Journal of Oil Palm Research Vol. 11 No. 1, June 1999, p. l-10

PHYSICAL AND CHEMICAL PROPERTIES OF SHORTENINGS FROM PALM OIL:TALLOW AND PALM OLEIN:TALLOW BLENDS WITH AND WITHOUT INTERESTERIFICATION

Keywords: Baking performance, creaming, interesterification. shortening, palm oil, palm olein, tallow.

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Palm oil and palm olein were blended with tallow at levels of 80%, 70% and 60%. Part of the blends was interesterified. Blends and interesterified blends were processed into shortenings. These shortenings and a commercial shortening as control were evaluated for their solid fat content (SFC) and slip melting points (SMP), fatty acid (FA) and triglycerides (TG) composition, and creaming and baking properties. The slip melting points of the interesterified shortenings for palm oil:tallow and palm olein:tallow blends were higher than those of non-interesterified, but lower than the commercial shortening. The two most abundant fatty acids present in both blends were palmitic and stearic. The shortenings were rich in C_{52} and C_{50} glycerides. Interesterification process increased the solid fat content of the blends, except in 60:40 palm olein:tallow. Creaming power after 12 minutes of beating improved in the interesterified palm olein:tallow blends. However, creaming properties of the interesterified palm oil:tallow blends were poorest among the shortenings. Baking performance of non-interesterifced palm oilfallow blends was better than interesterified group.

INTRODUCTION

Shortenings are products made entirely of oil and fat either straight or in mixture of the two for the preparation of food items. They are used for cooking, frying and as an ingredient in food products such as cakes, cookies, pastries, breads and others. It acts as carriers for fat soluble vitamins and provides essential fatty acids thus improving the quality and palatability of food products. In baked food, its role is in incorporating and entrapping air during mixing, enhancing the structure, providing a moisture barrier and extending the shelf life of the products (Greethhead, 1969; Cochran and Baeuerlen, 1981). The type and quantity of shortening in a food product affects both the dough and finished quality of baked products (Matz and Mats, 1978).

Blending and interesterification are the most commonly known practical processes applied to oils and fats in the production of shortenings (Gander, 1976).

The objective of this study was to evaluate shortenings made from palm oil:tallow and palm olein:tallow blends which are then subjected to interesterification and non-interesterification prior to production of shortenings. Evaluations were made on their physico-chemical characteristics and performance in cream and pound cakes.

MATERIALS AND METHODS

Commercial standard shortening (CSS) used in this experiment was imported from Mexico. The experimental shortenings consisted of in-house shortenings made from blended palm oil:tallow and palm olein:tallow. The palm oil and olein used were bought from a local refinery, and food grade tallow was imported. Melted palm oil, palm olein and tallow were blended at three different ratios on a w/w basis. The ratios of palm oil:tallow and palm olein: tallow used were 80:20, 70:30 and 60:40. For each blend, 120kg of oil were prepared and divided into two portions of 60kg each. They were kept in plastic containers and later stored in a cold room (<10°C) prior to production of the shortening. Half the blend was subjected to interesterification.

Interesterification

A reactor at PORIM's refinery pilot plant was used for interesterification of the blended palm olein and tallow. Sixty kilogrammes of blended oil were subjected to interesterification under the following conditions: temperature 110°C, catalyst 0.2% sodium methoxide, reaction time 30 minutes and maximum stirrer speed of 500rpm. The interesterified blends were then filtered, refined, bleached and deodorized at PORIM's pilot plant.

Production of Shortening

The blended oils were melted to a temperature 10°C above their slip melting points (SMP) and processed in a margarine and shortening pilot plant. The equipment used was a Schroeder Kombinator type WK B 01/60-400 (Lubeck, FRG). The blends were run at the standard pump speed of 250rpm and standard back pressure of 2.5kg cm^{-2}, and the refrigeration adjusted to obtain a standard filling temperature of 20° C. The shortenings were stored in temperature controlled cabinets at 20°C over a period of 60 days during which evaluations were conducted.

Slip Melting Point

The SMP was determined in triplicate according to AOCS method Cc 3-25 (Firestone, 1987).

Solid Fats Content

A Newport Analyser MK III wideline nuclear magnetic resonance (NMR) (Newport Pagnell, England) with temperature controller was used. The PORIM method was adopted in which the sample in the NMR tube was first melted at 70°C for 30 min, chilled at 0°C for 90 min and then held at each measuring temperature for 30 min prior to measurement (IUPAC, 19791. The PORIM method is similar to IUPAC method 2.150 (Timms, 19781, except that in the later method, the sample is melted at 80°C, transferred to a 60°C water bath for five minutes and then chilled at 0°C for 60 minutes.

Fatty Acid Composition

The fatty acid composition was analysed as content of methyl esters which were prepared according to Timms (Tan, 1990). Analysis was conducted on a glass column (1.8m x 3mm i.d.) of 10% SP 2330 on 100-120 Supelcoport (Supelco, Bellefonte, PA) at 200°C with a nitrogen flow of 40cm^3 min^{-1} in Perkin Elmer Sigma 100 gas cbromatograph (Norfolk, CT). The injector and detector temperature was set at 220°C. Analysis was conducted under isothermal conditions with a run time of 20 minutes.

Triglyceride Composition

The triglyceride composition was analysed in duplicate according to carbon number with a glass column (46cm x 3mm i.d.) in a Pye 104 gas cbromatograph (Pye Unicam, Cambridge, U.K.). The stationary phase was 1% Dexil 300 on 100-120 mesh Supelcoport (Supelco). The operating conditions for analysis were: injector and detector temperature 370°C; column temperature programmed to rise from 280°C to 345°C at 4°C min^{-1}; and carrier gas of N_2 with a flow of 80 ml min^{-1} (Nor Aini et al., 1989).

Creaming Test

The shortenings were evaluated for their creaming ability in duplicate according to the procedure described by Nor Aini et al. (1989).

Baking Test

The performances of the experimental shortenings were compared to CSS imported from Mexico. Samples were evaluated in triplicate using the shortenings in pound cake (*Table 1*). The volume of a cake was determined with rapeseed displacement method (Griswold, 1962). The volume was divided by its weight and the result reported as specific cake volume in cm^3 g'.

Shortening and sugar were mixed in a Hobart mixer model N50 (Hobart Manufacturing Co., London, UK) at speed for three minutes. After each minute of mixing, the mixer was stopped to scrape the bowl. Vanilla flavour was added to the beaten egg yolk and white, and added to the mixture. Further mixing was continued for 2 min. After each minute, the mixer was stopped to scrape of the bowl. The flour with baking soda was added and mixing carried out at speed 1 for 30 sec. After scraping the bowl, mixing was continued for further 2 min at speed 3, scraping the bowl again after each minute. The finished batter was placed into three baking containers, 154mm i.d., lined with grease proof paper. Each container held 375g batter. The batter was baked at 180°C in a Rotary Simon oven for lhr 15 min. When the cakes had cooled, their weights and volumes were measured. The specific volumes of the cake (cm^3 g^{-1}) was then calculated. The performances of the experimental shortenings were compared with that of a commercial standard shortenings. The standard cakes were always prepared using the same ingredients and CSS, and baked at the same time as the experimental cakes.

TABLE 1. FORMULA OF POUND CAKE

Ingredient weight	(g)
Flour	415
Shortening	350
Sugar	350
Egg yolk and white	350
Baking powder	3
Flavouring (vanilla)	1 ml

RESULTS AND DISCUSSION

Physico-chemical Characteristics

The physico-chemical characteristics of the experimental and control shortenings are presented in ***Tables 2*** and 3, respectively for the palm olein:tallow and palm oil:tallow blends. The SMP of the experimenal shortenings were lower than the 43.8°C of the control. Interesterification increased the SMP of the experimental shortenings. The palm olein:tallow blends experienced the biggest changes in SMP from the interesterification. The highest of palm olein to tallow blend (80:20) registered a 11.8°C or 43% increase in its SMP to 39.5°C. At the lowest palm olein blend (60:40), the increase in SMP was smallest at 1.6°C or 5%. In the palm oil:tallow blends, the 70:30 blend increased 5.2°C or 15% in its SMP from 35.9°C

TABLE 2. PHYSICAL AND CHEMICAL. CHARACTERISTICS OF SHORTENINGS FROM INTERESTERIFIED (IE) AND NON-INTERESTERIFIED (NIE) BLENDS OF PALM OLEIN AND TALLOW

Sample	IE80:20	NIE80:20	IE70:30	NIE70:30	IE60:40	NIE60:40	Control
Slip melting point (°C):							
	39.5	21.7	39.7	33.8	35.5	33.9	43.8
Fattyacids composition (wt%):							
12:o	0.2	0.2	0.3	0.2	0.2	0.2	0.2
14:0	1.3	1.3	1.5	1.5	1.6	1.6	3.4
16:0	37.9	36.3	34.3	34.5	33.2	32.8	26.0
16:1	0.9	1.1	0.9	0.9	1.2	1.2	2.0
18:0	6.4	6.9	8.2	8.2	9.5	9.4	19.8
18:1	44.8	43.7	43.0	43.0	43.1	43.3	37.9
18:2	7.7	9.6	9.5	9.1	8.4	8.7	7.1
18:3	0.1	0.1	0.1	0.1	0.3	0.3	0.6
20:o			0.2	0.3	0.3	0.4	0.3
Triglyceride composition (wt%) by carbon number:							
46	1.5	0.6	1.9	0.9	1.0	1.0	1.9
47	0.2	0.1	1.1	0.5			0.9
48	9.5	3.6	9.1	4.6	5.6	5.0	9.1
49	1.5	0.7	2.7	1.7			2.6
50	30.2	38.1	27.6	35.4	32.9	33.6	20.6
51	2.1	1.0	3.8	2.3			4.6
52	38.2	43.1	36.0	41.9	44.5	45.7	36.4
53	0.9	0.4	2.2	0.5			3.5
54	15.4	11.8	15.5	11.9	15.0	14.0	19.9
55							
56	0.3	0.4	0.3	0.4	0.5	0.5	

to 41.1°C. Interesterification increased the SMPs of all the experimental shortenings. In the palm oil:tallow blends, the increase in SMP ranges from 41°C to 42°C, and 36°C to 40°C in the palm olein:tallow blends. Berger (1985) suggested that a SMP of around 40°C as optimum for cake shortening.

Oleic acid and palmitic acid were the most abundant fatty acids in the experimental shortenings. The percentage of oleic acid varied from 40.6% to 44.8% among the groups, and 32.8% to 40.5% for palmitic acid. Stearic and linoliec acids were present at 6.3%-9.5% and 6.8%-9.6%, respectively in the two groups. However, the stearic acid content was highest in the control shortening at 19.8%. The higher amount of stearic acid in control shortening may have resulted from a hydrogenated oil or tallow. It is a standard practice to use a hydrogenated oil/fat for production of shortening in a country like Mexico.

The four highest triglycerides (TG) in the experimental shortenings present were C_{52} < C_{50} < C_{54} < C,. In the control shortening, C_{50} was only 1% higher than the C_{54}. The C_{52} and C_{50} glycerides were the most - 34.9% and 20.1 %, respectively. Interesterification increased the C_{48} and C_{54} triglycerides in the shortenings. The interesterified palm olein:tallow 80:20 and 70:30 blends showed the highest changes in the C_{48} glycerides, at 164% and 98%, respectively. Interesterification also increased the C_{48} triglycerides in the palm oil:tallow blends by 44%, 55% and 17% for the 80:20, 70:30 and

TABLE 3. PHYSICAL AND CHEMICAL CHARACTERISTICS OF SHORTENINGS FROM INTERESTERIFIED (IE) AND NON-INTERESTERIFIED (NIE) BLENDS OF PALM OIL AND TALLOW

Sample	IE80:20	NIE80:20	IE70:30	NIE70:30	IE60:40	NIE60:40	Control
Slip melting point (°C):							
	40.7	36.5	41.1	35.9	41.8	40.0	43.8
'Fattv acids comoosition (wt%):							
'12:o	0.3	0.3	0.2	0.2	0.2	0.3	0.2
14:o	1.3	1.3	1.5	1.5	1.6	1.6	3.4
16:0	40.1	40.5	37.6	38.2	36.4	35.8	26.0
16:1	1.1	1.1	1.5	1.2	1.2	1.3	2.0
18:0	6.4	6.3	7.6	7.6	9.4	9.5	19.8
18:1	42.4	42.1	43.4	42.9	40.6	41.6	37.9
18:2	7.3	7.3	6.8	6.9	7.8	7.9	7.1
18:3	0.1	0.1	0.1	0.1	0.3	0.3	0.6
20:0	0.1	0.1		0.1	0.3	0.3	0.3
Triglyceride composition (wt%) by carbon number:							
46	1.8	1.1	1.8	1.1	1.7	1.2	1.9
47	0.4	0.8	0.5	0.8			0.9
48	10.1	7.0	9.6	6.2	10.2	8.7	9.1
49	1.8	1.8	0.8	2.0			2.6
50	30.5	34.8	30.4	32.6	32	34.5	20.6
51	2.5	2.5	1.7	3.0			4.6
52	36.6	39.0	37.9	39.7	36.9	41.8	36.4
53	1.4	1.6	0.4	2.1			3.5
54	14.6	11.0	16.6	12.0	16.2	12.9	19.9
55							
56	0.3	0.4	0.3	0.4	0.5	0.5	

60:40 blends, respectively. The C_{54} triglyceride was the second most affected by interesterification. It increased by 7% and 31% in the palm olein:tallow (60:40 and 80:20) group. The changes were higher in the palm oil:tallow group. C_{54} increased by 26%, 38% and 33% in the 60:40, 70:30 and 80:20 blends, respectively. deMan and deMan (1993) cited that the high melting triglycerides (HMG) C_{48} and C_{54} are beta tending and less favourable for producing good shortening. As such, C_{54} should not be present at more than 20% of the total triglycerides in shortenings or margarines. None of the blended shortenings in this trial contained C_{54} glyceride higher than 16.6%, which is much less than the recommended rate of 20%.

Interesterification reduces the amount of C_{50} and C_{52} glycerides. Reduction in C_{50} and C_{52} in the palm olein:tallow blends of 80:20, 70:30, 60:40 were 21%, 22%, 2% and 11%, 14%, 3%, respectively. Smaller reductions of 12%, 5%. 7% and 6%, 5%, 7% occurred in the 80:20, 70:30, 60:40, for the palm oil tallow blend, respectively.

At the higher ratios of palm olein 80:20 and 70:30, interesterification increased the C_{48} and C_{54} triglycerides above the amount recommended by deMan and deMan (1993). However, these two triglycerides increased to a level that was recommended.

The SFC of the experimental and control shortenings for palm olein:tallow and palm oil:tallow blends are presented in Figures *1* and

2, respectively. The SFC of the control shortening was higher than those of the experimental shortenings. Interesterification was very effective in increasing the SFC of the blended shortenings. The SFC profiles of the interesterified 60:40 palm oil:tallow and 70:30 palm olein:tallow blends were very close to that of the control.

At 5°C, interesterification increased the SFC of palm olein:tallow by 57% and 62% in the 80:20 and 70:30 blends, respectively. There was no effect on SFC in the 60:40 blend. At 20°C, the SFC of interesterified palm olein: tallow blends increased from 8% to 27%, 15% to 31% and 14% to 16%, in the 80:20, 70:30 and 60:40 blends, respectively. The SFC of the control shortening at 20°C was 40%. Interesterification enhanced the SFC of the palm olein:tallow blends, especially 80:20 and 70:30.

At 5°C and 10°C, the SFC of experimental shortening of interesterified 60:40 was highest among the palm oil tallow group. However, its SFC at 15°C to 40°C were lower than those of the CSS, but higher than those of the rest of the experimental shortenings. The SFCs of the interesterified shortenings were closer to that of the CSS commercial. The order of closeness to the CSS curve was I60:40, I70:30 and I80:20. The SFCs of the non- interesterified shortenings were much lower than those of the CSS and interesterified shortenings.

Creaming Performance

The creaming performance of the experimental shortenings and CSS are presented in Figures 3 and 4, respectively, for the palm olein:tallow and palm oil:tallow blends. The data clearly showed that the creaming property of the experimental shortenings to be superior to that of control. Total amount of palmitic acid present in the experimental shortenings was higher than the control. The palmitic acid crystals in beta prime form are smaller in size, very stable and evenly distributed and a significant contributing factor to the improvement in creaming property. As such, the shortenings can entrap and retain air more strongly. Nor Aini et al. (1992) found similar results in that shortenings with 37.6% to 40.0% palmitic acid from palm and cottonseed oils had a similar stability with good creaming performance. Interesterification imparts greater improvement in creaming power to the palm oil:tallow blends especially in 80:20.

In palm oil:tallow blends, the non-interesterified group showed the best creaming power overtheinteresteritiedgroup. Interesterification was not beneficial to the palm oil:tallow blends in creaming property. Creaming performances in order of good to bad among the groups were, non-interesteritied (NIE) 60:40<NIE80:20 <NIE70:30 < interesterified (IE) 80:20<IE70:30 <IE60:40 < control.

With interesterification, the C_{48} and C_{54} triglycerides increased (*Tables* 2 and *3*), which, in turn, affected the triglycerides composition and consequently, the crystal structure of the shortenings. This finding is in agreement with earlier reports (Wiedermann, 1987; Meara *et* al., 1974; Brooker, 1993). The data from this study clearly demonstrated that palm oil and tallow complement each other and performed the best at a blend of 60:40 for creaming property.

Baking Performance

Data on the specific cake volume (SCV) of the experimental and control pound cakes are presented in *Tables* 4 and 5. Experimental shortenings from interesteritied and non-interesteritied palm olein:tallow blends produced better pound cake SCV than the non-interesterified 80:20. The SCV of the experimental shortenings were 2.39cm^3 g^{-1}, 2.38cm^3 g', 2.49cm^3 g^{-1}, us 1.94cm^3 g^{-1}, 2.33cm^3 g^{-1}, 2.46cm^3 g^{-1} from interesterified (IE) 80:20, IE70:30, IE60:40 us. 80:20, 70:30, 60:40 and control 2.3cm^3 g^{-1}, respectively.

The data showed improved SCV from the interesterified shortenings from palm olein:tallow. Their performances in this group were slightly better than the non-interesterified shortenings. All were superior to the control except that non-interesterified 80:20 at 1.94 cm^3 g^{-1}, was poorer to the control by a narrow diference of 0.06cm^3 g^{-1}.

Reducing the palm oil and increasing the tallow contents improve the SCV in both

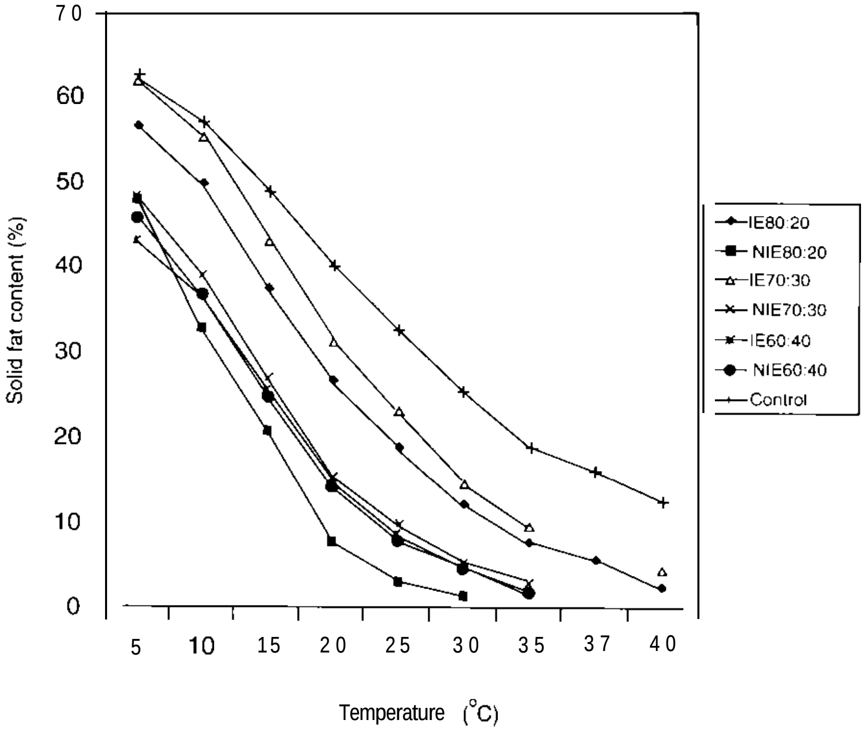

Figure 1. Solid fat content of shortening based on palm olein and tallow blends with and without interesterification.

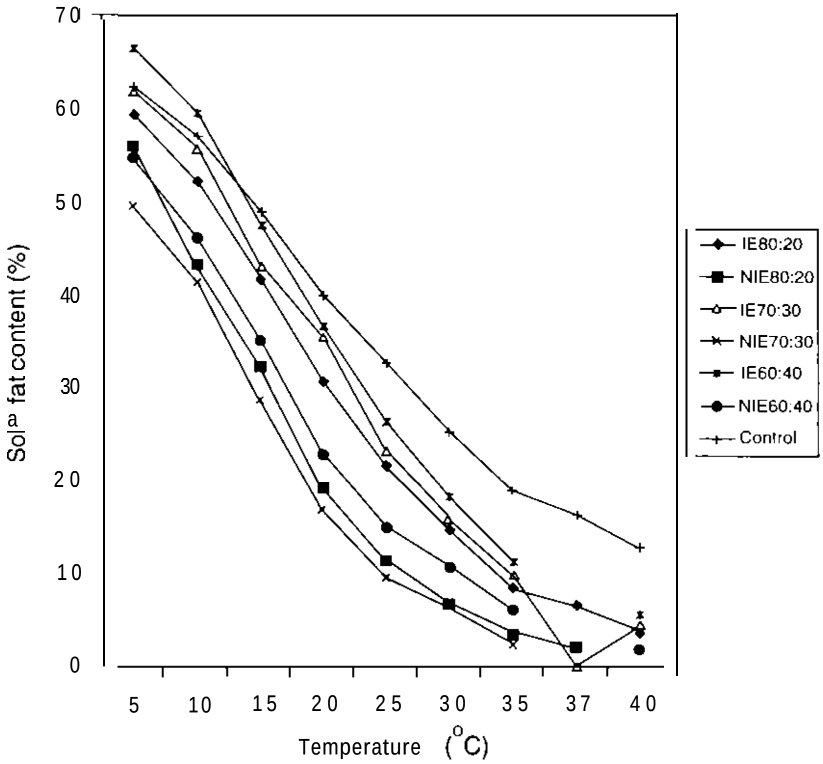

Figure 2. ***Solid fat content of shortening based on palm oil and tallow blends with and without interesterification.***

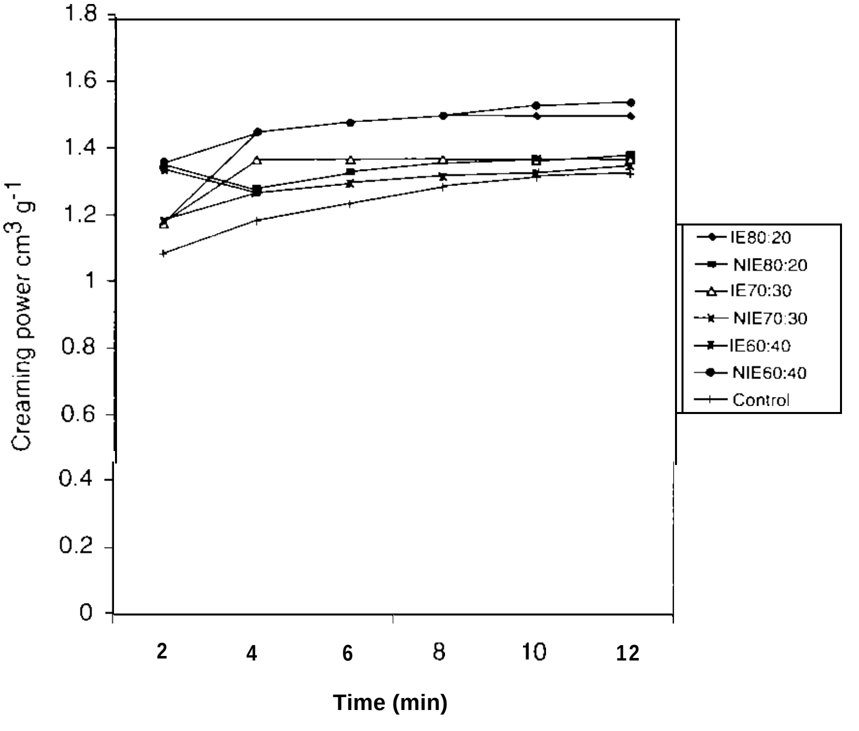

Figure 3. *Creaming power of shortenings based on palm oil and tallow blends with and without interesterification.*

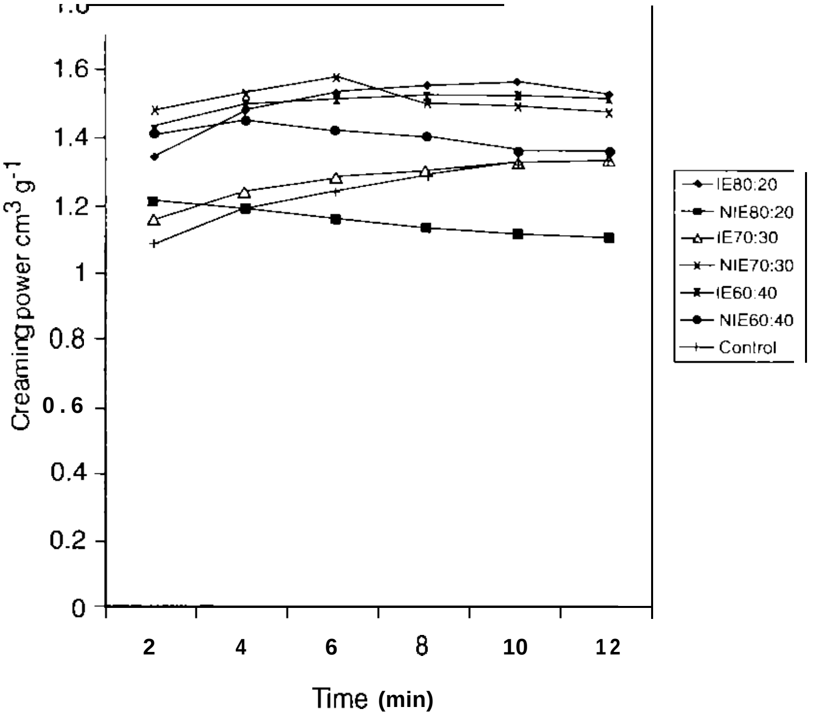

Figure 4. Creaming power of shortenings based on palm olein and tallow blends with and without interesterifiation.

TABLE 4. SHORTENING BAKING TEST FOR INTERESTERIFIED AND NON-INTERESTERIFIED BLENDS OF PALM OLEIN AND TALLOW

	Specific cake volume ($cm^3 g^{-1}$)	
Sample	Interesterified	Non-interesterified
80:20	2.39	1.94
70:30	2.38	2.33
60:40	2.49	2.46
Control		2.30

TABLE 5. SHORTENING BAKING TEST FOR INTERESTERIFIED AND NON-INTERESTERIFIED BLENDS OF PALM OIL AND TALLOW

	Specific cake volume ($cm^3 g^{-1}$)	
Sample	Interesterified	Non-interesterified
80:20	2.15	2.33
70:30	2.29	2.41
60:40	2.39	2.50
Control		2.41

interesterified and non-interesteritied shortenings (*Table* 5). This suggested that tallow is very effective in complementing palm oil in the production of shortenings. The non-interesterified 60:40 palm oil:tallow shortening produced the highest pound cake SCV of 2.50 $cm^3 g^{-1}$. At higher proportions of palm oil to tallow, 70:30 and 80:20, the pound cake SCVs were similar and lower than the control, respectively at 2.41 $cm^3 g^{-1}$ and 2.33 $cm^3 g^{-1}$ *vs* 2.41 $cm^3 g^{-1}$. Interesterified shortenings resulted in lower SCVs, 2.39 cm^3 g', 2.29 $cm^3 g^{-1}$ and 2.15 $cm^3 g^{-1}$ in the 60:40, 70:30 and 80:20 blends, respectively. The poor SCV performance of the interesterified group can be attributed to the effect of interesterification which greatly reduced the C_{50} and C_{52} and increased the C_{48} and C_{54} triglycerides. Increased C_{48} and C_{54} triglycerides also increased the beta crystals and reduced the beta prime crystals in the shortenings. Beta prime crystals are smaller than beta crystals and more stable. The crystals are evenly and well spread in the batter and during the baking, they produce a cake with evenly distributed air pockets, thus imparting greater volume to the baked cakes (Brooker, 19931.

CONCLUSION

Interesterification is found to be an effective tool to increase the SMP and SFC of palm olein:tallow and palm oil:tallow blends. Interesterification reduces the C_{52} and C_{50} and increases the C_{48} and C_{54} glycerides. The functional benefit of interesterification is best observed in the palm olein:tallow shortenings. There is no improvement in the shortenings made from palm oil:tallow blends as demonstrated by the SCVs of pound cakes.

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