Applications of Palm-Based Interesterified Fats

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INTRODUCTION

The physical characteristics of oils and fats are determined by their chemical properties, *i.e.*, the chain length and unsaturation of the fatty acids as well as their distribution among the three hydroxyl groups of glycerol. By changing them through hydrogenation, fractionation, blending or interesterification (IE), the physical properties can be changed as well, hence, widening the spectrum for usage and application of the oils/fats. For instance, by applying IE, palm stearin can be incorporated in various types of margarine and at the same time, increase its proportion in the formulations. Without IE, only very small amounts of palm stearin can be incorporated in a table margarine formulation but the percentage can be increased to more than 50% when IE is employed.

There are cases where IE is used to deal with the problems of plastic fat products such as granular development, texture breakdown, lumpy appearance, post hardening, *etc*. Nor Aini and Noor Lida (2003) measured the consistency of palm-based shortenings over a period of two months. It was found that the interesterified shortenings were softer than the non-uninteresterified ones and showed minimal changes in consistency during storage. IE, especially the enzymatic one, can also be used to design a fat of specific triglyceride structure such as in the production of cocoa butter extenders (CBEs) and infant formula fats.

The source fat for IE is obtainable at low prices. For example, palm stearin, the hard fraction of palm oil, is probably the cheapest edible vegetable fat readily and commercially available throughout the world. Palm stearin can be used in margarines, shortenings and other plastic fats, hence, becoming a saving to the manufacturers. IE will also enable manufacturers to exchange raw materials with the ones that are the most cost effective at the point of production because some of the physical properties of randomized samples can be, to a certain extent, predicted by their fatty acid composition. Corandomized mixtures of similar fatty acid composition, irrespective of the type or fraction of fat from which these mixtures are formulated, will have similar physical properties. IE, therefore, is a very useful process for substituting one fat with other in the formulations of most of the fat-based products, *e.g*. margarine, shortening, vanaspati, specialty fats, *etc*.

Nutritionally, IE contributes in many ways; apart from eliminating/reducing *trans* fatty acids, the amount of polyunsaturated fatty acids in the *cis* form is higher, providing higher essential fatty acid activity. A comparison of the fatty acid composition of a commercial vanaspati with an IE vanaspati was made by Kheiri *et al.* (1989) as shown in *Table 1*. In the commercial product, only 5% polyunsaturated fatty acids were available compared to 23.5% in the IE sample. The essential fatty acids level in the hydrogenated vanaspati was not only low, but consisted of mainly positional and geometric fatty acid isomers, with hence, very little essential fatty acid activity. In an animal study by Majumbar and Bhattacharyya (1986), it was revealed that rats fed with an interesterified fat showed more essential fatty acids in their tissue lipids compared to the rats fed with hydrogenated fats. The coefficients of digestibility of 94.7%-96.92% of interesterified vanaspati prepared from palm stearin and soyabean, rice bran, rapeseed and mustard oils, were also much higher than the 93.6% of hydrogenated vanaspati. The triglyceride levels were lower than in the hydrogenated vanaspati but with more or less similar levels of total cholesterol. In another study, they also found that the erythrocyte membrane isolated from the rats fed interesterified fats contained more phospholipids and less cholesterol compared to that of hydrogenated vanaspati (Majumbar and Bhattacharyya, 1985).

The nutritional benefits of using IE fats in comparison to hydrgenated fats can be achieved by maximizing the use of natural fats such as palm stearin. The use of fully hydrogenated fats as the hardstock for IE may give similar adverse effects as those of hydrogenated fats. Sundram *et al*. (2003) studied the effects of an interesterified fat of a fully hydrogenated oil with its native oil in comparison with a hydrogenated fat and palm oil. It appeared from the study that the IE and hydrogenated fats increased the lipoprotein associated CHD risk factors in normocholesterolemic humans compared to natural palm oil-based solid fat.

In terms of food safety, the possibility of having trace metal

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TABLE 1. FATTY ACID COMPOSITION OF COMMERCIAL AND INTERESTERIFIED VANASPATI

	Commercial vanaspati	IE blend SBO:HPOs (40:60)
I.V.	51.4	72.4
Total saturated fatty acids	46.9	42.7
Total unsaturated fatty acids	53.1	57.3
Total monounsaturated fatty acids	48.1	33.8
Total polyunsaturated fatty acids	5.0	23.5
Total *trans* fatty acids	13.5	12.5
Unsaturated/saturated ratio	1.13	1.34
Polyunsaturated/saturated ratio	0.10	0.55

Notes: IE – Interesterification; I.V.= Iodine value.
Source: Kheiri *et al*. (1989).

residues in IE fats, as is the case with hydrogenation, can be totally eliminated.

APPLICATIONS OF INTERESTERIFICATION (IE) FATS

IE was introduced in the 1940s and commercialized in the 1950s (Hamm, 2000). Since then, its applications in food have more or less been established. The major development by IE has been in the improvement of processing technology to higher efficiency through lower utility consumption and minimal oil loss, and as such, is a feasible option to hydrogenation in solid fats production.

Margarine, Shortening and Vanaspati

Palm stearin interesterified with unhdrogenated liquid vegetable oils is an excellent fat for margarines, shortenings and vanaspati. The advantages of using palm stearin not only lies on its low price but also the change length diversity of fatty acids for the formation of β' stable fats (DeMan, 2000). IE, on the other hand, helps stabilize and increase the amounts of β' crystals which are needed for a smooth texture and functional properties. An IE blend of palm stearin and sunflower oil had comparatively more β' crystals than the direct blend of the two (Nor Aini and Noor Lida, 2003). Similarly, the products of IE between palm stearin and palm kernel oil or its fractions have higher solid fat contents at ambient temperature with excellent melting

TABLE 2. SOME INTERESTERIFICATION (IE) FATS FOR MARGARINES, SHORTENINGS AND CONFECTIONERY FAT

IE blends		Fat (%)						
		POs	PKO	PKOo	RSO	CSO	SBO	SMP (°C)
Tub Margarines	1a	40	20	-	40	-	-	29.3
	2a	60	-	40	-	-	-	34.3
Packet Margarines	3a	70	-	30	-	-	-	36.2
	4a	75	25	-	-	-	-	32.5
Table margarine	5a	60	-	20	-	-	20*	38.5
Bakery Shortenings	5b	70	-	-	-	-	30	44.0
	6b	60	-	-	-	40	-	43.5

Note: * Sunflower oil.
Sources: a-Teah *et al.* (1992); b-Noor Lida and Yusof (1995).

TABLE 3. POSSIBLE FAT SPREAD FORMULATIONS USING SIMPLE AND INTERESTERIFICATION (IE) BLENDS OF PALM STEARIN, SUNFLOWER OIL AND PALM KERNEL OIL

Spread type	Simple blend			IE blend		
	POs (%)	SFO (%)	PKOo (%)	POs (%)	SFO (%)	PKOo (%)
Temperate tub spread	16.2 – 22.5	57.5 – 81.2	0 – 22.5	Not suitable		
Tropica tub spread	20.0 – 25.0	32.5 – 60.0	18.8 – 47.5	41.2 – 53.1	35.0 – 51.2	0.0 - 23.8
Block spread	Not suitable			47.5 – 52.5	37.5 – 47.5	0.0 – 15.0

Source: Noor Lida *et al.* (2001).

properties due to the presence of lauric acid. Such products are excellent base fats for both packet and tub margarines. In direct blending, only 10%-15% of palm stearin can be used in the formulation of table margarines. With IE, a much higher level of palm stearin can be incorporated (Teah *et al.,* 1992). Since no hydrogenated fat is involved, the products are free from *trans* fatty acids. Some formulations for margarines and shortenings are given in *Table 2.*

Noor Lida *et al.* (2001) studied the characteristics of tertiary IE blends of palm stearin, sunflower oil and palm kernel olein and found that more palm stearin and palm kernel olein can be incorporated in fat spreads compared to the simple blend of the three oils. The results are summarized in *Table 3*.

TABLE 4. INTERESTERIFICATION (IE) FATS-BASED FORMULATIONS FOR VANASPATI

Fat blend	Fat (%)							
	HPO	POs	RSO	RBO	SBO	CSO	SMP (°C)	Appearance.
1a	-	70	-	-	30	-	37.5	Uniform homogenous granulation, no phase separation.
2b	-	60	-	-	-	40	42.0	-
3a	-	50	-	50	-	-	36.5	Homogenous granulation, relatively soft, no phase separation.
4c	-	80	-	-	20	-	41	Firm consistency, no phase separation.
6a	-	70	30	-	-	-	37.5a	Uniform homogenous granulation, no phase separation.
6a	-	60	-	40	-	-	38.5	Granular mass almost like ghee, no phase separation.
7c	-	#60	-	-	40	-	38.6	Firm consistency, no oil separation.
8c	70-75	-	-	-	25-30	-	-	Firm consistency, no oil separation.
9d	-	60	-	40	-	-	39.0	Uniform homogenous granulation with no phase separation.
10d	-	70	-	30	-	-	39.4	Uniform homogenous granulation with no phase separation.

Note: # hydrogenated palm stearin.
Sources: a- Majumbar and Bhattacharyya (1986); b- Noor Lida and Yusof (1995); c- Kheiri *et al.* (1989); d-Yusof and Teah (undated).

A granular fat product is popular in the Indian Subcontinent and Middle East. It is called vanaspati in the former and popularly known as samna in the latter. Palm stearin can be used as the source of hard stock for IE-based vanapati *Table 4*. Majumbar and Bhattacharyya (1986) prepared vanaspati from IE of palm stearin with selected soft oils and concluded that between 50%-70% of palm stearin can be incorporated in vanaspati formulations. Kheiri *et al*. (1989) conducted a factory scale study on binary blends of soyabean oil and palm stearin to formulate a product comparable to commercial vanaspati products in Pakistan by using IE. It was discovered that at least 70% palm stearin had to be incorporated to produce a vanaspati of firm consistency and without phase separation. A softer product with lower melting point and without phase separation can be produced by interesterifying 60% hydrogenated palm oil with 40% soyabean oil. Yusof and Teah (undated) concluded that the IE blends for vanaspati must have less than 35% saturated fatty acids above which the average melting point of the products would be higher than 37ºC.

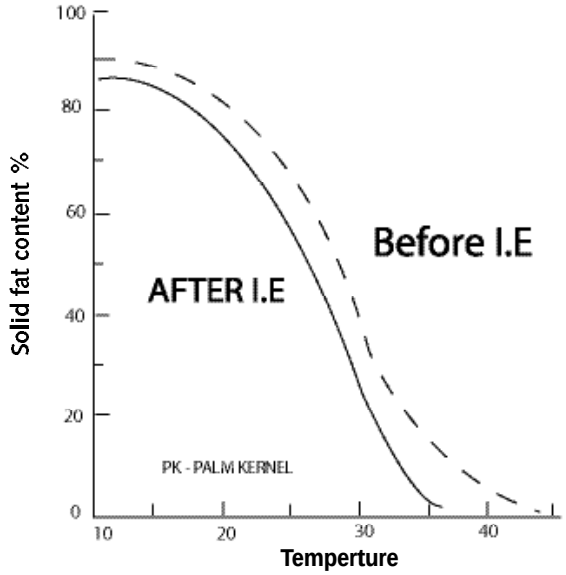
TABLE 5. CONFECTIONARY FATS FROM A BLEND OF HPKO AND IEHPKO

Fat	M.P. (°C)	SFI (%) 10	20	35	38
HPKOo	46.8	74.2	67.0	15.4	11.7
IEHPKO	35.0	65.0	49.9	1.4	1.1
50% HPKO	41.7	70.0	57.4	8.7	5.2
50% IEHPKO	-	-	-	-	-
65% HPKO	44.2	71.0	59.7	10.2	6.7
35% IEHPKO	-	-	-	-	-
80% HPKO	46.0	72.4	62.6	12.4	8.5
20% IEHPKO					

Source: Sreeniseevan (1976).

Specialty Fats

Most cocoa butter substitutes (CBSs) are made from lauric oils, mainly coconut and palm kernel oils. The earlier ones were made from the former while the latter is widely used nowadays. These oils are modified by hydrogenation or fractionation. Solvent fractionation is used in the production of high quality CBS but this process is expensive (Goh, 1994) and the coproduct has lower value than the premium product. The crystals of the fractionated product are not stable leading to fat bloom. Though using IE can solve some of these problems, fractionation is still preferred because the resultant product has a steeper melting profile resembling that of cocoa butter (Nielsen, 2000). A series of CBS can be produced by interesterifying PKO, PKOo on their own or in blends with palm stearin, followed by hydrogenation *(Table 5*). Interesterifying palm kernel oil will improve its melting properties (*Figure 1*).



Source: Goh (1994).

Figure1. Solid fat contents of fully hydrogenated palm kernel oil, before and after interesterification (IE).

Other specialty fats for applications such as coffee whitener, spray fats, *etc*. can also be made by interestrifying palm and palm kernel oil products. For instance, by interesterifying hydrogenated palm kernel oil, the melting point can be reduced from 46ºC, which causes a waxy feel in the mouth, to 35ºC. By blending them together (hydrogenated palm kernel oil and its interesterified product), a whole series of confectionery fats with highly desirable melting (rapid melt in mouth) qualities are obtained (Sreeniseevan, 1976).

Satisfactorily quality of confectionery fats can be produced by combining IE and hydrogenation. Noor Lida and Yusof (1995) prepared confectionery fats for cream filling biscuits by interesterifying palm stearin and palm kernel oil products (*Table 6*).

In the production of CBE, a product with similar chemical and

physical properties with those of cocoa butter, the use of chemical IE is not feasible. Instead, enzymatic IE can be used to produce IE fats of specific triglycerides. Enzymatic IE fats are already in commercial production. In 1993, Loders Croklaan built an enzymatic IE plant in Holland for the production of confectionery fats (Quilan and Moore, 1993). The company was also reported to have patented a process to produce human milkfat substitute from palm stearin using enzymatic interesterification (Yang and Xu, 2001).

TABLE 6. CONFECTIONERY FATS BY INTERESTERIFICATION

Blend No.	Fat (%)			
	POs	PKO	PKOo	SMP (°C)
1	25	-	75	32.6
2	30	-	70	34.5
3	25	37.5	37.5	35.9

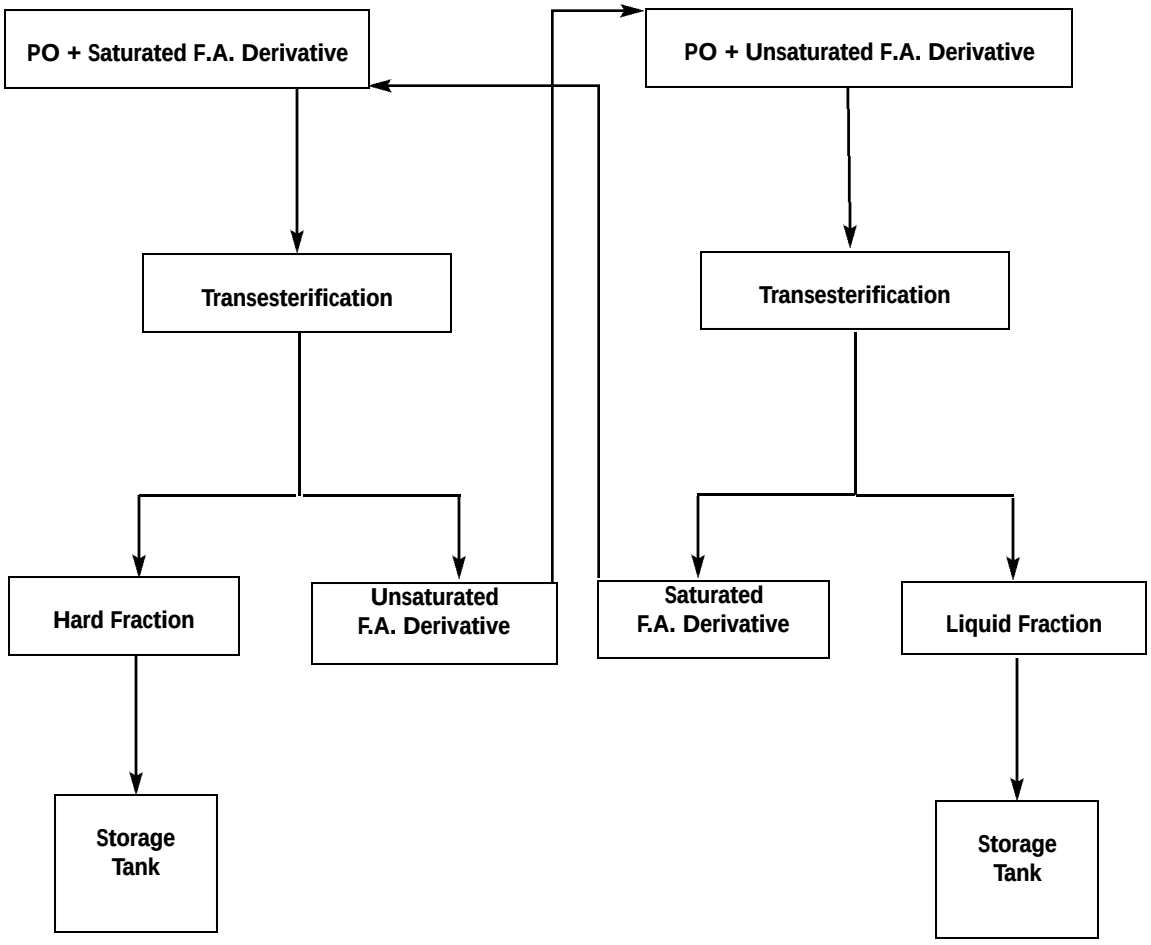
Source: Noor Lida and Yusof (1995).

Production of Imitation Olive Oil

Koslowsky (1974) described the production of imitation olive oil by transesterification and chemical fractionation. The process is illustrated in *Figure 2*.

In the process, a fatty acid derivative is used as the carrier of the saturated and unsaturated radicals. The fatty acid derivative is separated and regenerated from the mixture by physical methods. Palm oil and the fatty acid derivative are mixed and homogenized. Then, transesterification of the oil takes place at 60°C for not more than 30 min. The palm oil is then separated into liquid and solid fractions by chemical fractionation. The solid fraction has an I.V. of 5 and melting point of 62°C-63°C. It contains over 90% palmitic acid. The solid fraction is an excellent raw material for the oleochemicals industry. It can also be used in margarine and shortening.

The liquid fraction has an I.V. of 80. The fatty acid composition of the liquid fraction is given in *Table 7*. The fatty acid composition of the



Source: Koslowsky (1974).

Figure 2. Fractionating palm oil by transesterification.

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liquid fraction is quite identical with olive oil. It can be used as salad oil as well as suitable as for deep frying.

Other Uses

Interesterification can also be used to produce a waxy translucent for coating purposes. The product can be made by reacting triacetin with a hard fat such as palm stearin or hydrogenated fat. These will produce mono- and diacetin.

CONCLUSION

IE is an alternative process to hydrogenation in the production of plastic fat products such as margarine, shortening and even vanaspati. With the advance in technology, the major problem in IE, *i.e.*, high process loss, can be overcome. Furthermore, cheap raw materials such as stearin can be optimized in fat product formulations, which in turn, should be able to offset the loss during processing. The use of enzymatic IE is still limited to the production of high value products because of the high cost involved but more developments can be expected from this process as it is much more flexible in modifying oils and fats and environmentally friendly as well.

TABLE 7. THE FATTY ACID COMPOSITION OF PALM OIL AND ITS FRACTIONS AFTER FRACTIONATING BY TRANSESTERIFICATION

Fatty acid	Palm oil	Solid fraction	Liquid fraction	Olive oil
C14:0	1.2	1.2	Trace	Trace
C16:0	44.8	91.3	12.7	7-16
C18:0	2.6	2.3	6.4	1-3
C18:1	40.7	4.4	66.2	65-85
C18:2	10.7	0.8	13.7	4-15
I.V.	53	5.1	80	77-94

Source: Koslowsky (1974).

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