Interesterified Palm Products for Solid Fat Applications

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INTRODUCTION

Interesterification (IE) is a powerful tool for modifying the physical and chemical properties of oils and fats. IE involves redistribution and interchange of fatty acids (FAs) within and between the triaclglycerol (TAG) molecules, which make up all oils and fats. The result is a significantly changed TAG composition and consequently altered melting and crystallization behaviours of the oils and fats. No change occurs in the FA composition of the starting material as IE neither affects the degree of saturation nor causes isomerization of the FA double bonds (Rozendaal, 1989). Therefore, IE does not result in the formation of either *trans* or geometrical isomers of FAs.

Interesterified fats have not been given due attention in the food industry since partially hydrogenated fats were preferred, especially for the production of solid fats such as table and bakery margarines and shortenings. Partially hydrogenated fats are a near-perfect ingredient because they can be tailored for specific applications. However, they contain *trans* FAs because during the process of hydrogenation, some of the FA double bonds are isomerized into *trans* FAs from their *cis* configuration (Ghotra *et al*., 2002).

Trans FAs have been proven to raise low-density lipoprotein (bad) cholesterol levels, causing the arteries to become more rigid and clogged, and increase the risk for cardiovascular disease (Reddy and Jeyarani, 2001). It has thus been recommended that *trans* FAs be removed from our food systems.

Interesterified fats provide an alternative for food manufacturers looking to reduce *trans* fats in their products. In recent times, there has been a great increase in the use of interesterified fats, (especially in Europe) as hard stock for solid fat formulations to avoid incorporating *trans* fats. Interesterified fats are produced by two processes - chemical and enzymatic IE. Chemical IE uses a chemical as catalyst (Rousseau and Marangoni, 1998) to produce complete positional randomization of the acyl groups in the TAGs. Enzymatic IE, on the other hand, uses microbial lipases as catalyst (Husum *et al*., 2004) and they can target specific 1, 3 positions of the acyl groups in the TAG molecules.

This paper discusses the potential applications of chemically interesterified palm products as fat blend or hard stock for the manufacture of low or zero *trans* solid fats such as margarines, shortenings and spreads.

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MATERIALS AND METHODS

Chemical Interesterification

The process is as follows: (i) neutral feedstock is pumped batch-wise to the IE vessel, (ii) the oil is heated under vacuum and dried, (iii) a catalyst (sodium methoxide) is added and the reaction proceeds, (iv) after the reaction is complete, the catalyst is deactivated by addition of dilute aqueous citric acid solution, (v) the finished oil is washed with water to remove soap by-products and then dried under vacuum and (vi) light post-bleaching is carried out to remove any residual soap.

Fatty Acid Composition

Fatty Acid Composition (FAC) was determined as FA methyl esters according to the procedure described by Noor Lida *et al.* (2002).

Solid Fat Content

Solid fat content (SFC) was determined using a Bruker Minispec PC 120 Pulse Nuclear Magnetic Resonance (p-NMR) analyser (Karlsruhe, Germany) according to the procedure described in MPOB Test Method (2005). The sample in the pNMR tube was first melted at 70°C for 30 min, followed by chilling at 0°C for 90 min. It was then held at each measuring temperature for 30 min before measurement. SFC was measured in the temperature range of 5°C - 40°C.

Texture/Softness

Texture or softness of the sample was measured using TA-XT2 Texture Analyser (Stable Micro System, England). Load cell was 5 kg, test speed was 1.0 mm^{-1}, probe type was cylinder with 5 mm diameter (P/5) and trigger type was Auto – 5 g. Texture was measured in term of force required to penetrate the sample to a depth of 12 mm. Penetration was carried out in the original sample tub/packet, straight (for tub fat spreads) or 1 hr (for block fat spreads) after removal from a 5°C refrigerator.

Isosolid

Isosolid was measured using a p-NMR analyser. A sample taken from a 5°C refrigerator was filled in a p-NMR tube and held at that temperature for 1 hr before measurement.

Polymorphism

The polymorphic forms of fat crystals were determined by X-ray diffraction according to the procedure described by Noor Lida and Chong (2003).

Statistical Analyses

Analyses of general linear models and response surfaces were performed using the Design Expert statistical software by Stat-Ease Inc.

APPLICATION OF INTERESTERIFIED PALM PRODUCTS IN SOLID FAT FORMULATIONS

The SFC profiles of the various chemically interesterified palm products are shown in *Figure 1*. The products with different SFC profiles can be used as a fat blend or hard stock for the manufacture of low or zero *trans* FAs plastic fats such as margarines, fat spreads and shortenings. Using them provides an added advantage of reducing saturated FAs (SAFA) in the solid fat products.

Table Margarines/Fat Spreads

The fat blend plays a very critical role in producing table margarines /fat spreads. The SFC is the most critical factor as it is responsible for many of the product characteristics, including its general appearance, spreadability, oil exudation and organoleptic properties. SFC not higher than 40% at 5°C (De Greyt and Huyghebaert, 1993) or not higher than 32% at 10°C (Charteris and Keogh, 1991) are essential for table margarines/fat spreads to have good spreadability at refrigerator temperature. An SFC of not higher than 3% at 35°C is essential to ensure that products have a clean melt in the mouth (De Greyt and Huyghebaert, 1993). The products will have a *gummy and chewy* taste if the SFC is too high at 35°C.

Interesterified palm products can be used to produce tub and block table margarines/fat spreads with desirable mouth-feel, good spreadability at refrigerator temperature and low SAFA content. The SFC profiles of oil blends for interesterified palm products as such as table margarines/fat spreads are compared with oil blends extracted from commercial cold spreadable table margarine/fat spreads from the USA in *Figure 2*. The SAFA contents for the oil blends for block and tub table margarines/fat spreads are 25.1% and 17.3%, respectively.

Post-hardening, which frequently occurs in table margarines/fat spreads formulated with high amounts of palm products, especially after refrigerated storage, may also be averted/reduced by using interesterified palm products in the formulations. It has been reported that post-hardening in table margarines/fat spreads made from palm products is due to the slow crystallizing property of the palm products (Timms, 1985; Watanabe *et al.*, 1992).

Figure 3 shows the hardness of several palm-based fat spreads after three months storage at 5°C. The hardness is expressed as the force (in grammes) required to penetrate the fat spreads to a depth of 12 mm. The higher the reading

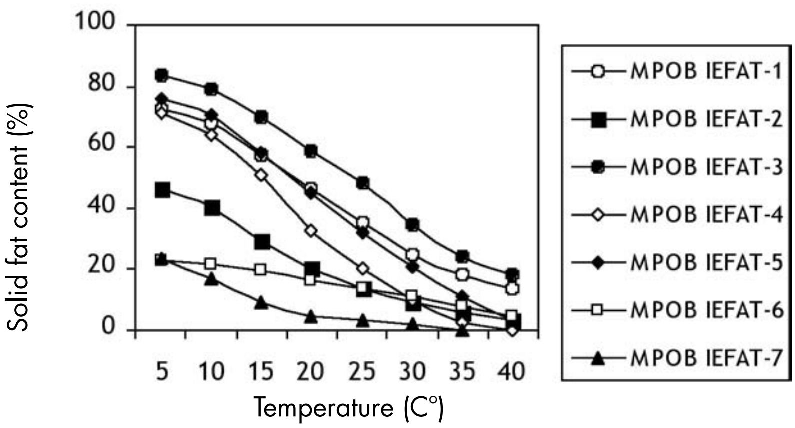

Figure 1. Solid fat content profiles of various interesterified palm products.

the firmer would be the samples and *vice versa* for a lower readings. Samples EB429 and EB435, and EB426 and ET427 were based on chemically interesterified and non-interesterified palm products, respectively. The SFCs of the palm-based cold spreadable fat spreads are shown in *Table 1*. The fat spreads made from non-interesterified palm products experienced a significant increase in hardness on storage. On the other hand, the spreads made from interesterified palm products maintained their softness throughout the storage. *Figure 4* shows clear evidence of the hardening of the fat spreads made from non-interesterified palm products on storage. The total solids in both samples significantly increased on storage. However, the total solids of the fat spreads made using interesterified palm products did not significantly increase in storage. The increases in hardness and total solids are the indicators of post-hardening in the products.

It is also important that the fat crystals of table margarines/fat spreads remain in the desirable β' form in storage in order to maintain their textural quality and functional properties. The β' crystals are relatively small and can incorporate a large amount of liquid oil in their crystal network. They, therefore, confer a glossy surface. The palm-based fat spreads made from interesterified palm products stabilized in both the β and β' polymorphs, with the ß' form dominating *(Table 2).* Although there was an increase in hardness (as shown by the isosolid and texture results) in the fat spreads made of non-interesterified palm products, there was no polymorphic transition in storage. The β' crystals of the fat spreads made of interesterified palm products are shown in *Figure 5*.

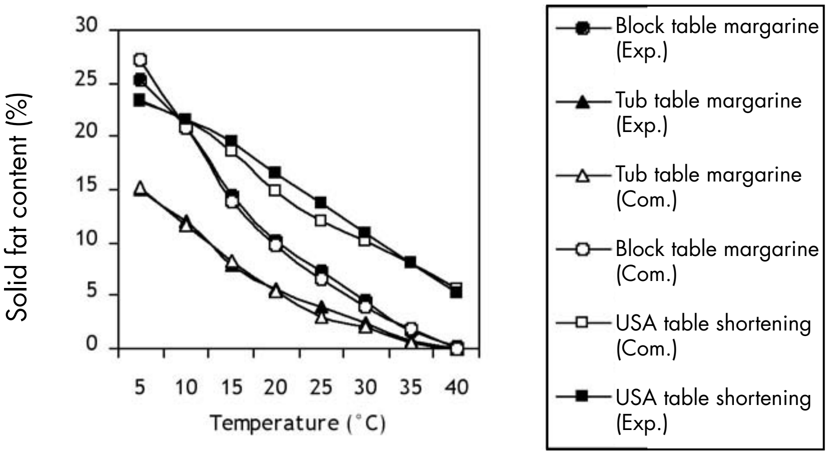

Figure 2. Solid fat content profiles of commercial (Com.) and MPOB blends for various solid fat products using palm-based interesterified fats (Exp.) as hard stock.

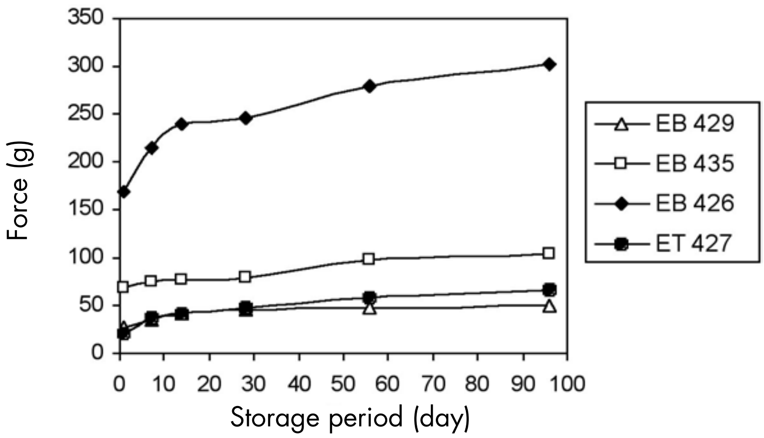

Figure 3. Consistency (force g^{-1}) of fat spreads of interesterified and non-interesterified palm-based blends after storage for three months at 5°C.

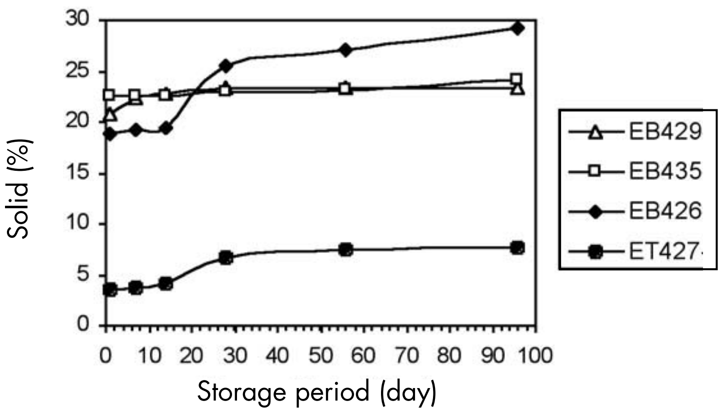

Figure 4. Isosolid (%) of fat spreads of interesterified and non-interesterified palm products after storage for three months at 5°C.

TABLE 1. SOLID FAT CONTENTS (SFC) AND SLIP MELTING POINTS (SMP) OF COMMERCIAL COLD SPREADABLE FAT SPREADS AND FAT SPREADS MADE OF INTERESTERIFIED AND NON-INTERESTERIFIED PALM-BASED FATS[a]

SFC (%)	Commercial fat spreads (n = 9)	EB 429 (block)	ET 427 (tub)	EB 426 (block)	EB 435 (block)
5°C	27.2 – 38.8	38.2	10.4	36.8	38.5
10°C	20.8 – 33.5	31.6	8.7	30.0	31.8
15°C	13.9 – 26.4	20.0	8.2	21.4	22.6
20°C	9.8 – 18.6	11.9	6.9	12.2	14.6
25°C	5.5 – 12.1	8.2	4.3	7.4	9.0
30°C	3.3 – 6.9	4.4	3.2	5.2	4.6
35°C	0 – 1.8	1.8	0.8	1.6	1.8
SMP (°C)	27.0 – 32.8	36.5	35.5	36.0	36.9

Notes: [a]Commercial fat spreads were purchased from the USA; ET 427, POs(SMP 50.5)/SFO/PKOo (17:80:3); EB 426, PO/SFO/PKOo (73:24:3); EB 429, chemically interesterified [POs(SMP 50.5)/SFO/PKOo] (50:45:5); EB 435, chemically interesterified [PO/SFO/PKOo] (65:25:10), where POs = palm stearin, SFO = sunflower oil, PKOo = palm kernel olein and PO = palm oil.

TABLE 2. POLYMORPHIC FORM (S) OF FAT SPREADS MADE OF INTERESTERIFIED AND NON-INTERESTERIFIED PALM-BASED BLENDS AFTER STORAGE FOR VARIOUS TIMES AT 5°C

Fat spread	Polymorphic form (s)					
	Day 1	Day 7	Day 14	Day 28	Day 56	Day 96
ET 427	β'>>>β	β'>>β	β'>>β	β'>>β	β'>>β	β'>>β
EB 426	β'	β'	β'	β'	β'	β'
EB 429	β'>>β'	β'>>β	β'>>β	β'>>β	β'>>β	β'>>β
EB 435	β'>>β	β'>>β	β'>>β	β'>>β	β'>>β	β'>>β

Note: For abbreviations of fat spreads, see *Table 1*.

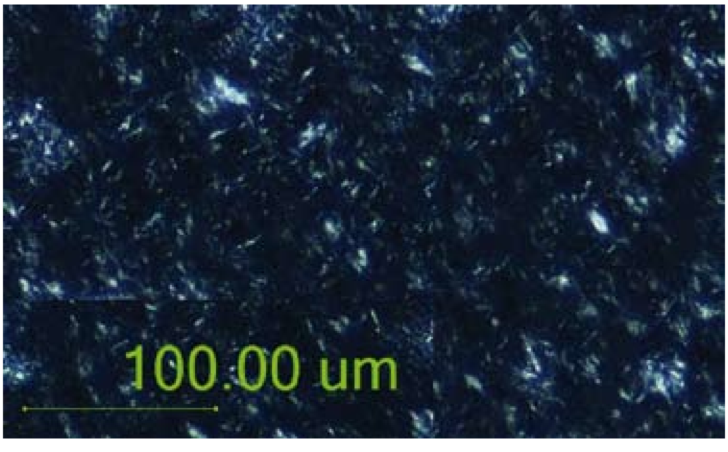

Figure 5. The β' crystals in a fat spread made of interesterified palm products.

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Bakery Fats

Bakery fats, *e.g.*, bakery margarines and shortenings, provide lubrication, improve palatability (tenderness or shortness) and provide nutrition to baked products. In the USA, most of its bakery fats currently used are made using *trans* fats, which are preferred for their fast crystallization. The fats generally contain 12%-38% *trans* FA (List, 2004).

Interesterified palm-based fats are suitable for formulating *trans*-free bakery fats low in SAFA content. The SFC profile of a bakery shortening blend made from palm-based interesterified fats was comparable to the SFC profile of a commercial shortening from the USA which had good plasticity in a broad temperature range and low SAFA as shown by blend C in *Figure 2*. The blend contained 29.5% SAFAs, much lower than the content in most popular American brands. Furthermore, bakery fats having a balanced saturated, monounsaturated and polyunsaturated FA contents can also be produced using interesterified palm products as a hard stock.

Figure 6 shows the possible fat blend formulations for American bakery shortening made from an interesterified palm product, a liquid oil and milk fat. As high as 36%-42% interesterified palm products, 54%-61% liquid oil and 0%-10% milk fat can be incorporated in the blend.

CONCLUSION

Interesterified palm products can be used as a hard stock in various solid fat products such as table margarines/spreads, bakery margarines and shortenings. These products are not only free of *trans* FAs but also likely low in saturated FAs. Therefore, interesterified palm products are good alternatives to partially hydrogenated fats which heve been commonly used to make table margarines/fat spreads and bakery fats in the USA.

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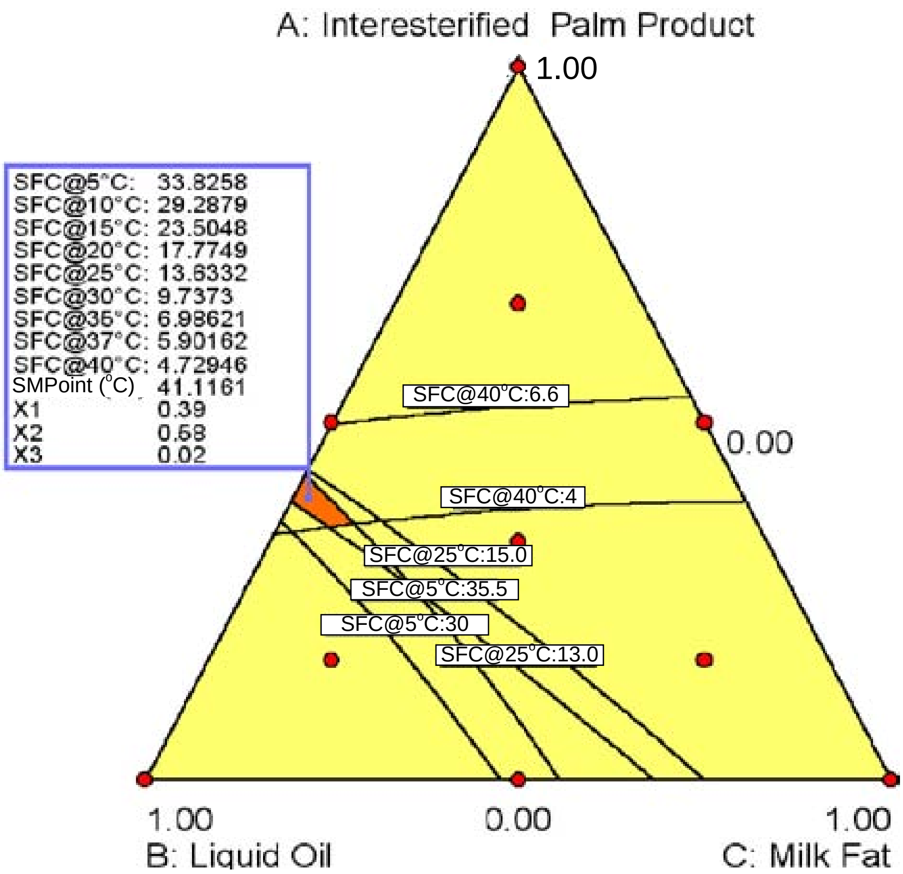

Figure 6. Overlay plot of solid fat content at 5°C, 25°C and 40°C for a fat blend formulation for trans-*free American bakery shortening.*

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