Physicochemical Properties, Baking Performance and Sensory Evaluation of Bakery Shortening Enriched with Diacylglycerol

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Abstract: The purpose of this study was to investigate the suitability of palm diacylglycerol (PDAG)-enriched formulations for bakery shortening. Three types of palm diacylglycerol olein (PDAGOL) at different degree of unsaturation (PDAGOLIV56, PDAGOLIV62 and PDAGOLIV64) were used as main raw materials blended with palm stearin (PS). The blending compositions ranged from 30% to 70% of PDAGOLIV56/PS, PDAGOLIV62/PS and PDAGOLIV64/PS, respectively. The physicochemical properties of all binary blend systems were characterized for fatty acid composition (FAC), slip melting point (SMP) and solid fat content (SFC). The selected bakery shortening formulations were further characterised for polymorphic form of fat crystal and thermal behavior, using X-ray diffractometer (XRD) and differential scanning calorimetry (DSC). Bakery shortening enriched with diacylglycerol that were produced from 40DS56 (40% PDAGOLIV56/60% PS), 40DS62 (40% PDAGOLIV62/60% PS) and 40DS64 (40% PDAGOLIV64/60% PS) had 45%-50% unsaturated fatty acid and crystallized in β' + β polymorphs; thus they were suitable for shortening system. Based on product's baking performance, it could be found that all Madeira cakes prepared from bakery shortening enriched with diacylglycerol had higher specific cake volume as compared to commercial shortening (CS). In customer acceptance test, Madeira cake made from 40DS56 shortening scored the highest rating for all sensory attributes, including overall customer acceptability. It had given an indication that 40DS56 shortening formulation was the most suitable fat blends to be used as bakery shortening.

Key words: Diacylglycerol, shortening, baking, sensory.

1. Introduction

Generally, bakery shortening is produced from a mixture of liquid oil (soybean oil, cottonseed oil, rapeseed oil or a mixture of these oils) and solid fat (hydrogenated soybean oil, cottonseed oil, rapeseed oil, palm oil or animal fat) [1]. However, in the late of 20th century to early 21st century, there was an attempt to include diacylglycerol (DAG) as one of the main component of bakery shortening to improve the nutritional properties of baked product [2]. Bakery shortening with DAG-enriched was found to produce cakes with better physical functionality. This is due to their content of both lipophilic (oil loving) and hydrophilic (water loving) groups in DAG, which has

marked surface activity [3].

Diacylglycerol or also known as DAG is the esters of glycerol, which formed when two fatty acids are esterified onto a glycerol molecule. DAG can exist in three isomers, namely 1,2-DAG, 2,3-DAG and 1,3-DAG. The amount of DAG present in edible oils may vary with the origin of the oil. In general, palm oil contains up to 6% DAG [4]. DAG, which is categorized under a class of nutraceutical lipid, is able to manage obesity by decreasing postprandial lipid levels [5, 6], increasing β -oxidation of fat [7, 8], suppressing accumulation of visceral abdominal fat [9] and also reducing body weight [10]. According to Marangoni and Lencki [11], 40% of DAG is required in edible fat composition to achieve DAG levels with beneficial health effects [11].

The aim of this study was to investigate the

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compatibility of DAG-enriched formulations to be used in shortening production. Five binary blends at composition ranging from 30% to 70% palm diacylglycerol olein (PDAGOL) were developed from three binary blend systems (PDAGOLIV56/PS, PDAGOLIV62/PS and PDAGOLIV64/PS). The fatty acid composition (FAC), slip melting point (SMP), solid fat content (SFC), differential scanning calorimetry (DSC) and x-ray diffraction (XRD) of all binary blends were examined and compared with the commercial shortening (CS). The selected fat blends enriched with DAG from each binary blend system were used to produce DAG shortening. The baking performance of Madeira cakes prepared from DAG shortening and CS were evaluated in term of specific cake volume. The sensory evaluations of Madeira cakes were carried out using untrained panellist to examine the customer's acceptability of DAG shortening for baking application as compared to CS.

2. Materials and Methods

2.1 Raw Materials

Crude palm diacylglycerol (PDAG) was produced by enzymatic glycerolysis and purified using short path distillation (SPD) at R&D Research Centre, Carey Island. The purified PDAG that had high DAG content (more than 80% DAG) was used to produce various palm diacylglycerol olein (PDAGOL), namely PDAGOLIV56, PDAGOLIV62 and PDAGOLIV64 using 50 kg dry-fractionation pilot plant. Palm stearin (PS) was obtained from Sime Darby Jomalina Sdn. Bhd., Telok Panglima Garang. JOMATM shortening that used as a CS was made from palm oil and PS.

2.2 Sample Preparation

Five binary formulations of various PDAGOL with PS were prepared at molar fraction of $X_{\text{PDAGOL}} = 0.3, 0.4, 0.5, 0.6, 0.7$ for three blending systems—PDAGOLIV56/PS, PDAGOLIV62/PS and

PDAGOLIV64/PS. Each blend was produced in triplicates for further analysis.

2.3 SMP

SMP was measured according to AOCS method Cc.3.25 [12]. The clean capillary tubes were dip into a liquid sample and filled with 1 cm high of melted fat. The capillary tubes were rolled against a piece of ice until fat solidified. Then it was transferred into a small beaker and placed into a water bath at 10 °C for 16 h. Subsequently, the capillary tubes were attached to a thermometer and suspended in a 600 mL beaker of cool distilled water at 4 °C. The distilled water was heated on the hot plate operated with magnetic stirrer at a rate of 1 °C/min. The temperature at which the fat column rises was reported as the SMP.

2.4 FAC

FAC of fat blends were determined by the rapid method of AOCS official method Cd 14c-94 [12]. FAC analysis was done by gas chromatography (model: Autosystem XL, Perkin Elmer, USA). Fatty acids present in oil were first converted to fatty acid methyl esters (FAME) before being injected into polar SPTM (Supelco, Bellefonte, PA) capillary column (0.25 mm i.d. × 60 m × 0.2 µm), to obtain the fatty acid profiles.

2.5 SFC

The SFC of fat blends were measured according to the Malaysian Palm Oil Board (MPOB) test method p4.8 [13]. The samples were analyzed using Bruker minispec pulsed-nuclear magnetic resonance (pNMR) (model No. 120; Hamburg, German). The sample in the nuclear magnetic resonance (NMR) tube was melted at 70 °C for 30 min, followed by chilling at 0 °C for 90 min prior to measurement. Melting, chilling and holding of the sample were carried out in a pre-equilibrated thermostat water bath. The percentage of SFC was analyzed at a set

temperature of 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55 and 60 °C.

2.6 DSC

Thermal properties of fat blends were measured using DSC from PerkinElmer (PerkinElmer Inc., Bridgeport Avenue, Shelton, USA). The data processor was PerkinElmer diamond DSC auto-sampler. Nitrogen (99.9% purity) was used as the purge gas and flowed at 20.0 mL/min. The DSC instrument was calibrated with indium (melting point 157 °C).

2.7 XRD Analysis

The polymorphic forms of fat crystals were determined with an FR592 Enraf-Nonius Diffractis X-ray generator (Delft, The Netherlands) and an Enraf-Nonius model FR 552 Guinier camera equipped with a customized single-compartment cell with the temperature controlled by an external-circulating thermostatic bath. The melted sample at 60 °C was placed in the cell, which was set at the crystallization temperature (T_c). Sample was held isothermally until all the polymorphic phases were fully observed.

2.8 Production of Shortening

The selected binary blends of 40DS56 ($X_{\text{PDAGOLIV56}} = 0.4$; $X_{\text{PS}} = 0.6$), 40DS62 ($X_{\text{PDAGOLIV62}} = 0.4$; $X_{\text{PS}} = 0.6$) and 40DS64 ($X_{\text{PDAGOLIV64}} = 0.4$; $X_{\text{PS}} = 0.6$) were selected to produce bakery shortening. The fat blend was stirred at 70 °C for about 30 min to erase the crystal memory until it was completely homogenized. Then the melted blend was stirred at 20 °C for about 20 min, followed by at 10 °C until it texturized and formed a shortening. The CS shortening followed similar method with DAG shortening production. Both shortenings were then stored at room temperature (25 °C).

2.9 Baking Performance in Madeira Cakes

The recipe for Madeira cake was shown in Table 1.

Firstly, shortening was mixed with sugar using a Kenwood Premier Chef model KMC570 mixer at speed 3 for 5 min. The eggs were added one by one followed by vanilla flavour. Dry ingredients including all-purpose flour, self-rising flour, sugar and salt were mixed until the homogenous dispersion was formed. The homogenous dry ingredients were then added into a batter and mixed using a Kenwood Premier Chef model KMC570 mixer at speed 2 for 3 min. Finally, the batter was placed into two round cake baking tins (internal diameter 140 mm i.d.) for about 400 g, which were lined with grease proof papers and baked in oven at 160 °C for about 1 h. Rapeseed displacement method was used to measure the weight and volume of cakes once it was sufficiently cooled. Then, the specific volumes of cakes were measured.

2.10 Sensory Evaluation

Sensory evaluation of Madeira cakes was evaluated through customer acceptance test. This acceptance test involved 30 untrained panellists randomly picked from R&D Laboratory (Downstream), Carey Island. Madeira cakes were cut into slices with thickness 1 cm and square cutter 3 cm × 3 cm. All cake samples were coded with three-digit random numbers and presented randomly to the untrained panellists. The panellists were asked to rate their degree of liking or disliking of the cake sample using hedonic scales that rated from 1 (extremely dislike) to 9 (extremely like) and neutral category at the centre of the scale. The sensory attributes were evaluated based on colour, texture, aroma, taste and overall acceptability.

Table 1 Madeira cake recipe.

Ingredient	Content
Self-rising flour	150 g
All-purpose flour	100 g
Shortening	175 g
Egg	3 whole
Castor sugar	175 g
Salt	A pinch of salt
Flavour	1 mL

Table 2 SMP of binary blends enriched with DAG and CS.

Blending composition	PDAGOLIV56/PS	PDAGOLIV62/PS	PDAGOLIV64/PS
$X_{\text{PDAGOL}} = 0.0$	50.00 ± 0.12	51.00 ± 0.07	51.00 ± 0.07
$X_{\text{PDAGOL}} = 0.3$	43.53 ± 0.12	45.25 ± 0.07	44.00 ± 0.00
$X_{\text{PDAGOL}} = 0.4$	43.27 ± 0.23	43.05 ± 0.07	42.85 ± 0.07
$X_{\text{PDAGOL}} = 0.5$	41.00 ± 0.35	42.50 ± 0.00	41.85 ± 0.07
$X_{\text{PDAGOL}} = 0.6$	40.40 ± 0.20	41.40 ± 0.14	40.45 ± 0.07
$X_{\text{PDAGOL}} = 0.7$	38.27 ± 0.23	27.45 ± 0.07	30.90 ± 0.00
$X_{\text{PDAGOL}} = 1.0$	33.33 ± 0.31	24.85 ± 0.07	22.10 ± 0.14
CS	46.87 ± 0.05	46.87 ± 0.05	46.87 ± 0.05

3. Results and Discussion

3.1 SMP

Table 2 shows the SMP of binary blends enriched with DAG (PDAGOLIV56, PDAGOLIV62 and PDAGOLIV64) and CS. PDAGOLIV56 with higher composition of palmitic acid (C16) had SMP of 33.3 °C as compared to PDAGOLIV62 and PDAGOLIV64 with SMP of 24.85 °C and 22.10 °C, respectively. PS that comprised more saturated fatty acid (SAFA) content had high SMP of 50-51 °C; CS had SMP of 46.87 °C. Hence, the binary blends of various PDAGOL with PS are important in producing the desired SMP of bakery shortening. Addition of 40%-70% PS into PDAGOLIV56/PS, PDAGOLIV62/PS and PDAGOLIV64/PS had produced a suitable SMP range for bakery shortening application between 40.4 °C and 45.25 °C.

3.2 FAC

Table 3 shows the FAC of binary blends enriched with DAG (PDAGOLIV56/PS, PDAGOLIV62/PS and PDAGOLIV64/PS) and CS. The major fatty acid found in CS was palmitic acid (50.34% C16), followed by oleic acid (35.30% C18-1). PS also had high composition of palmitic acid (approximately 55.5% C16), followed by oleic acid (approximately 31% C18-1). Inversely, PDAGOLIV56, PDAGOLIV62 and PDAGOLIV64 had high composition of oleic acid (47.6%-53% C18-1), followed by palmitic acid (30.5%-36.78% C16). Addition of 30%-70% PS to PDAGOLIV56,

PDAGOLIV62 and PDAGOLIV64 had increased the amount of saturated fatty acid (SAFA) from 47.5% to 56.48% (PDAGOLIV56/PS), 43.64% to 54.3% (PDAGOLIV62/PS) and 40.86% to 52.59% (PDAGOLIV64/PS), respectively. Meanwhile, the amount of unsaturated fatty acid (MUFA and PUFA) had decreased from 52.52% to 43.52% (PDAGOLIV56/PS), 56.35% to 45.7% (PDAGOLIV62/PS) and 65.61% to 47.41% (PDAGOLIV64/PS), respectively. All binary blend systems had closed FAC profile with CS at fat blends of $X_{\text{PDAGOL}} = 0.3-0.4$.

3.3 SFC

Fig. 1 shows the SFC curve of PDAGOLIV56, PS, PDAGOLIV56/PS blends and CS by using NMR method. PDAGOLIV56 had 10.72% SFC at 25 °C (room temperature), 3.37% SFC at 37 °C (body temperature) and completely liquid at 50 °C. Meanwhile, PS had high SFC content 50.2% at 25 °C, 19.8% SFC at 37 °C and completely liquid at 55 °C. Addition of 30%-70% PS to PDAGOLIV56 had increased the fat content of PDAGOLIV56/PS blends from 16% to 30.36% SFC at 25 °C and from 6.7% to 14% SFC at 37 °C.

The SFC curve of PDAGOLIV62, PS, PDAGOLIV62/PS blends and CS are shown in Fig. 2. PDAGOLIV62 had 5.26% SFC at 25 °C and completely liquid at 37 °C. Addition of 30%-70% PS to PDAGOLIV62 had increased the fat content of PDAGOLIV62/PS blends from 12.58% to 31.13% SFC at 25 °C and from 3.2% to 11% SFC at 37 °C. The

Table 3 FAC of binary blends enriched with DAG and CS.

Fat blends	Fatty acid composition (%)						
	C16	C18	C18:1	C18:2	SAFA	MUFA	PUFA
PDAGOLIV56/PS							
$X_{PDAGOL} = 0.0$	55.49 ± 0.07	4.97 ± 0.03	30.94 ± 0.06	6.56 ± 0.03	62.03 ± 0.04	31.02 ± 0.07	6.95 ± 0.04
$X_{PDAGOL} = 0.3$	50.50 ± 0.11	4.46 ± 0.08	35.60 ± 0.18	7.44 ± 0.03	56.48 ± 0.18	35.73 ± 0.18	7.79 ± 0.02
$X_{PDAGOL} = 0.4$	48.37 ± 0.15	4.36 ± 0.00	37.49 ± 0.10	7.80 ± 0.06	54.25 ± 0.17	37.62 ± 0.09	8.16 ± 0.05
$X_{PDAGOL} = 0.5$	46.43 ± 0.04	4.19 ± 0.01	39.10 ± 0.03	8.22 ± 0.03	52.14 ± 0.04	39.27 ± 0.02	8.59 ± 0.04
$X_{PDAGOL} = 0.6$	44.50 ± 0.04	4.03 ± 0.03	40.86 ± 0.08	8.54 ± 0.11	50.09 ± 0.01	40.98 ± 0.08	8.94 ± 0.11
$X_{PDAGOL} = 0.7$	42.14 ± 0.06	3.81 ± 0.01	42.87 ± 0.04	8.99 ± 0.05	47.50 ± 0.04	43.01 ± 0.01	9.51 ± 0.04
$X_{PDAGOL} = 1.0$	36.78 ± 0.06	3.37 ± 0.04	47.58 ± 0.17	9.94 ± 0.25	41.71 ± 0.14	47.75 ± 0.18	10.55 ± 0.06
PDAGOLIV62/PS							
$X_{PDAGOL} = 0.0$	55.69 ± 0.25	4.94 ± 0.04	30.78 ± 0.08	6.53 ± 0.04	62.18 ± 0.18	30.92 ± 0.10	6.90 ± 0.08
$X_{PDAGOL} = 0.3$	48.47 ± 0.01	4.30 ± 0.01	36.96 ± 0.01	8.08 ± 0.01	54.30 ± 0.04	37.15 ± 0.01	8.55 ± 0.05
$X_{PDAGOL} = 0.4$	46.13 ± 0.02	4.08 ± 0.01	39.07 ± 0.04	8.59 ± 0.01	51.71 ± 0.01	39.23 ± 0.04	9.06 ± 0.04
$X_{PDAGOL} = 0.5$	43.68 ± 0.04	3.86 ± 0.02	41.17 ± 0.08	9.09 ± 0.04	49.05 ± 0.01	41.34 ± 0.08	9.62 ± 0.05
$X_{PDAGOL} = 0.6$	41.37 ± 0.02	3.64 ± 0.02	43.26 ± 0.08	9.53 ± 0.08	46.51 ± 0.01	43.45 ± 0.09	10.04 ± 0.10
$X_{PDAGOL} = 0.7$	38.75 ± 0.21	3.38 ± 0.01	45.38 ± 0.19	10.18 ± 0.07	43.64 ± 0.23	45.60 ± 0.16	10.75 ± 0.07
$X_{PDAGOL} = 1.0$	31.58 ± 0.03	2.81 ± 0.11	51.75 ± 0.11	11.60 ± 0.11	35.78 ± 0.21	51.99 ± 0.09	12.21 ± 0.16
PDAGOLIV64/PS							
$X_{PDAGOL} = 0.0$	55.69 ± 0.25	4.94 ± 0.04	30.78 ± 0.08	6.53 ± 0.04	62.18 ± 0.18	30.92 ± 0.10	6.90 ± 0.08
$X_{PDAGOL} = 0.3$	46.90 ± 0.08	4.17 ± 0.11	38.26 ± 0.07	8.47 ± 0.01	52.59 ± 0.17	38.45 ± 0.12	8.97 ± 0.05
$X_{PDAGOL} = 0.4$	44.02 ± 0.25	3.90 ± 0.06	41.03 ± 0.23	8.83 ± 0.18	49.44 ± 0.35	41.21 ± 0.23	9.37 ± 0.12
$X_{PDAGOL} = 0.5$	38.21 ± 0.12	3.53 ± 0.10	45.85 ± 0.09	10.05 ± 0.06	43.26 ± 0.04	46.09 ± 0.04	10.65 ± 0.00
$X_{PDAGOL} = 0.6$	36.60 ± 0.18	3.24 ± 0.05	47.35 ± 0.19	10.54 ± 0.17	41.34 ± 0.18	47.60 ± 0.15	11.17 ± 0.18
$X_{PDAGOL} = 0.7$	36.11 ± 0.16	3.26 ± 0.12	47.98 ± 0.01	10.37 ± 0.33	40.86 ± 0.30	48.18 ± 0.00	10.97 ± 0.30
$X_{PDAGOL} = 1.0$	30.49 ± 0.32	2.65 ± 0.06	52.91 ± 0.13	11.74 ± 0.00	34.48 ± 0.16	53.17 ± 0.18	12.34 ± 0.02
CS	50.34 ± 0.02	4.61 ± 0.06	35.30 ± 0.04	7.62 ± 0.08	56.51 ± 0.06	35.42 ± 0.04	8.07 ± 0.10

Fig. 1 SFC of PDAGOLIV56/PS blends and CS.

Fig. 2 SFC of PDAGOLIV62/PS blends and CS.

Fig. 3 SFC of PDAGOLIV64/PS blends and CS.

SFC of PDAGOLIV64/PS blends and CS are shown in Fig. 3. PDAGOLIV64 had 6.41% SFC at 25 °C and completely liquid at 37 °C. Addition of 30%-70% PS to PDAGOLIV64 had increased the fat content of PDAGOLIV64/PS blends from 12.46% to 30.51% SFC at 25 °C and from 2.43% to 9.83% SFC at 37 °C.

For optimum baking performance, bakery shortening should have a minimum of 20% SFC at 25 °C and also a minimum of 5% SFC at high temperature (40 °C). This is to encourage the structural formation of cake for baking application [14]. CS had 37.4% SFC at 25 °C and 7.97% SFC at

40 °C, which is within the specification of optimum SFC profile for bakery shortening. Meanwhile, from the binary blends of PDAGOLIV56/PS, PDAGOLIV62/PS and PDAGOLIV64/PS, the optimum SFC profile was recorded at $X_{\text{PDAGOL}} = 0.3-0.4$.

3.4 DSC

The DSC melting thermograms shown in Fig. 4 can be divided into three melting fractions, known as low melting fraction (LMF), medium melting fraction (MMF) and high melting fraction (HMF). CS had broad shoulder melting peak (P3 and P4) at MMF region and small melting peak (P5) at HMF region. This may due to the complex nature of fats and oil that comprised various types of triglycerides. CS was completely melted at 51 °C. Meanwhile, all DAG shortening (40DS56, 40DS62 and 40DS64) had very high and sharp melting peak (P2) up to 22 °C at MMF region, broad melting peak (P3) in a range of 46.55 °C to 48.6 °C at HMF region and small melting peak (P1) at LMF region. 40DS64 was completely melted at 51 °C, followed by 40DS62 at 51.5 °C and 40DS56 at 52.2 °C. It seems that all DAG shortening had closed

end melting temperature, where the oils and fats were completely melted. This had improved the compact texture of cake produced from the stearin fraction of PDAG [15] and further improved the cake volume.

3.5 Subcell Packing and Polymorphs

The subcell packing and polymorphs of DAG shortenings (40DS56, 40DS62, and 40DS64) and CS are shown in Table 4. β' polymorph consists of small, uniform needle-like crystals, which are densely packed in orthorhombic perpendicular subcell ($O \pm$) [16]. β' form is the most functional and desirable in shortening due to its better crystalline network and thin-needle shape morphology. These results in smoother texture, better aeration and excellent creaming properties in cake shortening [14]. The transformation of crystal from β' form to more stable β form that densely packed in triclinic parallel subcell packing is unfavourable, because it results in deterioration of the end product [17]. However, the metastable $\beta' + \beta$ polymorph is the most desirable for bakery shortening system. All the selected DAG shortenings had crystallized in $\beta' + \beta$ polymorphs similar to CS.

Fig. 4 DSC melting curve of DAG shortenings and CS.

Table 4 Subcell packing and polymorphs of DAG shortenings (40DS56, 40DS62 and 40DS64) and CS.

Shortening	Subcell packing	Polymorphic form
40DS56	$O_{\perp} + T_{//}$	$\beta' + \beta$
40DS62	$O_{\perp} + T_{//}$	$\beta' + \beta$
40DS64	$O_{\perp} + T_{//}$	$\beta' + \beta$
CS	$O_{\perp} + T_{//}$	$\beta' + \beta$

All $\beta' + \beta$ polymorphs was categorised under orthorhombic perpendicular ($O_{\perp} + T_{//}$) subcell packing.

Table 5 Specific volume and percentage of specific volume of Madeira cakes prepared from DAG shortenings (40DS56, 40DS62, and 40DS64) and CS.

Shortening	CS	40DS56	40DS62	40DS64
Specific volume of cake (cm^3/g)	2.2	2.35	2.36	2.22
Specific volume of cake (% of CS)	n/a	107%	109%	101%

n/a: not applicable, because the % of specific volume was calculated by comparing the specific volume of Madeira cakes prepared from DAG shortening vs. CS.

Fig. 5 Sensory evaluation of Madeira cakes made from DAG shortenings and CS.

3.6 Baking Performance in Madeira Cakes

The baking performance of Madeira cakes is shown in Table 5. All Madeira cakes made from DAG shortenings had higher percentage of specific cake volume up to 109% as compared to CS. Similar results were reported by Sikorski [2] that cake baked from DAG shortening had the higher cake volume. Fig. 5 shows the sensory evaluation of Madeira cakes prepared from DAG shortenings (40DS56, 40DS62 and 40DS64) and CS for customer acceptance test using hedonic scale. Cake made from 40DS56 had the highest mean values for all sensory attributes for

colour, texture, aroma, taste and overall acceptability. Cake made from CS had the second highest score in all sensory attributes. Nevertheless, other two cakes made from 40DS62 and 40DS64 were also acceptable as panellist rated at least five in all attributes.

4. Conclusions

FAC of DAG-enriched formulation had a great influence on the SFC and heating behaviour of bakery shortening. All DAG shortening produced from 40DS56, 40DS62 and 40DS64 had the higher unsaturated FAC as compared to CS. Apart from that, the present of more DAG content in the shortening

system showed the appearance of sharp medium melting fraction peak as compared to the normal DAG-enriched formulation of CS. In term of baking performance, Madeira cakes prepared from all DAG shortenings had the higher specific volume of cake as compared to CS. Nevertheless, panellists of sensory evaluation rated Madeira cake made from 40DS56 shortening the highest mean value for all sensory attributes. The results from physicochemical properties, baking performance and sensory evaluation had provided an indication that 40DS56 shortening formulation was the most suitable fat blends to be used as bakery shortening.

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