectroscopy for analysis of lard adulteration in virgin coconut oil. *Food Analytical Methods* 4: 365–372.

Marangoni, A.G. and Rousseau, D. 1998. The influence of chemical interesterification on the physicochemical properties of complex fat systems 1. Melting and crystallization. *Journal of the American Oil Chemists' Society* 75: 1265–1271.

Marangoni, A.G. 2002. Special issue of FRI – crystallisation, structure and functionality of fats. *Food Research International* 35: 907–908.

Marangoni, A.G. and Narine, S.S. 2002. Identifying key structural indicators of mechanical strength in networks of fat crystals. *Food Research International* 35: 957–969.

Marangoni, A.G. and Rousseau. D. 1998. The Influence of chemical interesterification on physicochemical properties of complex fat systems 1. Melting and crystallization. *Journal of the American Oil Chemist' Soc*iety 75: 1265–1271.

Marikkar, J.M.N. and Ghazali, H.M. 2011. Effect of Moringa oleifera oil blending on fractional crystallization behavior of palm oil. *International Journal of Food Properties* 14: 1049–1059.

Marikkar, J.M.N., Ghazali, H.M. and Long, K. 2010. Composition and thermal characteristics of *Madhuca longifolia* seed fat and its solid and liquid fractions. *Journal of Oleo Sci*ence 59: 7–14.

Marikkar, J.M.N., Ghazali, H.M., Che Man, Y.B., Peiris, T.S.G. and Lai, O. M. 2005. Distinguishing lard from other animal fats in admixtures of some vegetable oils using liquid chromatographic data coupled with multivariate data analysis. *Food Chemistry* 91: 5–14.

Marikkar, J.M.N., Ghazali, H.M., Long, K. and Lai, O.M. 2003. Lard uptake and its detection in selected food products deep-fried in lard. *Food Research International* 36: 1047–1060.

Marikkar, J.M.N., Lai, O.M., Ghazali, H.M. and Che Man, Y.B. 2001. Detection of lard and randomised lard as adulterants in RBD palm oil by differential scanning calorimetry. *Journal of the American Oil Chemist' Soc*iety 78: 1113–1119.

Marina, M.A., Che Man, Y.B. and Amin, I. 2010. Use of the SAW sensor electronic nose for detecting the adulteration of virgin coconut oil with RBD palm kernel olein. *Journal of the American Oil Chemists' Society* 87: 263–270.

Mariod, A., Mattaus, B., Eichner, K. and Hussein, I.H. 2005. Improving the oxidative stability of sunflower oil by blending with Sclerocarya birrea and Aspongopus viduatus oils. *Journal of Food Lipids* 12: 150–158.

Martini, S., Awad, T., and Marangoni, A.G. 2006. *Modifying Lipids for Use in Food*. Cambridge: Woodhead Publishing.

Martini, S., Herrera, M.L. and Hartel, R.W. 2002. Effect of processing conditions on microstructure of milk fat fraction/sunflower oil blends. *Journal of the American Oil Chemists' Society* 79: 1063–1068.

Mayamol, P.N., Samuel, T., Balachandran, C., Sundaresan, A. and Arumughan, C. 2004. Zero-trans shortening using palm stearin and rice bran oil. *Journal of the American Oil Chemist' Society* 81: 407–413.

Meng, Z., Liu, Y., Shan, L., Jin, Q., Wang, F. and Wang, X. 2011. Specialty fats from beef tallow and canola oil: Establishment of reaction conditions, characterization of products, and evaluation of crystal stability. *Food Biophysics* 6: 115–126.

Mensink, R.P. 2005. Effects of stearic acid on plasma lipid and lipoproteins in humans. *Lipids* 40: 1201–1205.

Metin, S., and Hartel, R.W. 2005. *Bailey's Industrial Oil and Fat Products*. New York, USA: Wiley Interscience.

Metzroth, D.J. 1996. *Edible Oil and Fat Products: Products and Application Technology*.. New York, USA: John Wiley and Sons.

Metzroth, D.J. 2005. Shortenings: Science and technology. In *Bailey's Industrial Oil and Fat Products*, ed. F. Shahidi, pp: 83–123. New York: John Wiley and Sons, Inc.

Miskandar, M.S. and Nor Aini, I. 2010. Palm stearin as low trans hard stock for margarine. *Sains Malaysiana* 39: 821–827.

Miskandar, M.S., Che Man, Y.B., Yusoff, M.S.A. and Rahman, R.A. 2005. Quality of margarine: fats selection and processing parameter. *Asia Pacific Journal of Clinical Nutrition* 14: 387–395.

Montiel-Sosa, J.F., Ruiz-Pesini, E., Montoya, J., Roncalés, P., López-Pérez, M.J. and Pérez-Martos, A. 2000. Direct and highly species-specific detection of pork meat and fat in meat products by PCR amplification of mitochondrial DNA. *Journal of Agriculture of Food and Chemistry* 48: 2829–2832.

Morell, S.F. and Enig, M. 2000. *Thailand: Land of the coconut*. Retrieved 12 October 2014 from www.wesonaprice.org/tradional-diets/thailand-land-of-coconut.

Moreno, A.O., Dorantes, L., Galindez, J. and Guzman, R.I. 2003. Effect of different extraction methods on fatty acids, volatile compounds, and physical and chemical properties of avocado (*Persea americana* Mill.) oil. *Journal of Agriculture of Food of Chemistry* 51: 2216–2221.

Morris, S.G., Gorden, C.F., Brenner, N., Meyers, J.S., Riemenschneider, R.W., Ault, W.C. 1952. Fractionation of animal fat glycerides by crystallization from acetone. *Journal of the American Oil Chemist' Soc*iety 29: 441–443.

Moziar C., deMan, J.M. and deMan, L. 1989. Effect of tempering on the physical properties of shortening. *Canadian Institute of Food Science and Technology Journal* 22: 238–242.

Muguerza, E., Ansorena, D. and Astiasara´n, I. 2003. Improvement of nutritional properties of Chorizo de Pamplona by replacement of pork backfat with soy oil. *Meat Science* 65: 1361–1367.

Murano, S.P. 2003. *Understanding Food Science and Technology*. California: Thomson Wadsworth.

Narine, S.S. and Humprey, K L. 2004. A comparison of lipid shortening functionality as a function of molecular ensemble and shear: microstructure, polymorphism, solid fat content and texture. *Food Research International* 37: 28–38.

Narine, S.S. and Marangoni, J. 1999. Microscopic and rheological studies of fat crystal networks. *Journal of Crystal Growth* 198: 1315–1319.

Nawar, W.W. 1985. Lipids. In *Food Chemistry*, ed. R. F. Owen, pp. 139–245. New York: Marcel Dekker Inc.

Nethsingha, C. 1993. *Avocado*. Sri Lanka: Ceylon Institute of Scientific and Industrial Research.

Nielsen, N.S., Yang, T., Xu, X. and Jacobsen, C. 2006. Production and oxidative stability of a human milk fat substitute produced from lard by enzyme technology in a pilot packed-bed reactor. *Food Chemistry* 94: 53–60.

Nor Aini, I. and Miskandar, M.S. 2007. Utilization of palm oil and palm products in shortenings and margarines. *European Journal of Lipid Science and Technology* 109: 422–432.

Norizzah, A.R., Chong, C.L,, Cheow, C.S. and Zaliha O. 2004. Effects of chemical interesterification on physicochemical properties of palm stearin and palm kernel olein blends. *Food Chemistry* 86: 229–35.

Noor Lida, H.M.D., Sundram, K., Siew, W.L., Aminah, A. and Mamot, S. 2002. TAG composition and solid fat content of palm oil, sunflower oil and palm kernel olein blends before and after chemical interesterification. *Journal of the American Oil Chemist' Soc*iety 79: 1137–1144.

Nur Illiyin, M.R., Marikkar, J.M.N., Shuhaimi, M., Mahiran, B. and Miskandar, M.S.A. 2013. Comparison of the thermo physical behavior of Engkabang (*Shorea macrophylla*) seed fat - canola oil blends and lard. *Journal of the American Oil Chemist' Soc*iety 90: 1485–1493.

Nurjuliana, M., Che Man, Y.B. and Mat Hashim, D. 2010. Analysis of lard's aroma by an electric nose for rapid halal authentication. *Journal of the American Oil Chemist' Soc*iety 88: 75–82.

Nusantoro, B.P., De Clercq, N., Anthierens, K. and Dewettinck, K. 2013. Changing the SFC profile of lauric fat blends based on melting group triacylglycerol formulation. *Journal of the American Oil Chemist' Soc*iety 90: 1607–1619.

O'Brien, R.D. 2009. *Fats and Oils-Formulating and Processing for Applications*. New York: CRC Press.

O'Brien, R.D. 1998. *Fats and Oil: Formulating and Processing for Applications*. USA: Technomic Publishing Co. Inc.

O'Brien, R.D. 2000. Shortening technology. In *Introduction to Fats and Oils Technology*, ed. R.D. O'Brien, W.E. Farr, and P.J. Wan, pp. 421–451. Champaign, IL: AOCS Press.

O'Brien, R.D. 2004. Fats and oils analysis. In *Fats and Oils Formulating and Processing for Applications,* ed. R.D. O'Brien, pp. 175–227. Boca Raton, FL: CRC Press.

O'Brien, R.D. 2005. Shortenings: Types and formulations. In *Bailey's Industrial Oil and Fat Products*, ed. F. Shahidi, pp. 83–123. New York: John Wiley and Sons, Inc.

O'Brien, R.D. 2003. *Fats and Oils: Formulating and Processing for Applications.* New York: Springer.

Oh, J., Mc Curdy, A.R., Clark, S. and Swanson, B.G. 2005. Stabilizing polymorphic transitions of tristearin using diacylglycerols and sucrose polyesters. *Journal of the American Oil Chemists' Society* 82: 13–19.

Olewnik, M.C. and Kulp, K. 1984. The effect of mixing time and ingredient variation on farinograms of cookie dough. *Cereal Chemistry* 61: 532–537.

Omar, M.N., Nor-Nazuha, M.N., Nor-Dalilah M.N. and Sahri, M.M. 2010. Frying performance of palm-based solid frying shortening. *Pakistan Journal of Biological Science* 13: 298–302.

Orthoefer, F.T. 1996. Rice bran oil: Healthy lipid source. *Food Technology* 50: 62–64.

Osborn, H.T. and Akoh, C.C. 2002. Structured Lipids – Novel Fats with Medical Nutraceutical and Food Applications. *Comprehensive Reviews in Food Science and Food Safety* 3: 110–120.

Ospina-E, J.C., Cruz-S, A., Pérez-Álvarez, J. and Fernández-López, J. 2010. Development of combinations of chemically modified vegetable oils as pork back-fat substitutes in sausages formulation. *Meat Science* 84: 491–497.

Ozdemir, F. and Topuz, A. 2004. Changes in dry matter, oil content and fatty acids composition of avocado during harvesting time and post harvesting ripening period. *Food Chemistry* 86: 79–83.

Padley, F., Gunstone, F., and Harwood, J. 1986. *Occurrence and Characteristics of Oils and Fats*, ed. F.D. Gunstone, J.L. Harwood, and F.B. Padley, pp. 49–170. London: Chapman and Hall.

Pareyt, B., Talhaoui, F., Kerckhofs, G., Brijs, K., Goesaert, H. and Wevers, M. 2009. The role of sugar and fat in sugar-snap cookies: Structural and textural properties. *Journal of Food Engineering* 90: 400−408.

Pearson, T.A. 1994. Stearic acid: a unique saturated fatty acid. *The American Journal of Clinical Nutrition* 60: 983−1072.

Pentzaris, T.P. and Basiron, Y. 2002. *Vegetable Oils in Food Technology Composition, Properties and Uses*, ed. F.D. Gunstone, pp. 157–201, Boca Raton, FL: CRC Press.

Perez-Martinez, J.D., Reyes-Hernández, J., Dibildox-Alvarado, E. and Toro-Vazquez, J.F. 2011. Physical properties of cocoa butter/vegetable oil blends crystallized in a scraped surface heat exchanger. *Journal of the American Oil Chemists' Society* 89: 199–209.

Peter, J.W. 1991. Properties of fats and oil. In *Introduction to Fats and Oils Technology*, ed. J.W. Peter, pp. 16–50. Champaign, IL: AOCS Press.

Petukhov, I., Malcolmson, L.J. Przybylski, R. and Amstrong L. 1999. Frying performance of genetically modified canola oils. *Journal of the American Oil Chemists' Society* 76: 627–632.

PORAM. 2003. *PORAM Standard Specifications for Processed Palm Oil*. Selangor: The Palm Oil Refiners Association of Malaysia.

PORIM. 1995. *PORIM Test Methods*. Kuala Lumpur: Palm Oil Research Institute of Malaysia.

Ramadan, M. F. 2013. Healthy blends of high linoleic sunflower oil with selected cold pressed oils: Functionality, stability and antioxidative characteristics. *Industrial Crops and Products* 43: 65–72.

Ramadan, M.F. and Moersel, J.T. 2006. Mowrah butter: nature's novel fat. *Inform* 17: 124–126.

Ramadan, M.F., Sharanabasappa, G., Parmjyothi, S., Seshagri, M. and Moersel, J.T. 2006. Profile and levels of fatty acids and bioactive constituents in mahua butter from fruit seeds of butter cup tree (*Madhca longifolia*). *European Food Research and Technology* 222: 710–718.

Ramli, N., Said, M. and Loon, N.T. 2005. Physicochemical characteristics of binary mixtures of hydrogenated palm kernel oil and goat fat milk. *Journal of Food Lipids* 12: 243–260.

Rashood, K A., Shaaban, R.R.A., Moety, E.M.A. and Rauf, A. 1996. Compositional and thermal characterization of genuine and randomized lard: a comparative study. *Journal of the American Oil Chemists' Society* 73: 303–309.

Reddy, B.S. 1992. Dietary fat and colon cancer: Animal model studies. *Lipid* 27: 807–813.

Reddy, S.Y. and Jeyarani, T. 2001. Trans-free bakery shortenings from mango kernel and mahua fats by fractionation and blending. *Journal of the American Oil Chemist' Soc*iety 78: 635–640.

Regenstein, J.M., Chaudry, M.M. and Regenstein, C.E. 2003. The kosher and halal food laws. *Comprehensive Reviews in Food Science and Food Safety* 2: 111–127.

Reshma, M.V., Saritha, S.S., Balachandran, C. and Arumughan, C. 2008. Lipase catalyzed interesterificationof palm stearin and rice bran oil blends for preparation of zero trans shortening with bioactive phytochemicals. *Bioresource Technology* 99: 5011–5019.

Riaz, M.N., and Chaudry, M.M. 2004. *Halal Food Production*. Florida: CRC Press.

Ribeiro, A.P.B., Basso, R.C., Grimaldi, R., Gioielli, L.A. and Gonçalves, L.A.G. 2009. Instrumental methods for the evaluation of interesterified fats. *Food Analytical Method* 2: 282–302.

Rao, R., Sankar, K.U., Sambaiah, K. and Lokesh, B.R. 2001. Differential scanning calorimetric studies on structured lipids from coconut oil triglyceride containing stearic acid. *European Food Research and Technology*. 212: 334–343.

Rodriguez–Carpena, J.G., Morcuende, D. and Estevez, M. 2011. Partial replacement of pork back-fat by vegetable oils in burger patties: Effect on oxidative stability and texture and color changes during cooking and chilled storage. *Journal of Food Science* 6: 1025–1031.

Rogers, A.E., Conner, B., Boulanger, C. and Lee, S. 1986. Mammary tumorigenesis in rats fed diets high in lard. *Lipids* 21: 275–280.

Rogers, A.E., Zeisel, S.H. and Groopman J. 1993. Diet and carcinogenesis. *Carcinogenesis* 14: 2205–17.

Rogers, D. 2004. Functions of fats and oils in bakery products. *Inform* 15: 572–574.

Rohman, A., Sismindari, Erwanto, Y. and Che Man, Y.B. 2011. Analysis of pork adulteration in beef meatball using Fourier transform infrared (FTIR) spectroscopy. *Meat Science* 88: 91–95.

Rousseau, D., Hill, A.R. and Marangoni, A.G. 1996. Restructuring butterfat through blending and chemical interesterification 2. Microstructure and polymorphism. *Journal of the American Oil Chemists' Society* 73: 973–981.

Rousseau, D., Hodge, S. M., Nickerson, M.T. and. Paulson, A.T. 2005. Regulating the β'→β-polymorphic transition in food fats. *Journal of the American Oil Chemist' Soc*iety 82: 7–12.

Rousseau, D., Marangoni, A.G. and Jeffrey, K.R. 1998. The influence of chemical interesterification on the physicochemical properties of complex fat systems. 2. Morphology and polymorphism. *Journal of the American Oil Chemists' Society* 75: 1833–1839.

Rye, G.G., Litwinenko, J.W. and Marangoni, A.G. 2005. Fat crystal tetworks. In *Bailey's Industrial Oil and Fat Products*, ed. F. Shahidi, pp. 121–160. New York, USA: Wiley-Interscience.

Salgado, J.M., Danieli, F. Marisa Aparecisa Bismara Regitano-D'Arce, A.B., Frias, A. and Mansi, D.N. 2008. The avocado oil (*Persea americana* Mill) as a raw material for the food industry. *Ciência e Tecnologia de Alimentos* 28: 20–26.

Salmiah, A. 2000. *Non-food Uses of Palm Oil and Palm Kernel Oil*. Kuala Lumpur: MPOPC Palm Oil Information Series.

Salunkhe, D.K., Chavan, J.K., and Adsule, R.N. 1992. *World Oilseeds, Chemistry, Technology and Utilization*. London: The Avi Publishing Company, Inc.

Sato, K. 2001. Crystallization behaviour of fats and lipids - A review. *Chemical Engineering Science* 56: 2255–2265.

Sciarini, L.S., Van Bockstaele, F., Nusantoro, B., Pérez, G.T. and Dewettinck, K. 2013. Properties of sugar-snap cookies as influenced by lauric-based shortenings. *Journal of Cereal Science* 58: 234–240.

Segall, S.D., Artz, W.E., Raslan, D.S., Ferraz, V.P. and Takahashi, J.A. 2005. Analysis of triacylglycerol isomers in Malaysian cocoa butter using HPLC-mass spectroscopy. *Food Research International* 38: 167–174.

Seker, I.T., Ozboy-Ozbas, O., Gokbulut, I., Ozturk, S. and Koksel, H. 2010. Utilization of apricot kernel flour as fat replacer in cookies. *Journal of Food Processing and Preservation* 34: 15−26.

Seriburi, V. and Akoh, C.C. 1998. Enzymatic interesterification of lard and high-oleic sunflower oil with *Candida antarctica* lipase to produce plastic fats. *Journal of the American Oil Chemists' Society* 75: 1339–1345.

Severini, C., De Pilli, T. and Baiano T. 2003. A Partial substitution of pork backfat with extra-virgin olive oil in 'salami' products: effects on chemical, physical and sensorial quality. *Meat Science* 64: 323–331.

Siddique, B.M., Ahmad, A., Ibrahim, H. and Hena, S. 2010. Physico-chemical properties of blends of palm olein with other vegetable oils. *Grasas Aceites* 61: 423–429.

Siew, W.L. 2002. Palm oil. In *Vegetable Oils in Food Technology: Composition, Properties and Uses*, ed. F.D. Gunstone, pp. 59–97. Florida: CRC Press.

Siew, W.L. and Ng, W.L. 1996. Effect of diglycerides on the crystallisation of palm oleins. *Journal of Food Science and Agriculture* 71: 96–500.

Siew, W.L., Cheah, K.Y. and Tang, W.L. 2007. Physical properties of lipase-catalyzed interesterification of palm stearin with canola oil blends. *European Journal of Lipid Science and Technology* 109: 97–106.

Sikorski, D. 2004. Application of diacylglycerol oil in baked goods, nutritional beverages/bars, sauces and gravies. In *Diacylglycerol*, ed. Y. Katsuragi, T. Yasukawa, N. Matsuo, B.D. Flickinger, I. Tokimitsu, and M.G. Matlock, Champaign: AOCS Press.

Silva, R.C., Cotting, L.N., Poltronieri, T.P., Balcao, V.M., Almeida, D.B., Goncalves, L.A.G., Grimaldi, R. and Gioielli, L.A. 2009. The effect of enzymatic interesterification on the physic-chemical properties of blends of lard and soybean oil. *LWT–Food Science Technology* 42: 1275–1282.

Silva, R.C., Escobedo, J.P. and Gioielli, L.A. 2008. Crystallization behavior of structured lipids by chemical interesterification of lard and soybean oil. *Quimica Nova* 31: 330–335.

Silva, R.C., De Martini Soares, F.A.S., Fernandes, T.G., Castells, A.L.D., Silva, K.C.G., Gonçalves, M.I.A., Ming, C.C., Gonçalves, L.A.G. and Gioielli, L.A. 2011. Interesterification of lard and soybean oil blends catalyzed by immobilized lipase in continue packed bed reactor. *Journal of the American Oil Chemists' Society* 88: 1925–1933.

Sinkeldam, E.J., Kuper, C.F., Bosland, M.C., Hollanders, V.M.H. and Vedder, D.M. 1990. Interactive effects of dietary wheat bran and lard on N-methyl-N‘-nitro-N-nitrosoguanidine-induced colon carcinogenesis in rats. *Cancer Research* 50: 1092–1096.

Smith, N.J.H, Williams, J.T., Plucknett, D.L., and Talbot, J.P. 1992. *Tropical Forests and Their Crops*. New York: Comstock Publishing Associates.

Smith, K.W. 2001. Cocoa butter and cocoa butter equivalents. In *Structured and Modified Lipids*, ed. FD. Gunstone, pp. 401-422. Marcel Dekker, New York.

Stauffer, C.E. 1996. Bakery products applications. In *Fats and Oils*, ed. C.E. Stauffer, pp. 61–80. St. Paul: Eagen Press.

Stauffer, C.E., 2005. Fats and oils in bakery products. In *Bailey's Industrial Oil and Fat Products*, ed. F. Shahidi, pp. 207–227. New York: Wiley and Sons, Inc.

Svenstrup, G., Brüggemann, D., Kristensen, L., Risbo, J. and Abd Skibsted, L.H. 2005. The influence of pretreatment on pork fat crystallization. *European Journal of Lipid Science and Technology* 107: 607–615.

Swanson, R. and Munsayac, L. 1999. Acceptability of fruit purees in peanut butter, oatmeal and chocolate chip reduced fat cookies. *Journal of American Diet Association* 99: 343–345.

Swisher, H.E. 1988. Avocado oil: from food use to skin care. *Journal of the American Oil Chemists' Society* 65: 1704–1706.

Sylvester, P.W., Russell, M., Ip, M.M. and Ip, C. 1986. Comparative effects of different animal and vegetable fats fed before and during carcinogen administration on mammary tumorigenesis, sexual maturation and endocrine function in rats maturation and endocrine function in rats. *Cancer Research* 46: 757–762.

Takenaga, F., Matsuyama, K., Abe, S., Torii, Y. and Itoh, S. 2008. Lipid and fatty acid composition of mesocarp and seed of avocado fruits harvested at Northen range in Japan. *Journal of Oleo Science* 57: 591–597.

Talbot, G. 1995. Fat eutectic and crystallization. In *Physico-chemical Aspects of Food Processing*, ed. S.T. Beckett, pp. 143–151. Glasgow: Blackie Academic and Professional.

Tamaya-Mori, N., Uemura, K., Tanaka, S. and Iguchi, A. 2003. Aging accelerates dietary lard-induced increase in blood pressure in rats. *Experimental Gerontology* 38: 905–910.

Tan, C.P. and Che Man, Y.B. 2000. Differential scanning calorimetry analysis of edible oils: comparison of thermal properties and chemical composition. *Journal of the American Oil Chemist' Soc*iety 77: 143–155.

Tan, C.P. and Che Man, Y.B. 2002. Recent developments in differential scanning calorimetry for assessing oxidative deterioration of vegetable oils. *Trends in Food Science and Technology* 13: 312–318.

Tarmizi, A.H.A., Lin, S. W. and Kuntom, A. 2008. Palm-based standard reference materials for iodine value and slip melting point. *Analytical Chemistry Insights* 3: 127–133.

Teah, Y.K. 2004. Proceeding from Sino-Malaysian Seminar: *Palm Oil in Shortenings for the Chinese Market*. Kunming, China.

Teah, Y.K., and Ong, A.S.H. 1985. Proceeding from The Third Chemistry of Fatty Acid and Lipid Course: *Formulation of margarine using palm oil and palm oil products.* Kuala Lumpur: Palm Oil Research Institute Malaysia.

Timms, R.E. 2003. *Confectionery Fats Handbook.* Dundee: The Oily Press.

Undurraga, D., Markovits, A. and Erazo, S. 2001. Cocoa butter equivalent through enzymic interesterification of palm oil midfraction. *Process Biochemistry* 36: 933–939.

Wainwright, B. 1999. Oil and fats for the baking industry. *Cereal Foods World* 44: 16–19.

Wang, F.S. and Lin, C.W. 1995a. Turbidity for crystalline fractionation of lard. *Journal of the American Oil Chemists' Society* 72: 585–589.

Wang, F.S. and Lin, C.W. 1995b. Contribution of particle sizes and particle size distribution in crystalline fractionation of lard. *Journal of Agricultural and Food Chemistry* 43: 785–790.

Wang, X., Cheng, M., Zhao, M., Guo, G.F., Zhang, M., Yang, Y., Liu, L. and Yang, N. 2013. Differential effects of high-fat-diet rich in lard oil or soybean oil on osteopontin expression and inflammation of adipose tissue in diet-induced obese rats. *European Journal of Nutrition* 52: 1181–1189

Warner, K. and Knowlton, S. 1997. Frying quality and oxidative stability of high oleic corn oils. *Journal of the American Oil Chemists' Society* 74: 1317–1322.

Warner, K. and Mounts, T.L. 1993. Frying stability of soybean and canola oils with modified fatty acid compositions. *Journal of the American Oil Chemist' Soc*iety 70: 983–988.

Wassel, P. and Young, N.W.G. 2007. Food applications of *trans* fatty acid substitutes. *International Journal of Food Science and Technology* 42: 503–517.

Weiss, T.J. 1983. Shortening-Introduction. In *Food Oils and Their Use*, ed. T.J. Weiss, pp. 121–129. Westport, CT: AVI Publishing Co. Inc.

Werman, M.J. and Neeman, I. 1987. Avocado oil production and chemical characteristics. *Journal of the American Oil Chemist' Soc*iety 64: 229–232.

Wiedermann, L.H. 1978. Margarine and margarine oil, formulation and control. *Ibid* 55: 823–829.

Woerfel, J.B. 1995. Formulation of soy oil products. *Grasas Aceites* 46: 357–365.

Wong Soon, 1991. *Specialty Fats versus Cocoa Butter*. Subang Jaya: Altanto Sdn Bhd.

Yang, T., Xu, X., He, C. and Li, L. 2003. Lipase-catalyzed modification of lard to produce human milk fat substitutes. *Food Chemistry* 80: 473–481.

Yap, P.H., deMan, J.M. and deMan, L. 1989. Chemical and physical properties of palm oil and palm olein as affected by hydrogenation. *Canada Institute of Food Science and Technology* 22: 243–248.

Zeitoun, M.A.M., Neff, W.E., List, G.R. and. Mounts, T.L. 1993. Physical properties of interesterified fat blends. *Journal of the American Oil Chemists' Society* 70: 467–471.

BIODATA OF STUDENT

Yanty Noorzianna binti Abdul Manaf was born on the 20th of August 1978 in Penang, Malaysia. She attended Sekolah Kebangsaan Simpor as her and primary school and obtained her secondary education in Sekolah Menengah Sultan Abdul Halim. In 1996, she attended Chermai Jaya Matriculation Centre in Kota Samarahan, Sarawak. In 1993, she enrolled as an undergraduate student in Universiti Putra Malaysia and graduated three years later with Bachelor Science in Biotechnology. She obtained her Master Science Degree (Food Biotechnology), also from UPM, on her research entitled "Characterisation of Oils and Fats from Seeds of Several Malaysian Fruits and Their Enzymatic Interesterification". In 2010, she joined Halal Products Research Institute, UPM as a Graduate research assistant pursuing her degree of Doctor of Philosophy.

LIST OF PUBLICATIONS

Publications

Yanty, N.A.M., Marikkar, J.M.N., Che Man, Y.B. and Long, K. 2011. Composition and thermal analysis of lard stearin and lard olein. *Journal of Oleo Science* 60: 333–338.

Yanty, N.A.M., Marikkar, J.M.N. and Long, K. 2011. Effect of varietal differences on composition and thermal characteristics of avocado oil. *Journal of the American Oil Chemists' Society* 88: 1997–2003.

Marikkar, J.M.N. and **Yanty, N.A.M.** 2011. Effect of Chemical and Enzymatic Modifications on the Identity Characteristics of Lard –Review. *International Journal of Food Properties* 17: 321–330.

Yanty, N.A.M., Marikkar, J.M.N. and Miskandar, M.S. 2012. Comparing the thermo-physical characteristics of lard and selected plant fats. *Grasas y Aceites* 63: 328–334.

Marikkar, J.M.N. and **Yanty, N.A.M.** 2012. Seed fat from *Madhuca longifolia* as raw material for halal alternative fats. *Borneo Science (The Journal of Science and Technology)* 31: 84–94.

Yanty, N.A.M., Marikkar, J.M.N. and Che Man, Y.B. 2013. Effect of fractional crystallization on composition and thermal characteristics of avocado (*Persea americana*) butter. *Journal of Thermal Analysis and Calorimetry* 111: 2203–2209.

Yanty, N.A.M., Marikkar, J.M.N. and Shuhaimi, M. 2013. Effect of fractional crystallization and thermal properties of engkabang (*Shorea macrophylla*) seed fat and cocoa butter. *Grasas y Aceites* 64: 546–553.

Yanty, N.A.M., Marikkar, J.M.N., Shuhaimi, M. and Miskandar, M.S 2014. Composition and thermal analysis of binary mixtures of mee fat and palm stearin. *Journal Oleo Science* 63: 325–332.

Yanty, N.A.M. and Marikkar, J.M.N. and Abdulkarim, S.M. 2014. Determination of types of fat ingredient in some commercial biscuit. *International Food Research Journal* 21: 277–282.

Yanty, N.A.M., Marikkar, J.M.N., Shuhaimi, M. and Miskandar, M.S 2015. Composition and thermal analysis of ternary mixtures of avocado:fat:palm stearin:cocoa butter (Avo:PS:CB). *International Journal of Food Properties* (LJFP-2015-1067) –Accepted

Proceedings/Conferences

Yanty, N.A.M. and Marikkar, J.M.N. Isolation of hard butter (HMF) from Malaysian avocado oil. In proceeding of the 2nd Conference on Food Science and Technology, November 9–12, 2011, Can Tho, Vietnam.

Yanty, N.A.M., Marikkar, J.M.N. and Miskandar, M.S. Palm oil based substitutes for lard based fat derivaties. In proceeding of the International Palm Oil Conference, November 15–17, 2011, Kuala Lumpur, Malaysia.

Yanty, N.A.M. and Marikkar, J.M.N. Seed fat from *Madhuca longifolia* as raw material for halal alternative fats. In proceeding of the International Conference on Food Science and Nutrition, April 2–4, 2012, Kota Kinabalu, Malaysia.

Yanty, N.A.M., Marikkar, J.M.N., Nusantoro, B.P., Dewettinck, K. and Van Bockstaele, F. 2014. A comparison of palm-based and lard shorteningson cookie dough properties and cookies quality. In proceeding of the Food Structure and Functionality Forum Symposium, 30 April–2 March, Amsterdam, The Netherlands.

Nusantoro, B.P., **Yanty, N.A.M.**, Marikkar, J.M.N. and Dewettinck, K. 2014. Correlation between microstructure and hardness of formulated palmitic and lauric-based shortenings. In proceeding of the Food Structure and Functionality Forum Symposium, 30 April–2 March, Amsterdam, The Netherlands.

Research Awards Obtained

Yanty, N.A.M., Marikkar, J.M.N. and Ghazali, H.M. Mee fat from Madhuca longifolia seeds as raw material for halal alternative fats. Research, Innovation and Invention, July 20-22, 2010, UPM, Malaysia. –**Silver medal**

Yanty, N.A.M., Marikkar, J.M.N., Nor Nadiha, M.Z. and Che Man, Y.B. Identity characteristics of lard for its detection in sunflower oil. Research, Innovation and Invention, July 19-21, 2011, UPM, Malaysia. –**Bronze medal**

Yanty, N.A.M., Marikkar, J.M.N. and Long, K. Evaluation of avocado fat from Malaysian cultivars for halal fat formulation. Research, Innovation and Invention, July 17-19, 2012, UPM, Malaysia. –**Bronze medal**

Yanty, N.A.M. Khasiat avocado. –published in Berita Harian, Aug 16, 2012.

Yanty, N.A.M., Marikkar, J.M.N. and Miskandar, M.S. Evaluation of avocado fat from Malaysian cultivars for halal fat formulation. Competition and Exhibition Research, Invention, Innovation and Design, November 7-8, 2012, Melaka, Malaysia. –**Gold medal**

Yanty, N.A.M., Marikkar, J.M.N. and Miskandar, M.S. Evaluation of avocado fat from Malaysian cultivars for halal fat formulation. Malaysia Technology Expo, February 21-23, 2013, Kuala Lumpur, Malaysia. –**Bronze medal**

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