A basket of new oil compositions from palm oil products via enzymatic process

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Outline

Products	Introduction	Results & discussion	Conclusion
Palm-based margarine with n-3 FA	√	√	√
Structural modification of palm stearin	√	√	√

Production of Palm-based Margarine Containing Omega-3 Fatty Acids by Enzymatic Interesterification

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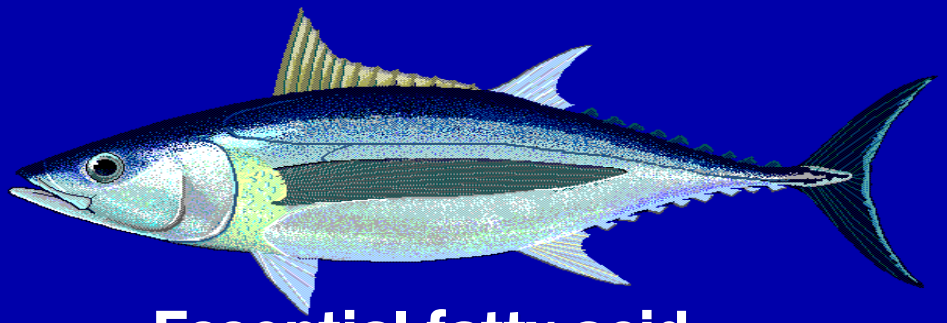
Objectives

- To produce palm-based margarine enriched with omega-3 fatty acids
- To study the effect of adding fish oil on the blends and enzymatic products

Omega-3 fatty acids: EPA & DHA

Eicosapentaenoic acid

Docosahexaenoic acid



Essential fatty acid

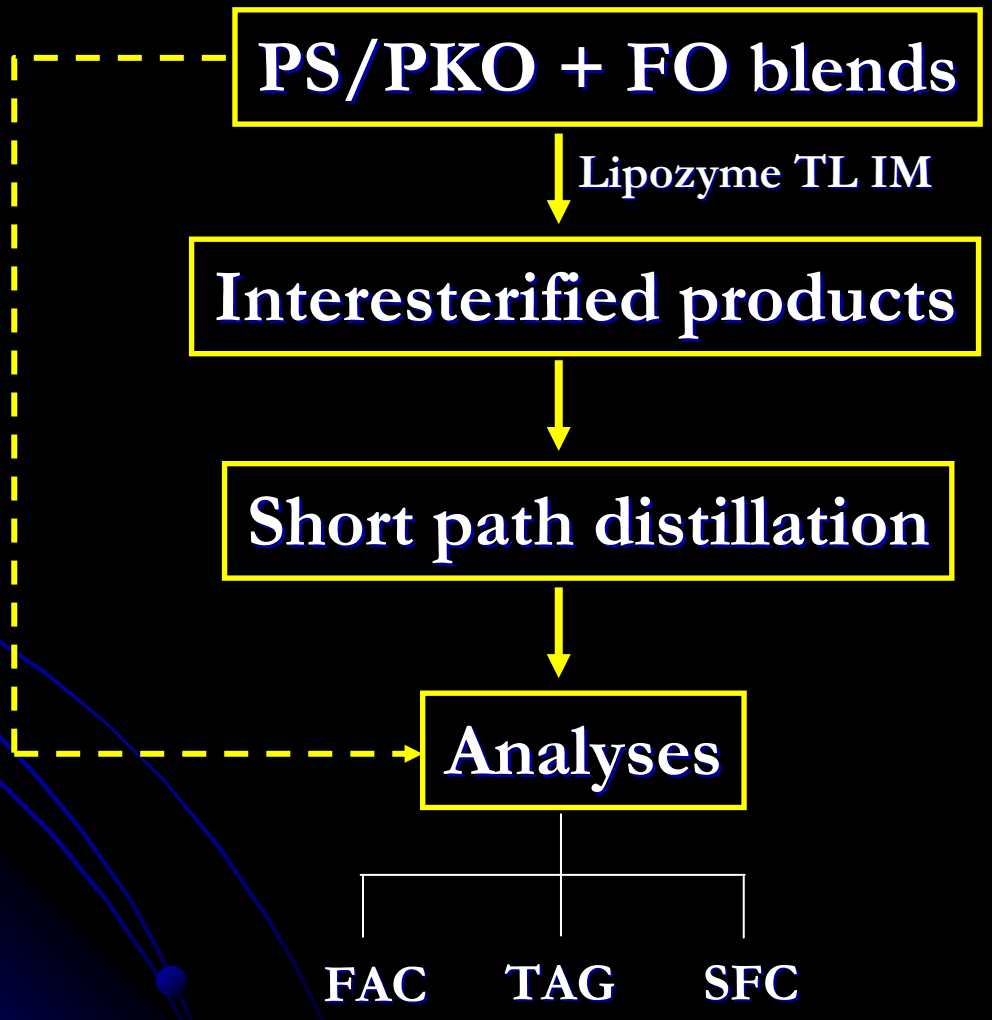
Major source: Fish oil

Omega-3 fatty acids (EPA & DHA)

Potential health effects:

- Reduction of cardiovascular disease risk,
  - Harris W. S (1989), *J. Lipid Res,* 30, p 785-807.
- Anti-inflammatory effects including reduction of symptoms of rheumatoid arthritis
  - Kremer J. M et al. (1995), *Arthritis Rheum,* 38, p 1107-1114.

Experimental approach



Results and discussion

Fatty Acid Composition (%)

	C12	C14	C16	C18	C18:1	C18:2	n-3
PS	0.3	1.0	57.9	5.1	27.9	6.7	0.0
PKO	48.8	15.8	7.9	2.0	14.4	2.6	0.0
FO	0.0	3.0	13.7	7.1	26.2	3.9	28.0
+10% FO PS/PKO 50/50	22.9	8.0	28.1	4.0	19.9	4.8	3.3
PS/PKO 60/40	18.4	6.7	32.5	4.3	21.3	5.0	3.3
PS/PKO 70/30	14.7	5.6	35.8	4.8	21.6	5.2	3.2

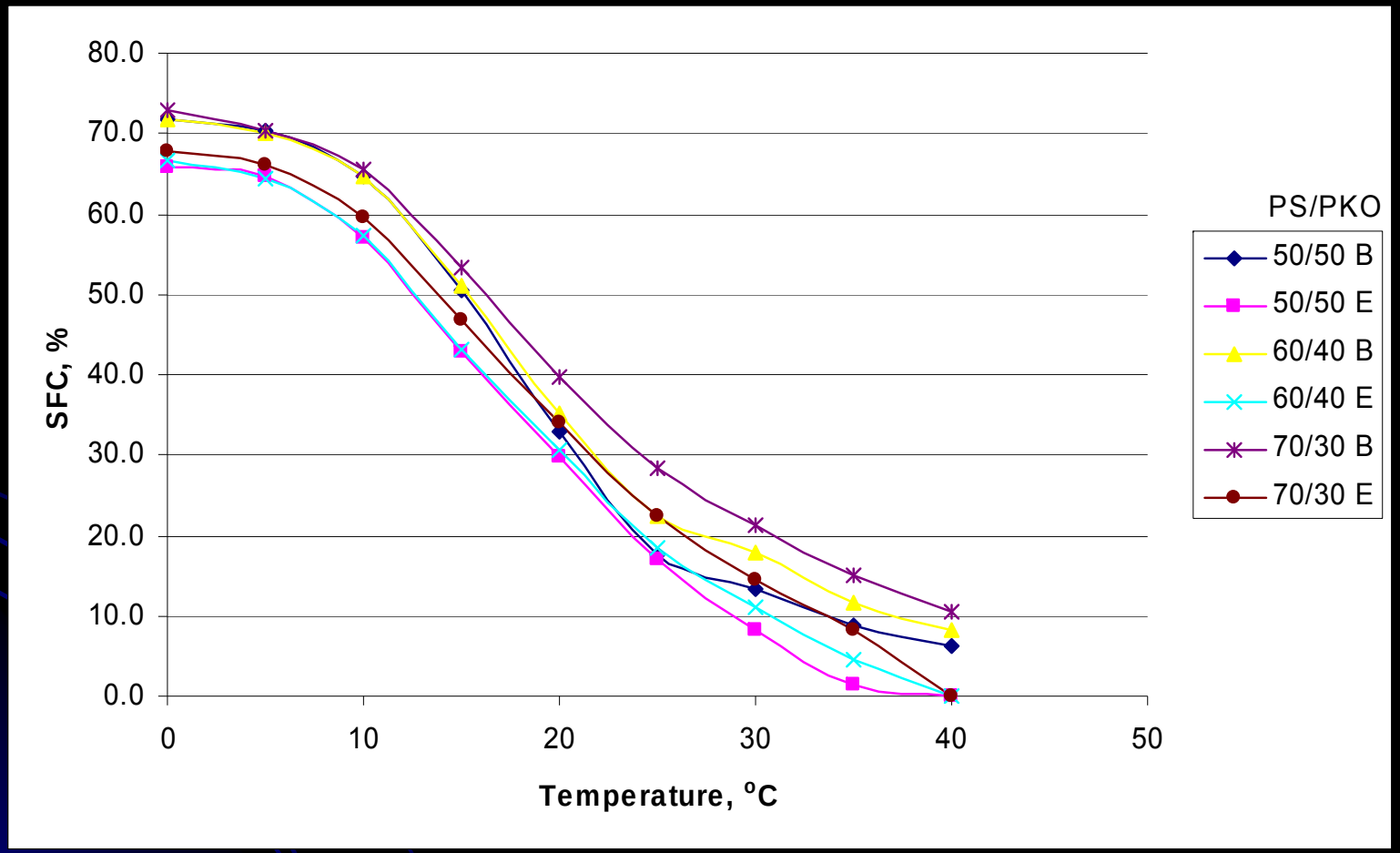
Only major FAC

Lab-scale: Batch EIE (continue)

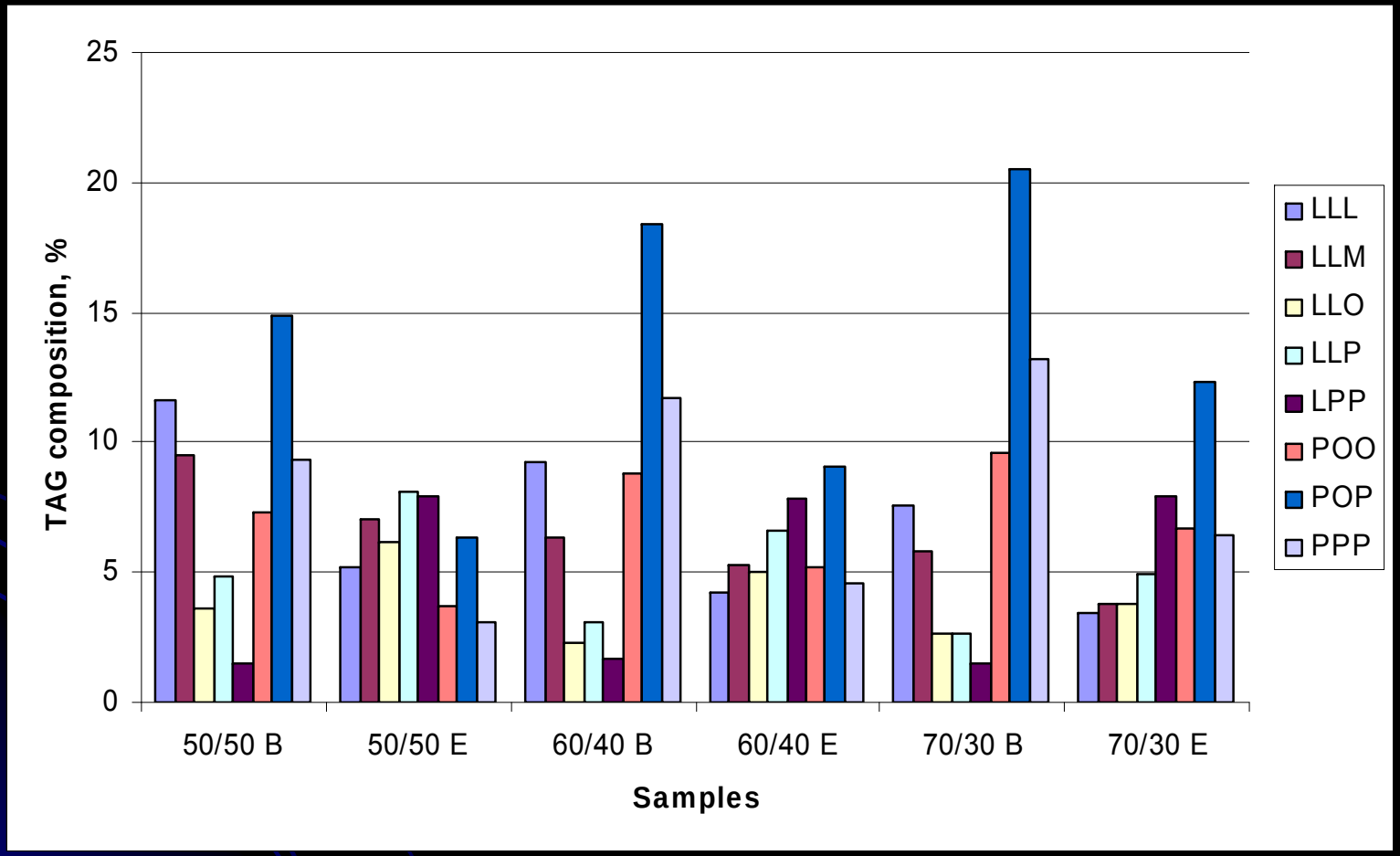
FO: 10%	Temp	SFC, % 0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	Crystal form
50/50											
PS/PKO B		78.3	76.7	72.2	57.4	39.2	19.8	14.8	10.3	6.4	β'+β
PS/PKO E		74.5	72.9	66.1	49.8	34.4	18.9	9.2	1.7	0.0	β'
+ FO B		71.8	70.4	64.6	50.4	32.9	17.6	13.4	8.9	6.1	β'+β
+ FO E		65.9	64.6	56.9	42.7	29.8	16.9	8.3	1.5	0.0	β'
60/40											
PS/PKO B		79.0	77.7	72.1	58.8	41.0	25.3	19.9	14.0	9.0	β'+β
PS/PKO E		74.5	72.3	65.5	51.3	36.6	22.5	13.7	6.0	0.0	β'
+ FO B		71.9	70.0	64.8	51.2	35.3	22.5	17.8	11.7	8.3	β'+β
+ FO E		66.6	64.4	57.3	43.2	30.5	18.3	11.1	4.6	0.0	β'
70/30											
PS/PKO B		79.8	78.4	72.5	60.4	45.2	31.8	24.3	17.6	10.9	β'+β
PS/PKO E		74.8	73.7	68.3	56.3	42.2	28.8	19.4	11.7	1.9	β'+β
+ FO B		72.8	70.3	65.5	53.3	39.8	28.3	21.3	15.0	10.5	β'+β
+ FO E		67.8	66.0	59.6	46.8	34.1	22.4	14.6	8.1	0.0	β'+β

B: Blend; E: EIE product

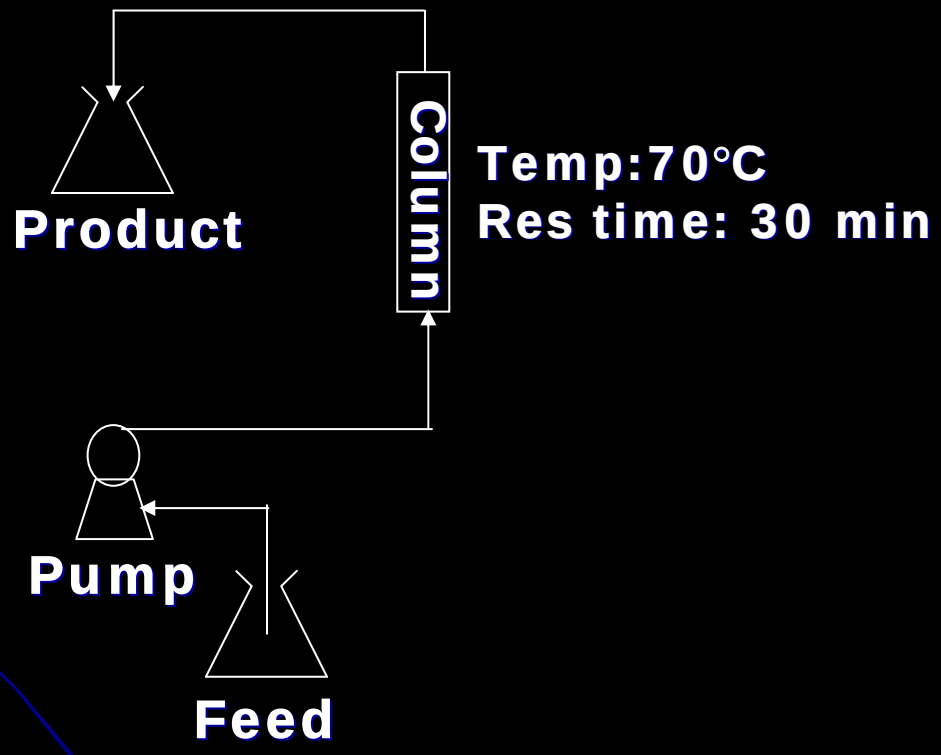
SFC
(FO: 10%)


80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
SFC, %
0
10
20
30
40
50
Temperature, °C
PS/PKO
50/50 B
50/50 E
60/40 B
60/40 E
70/30 B
70/30 E

Triacylglycerol content
Samples: + 10% FO



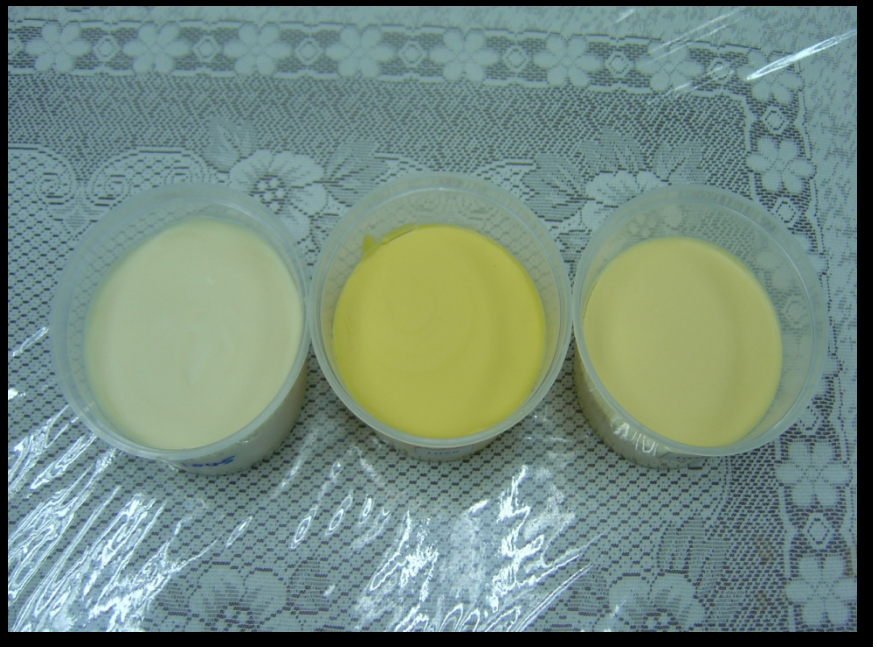
Continuous Enzymatic IE: Pilot-plant scale



Margarine formulation

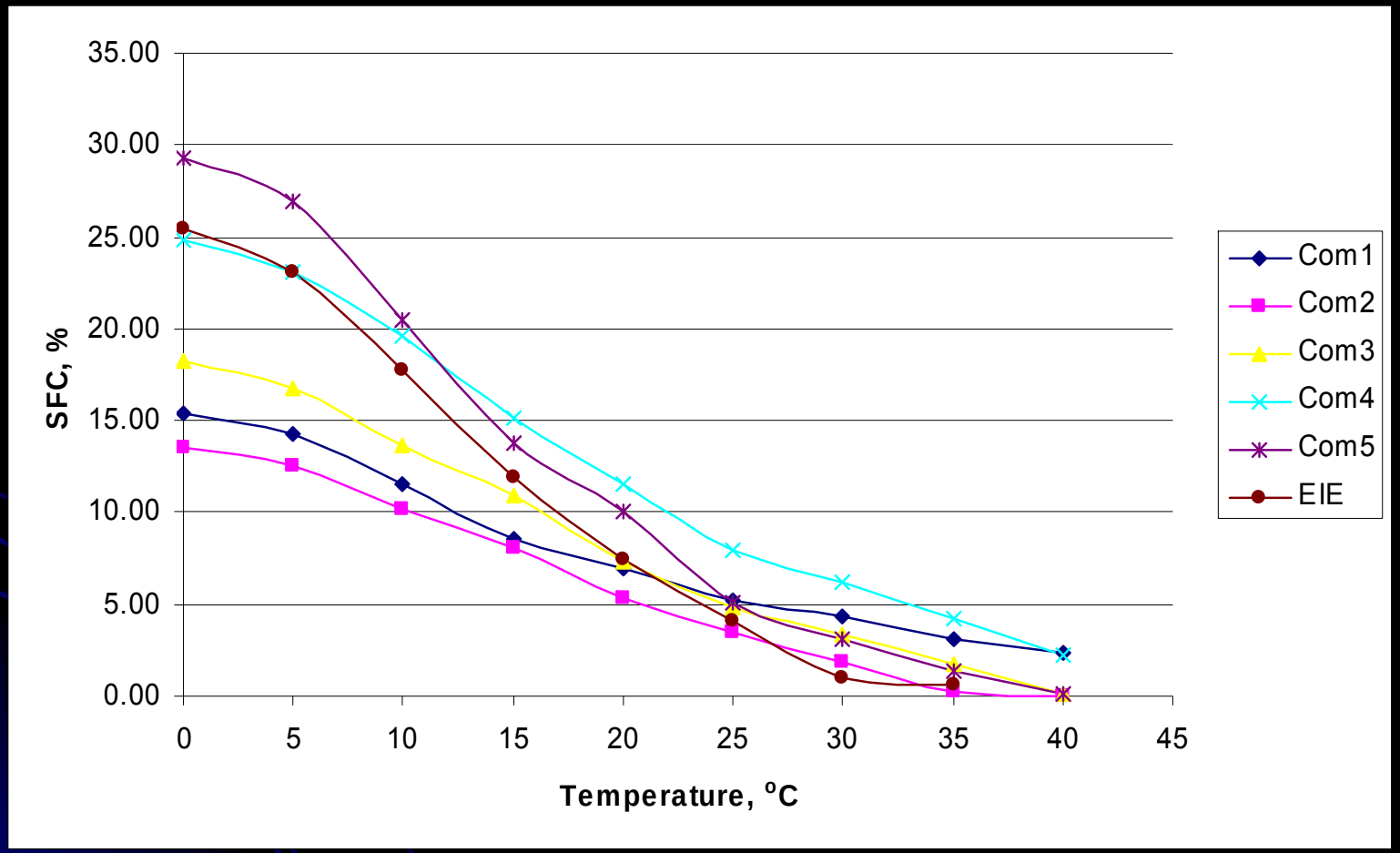
Interesterified PS/PKO 1/1 + 10% FO

- Liquid oil: Canola
- Other ingredients: Water, colour, antioxidant, emulsifier, butter/+ peanut flavour
- Properties:
  - Spreadable
  - Strong fishy odour and taste
  - 3% FO: mild fishy odour and taste



SFC

Comparison with commercial n-3 margarine



Effect of oils on SFC

- Fractional factorial design by RSM assisted by MODDE7
  - 3 factors and 3 levels
  - Factors: PS, PKO, FO
  - Response: SFC (5, 20, 30, 35, 40 °C)
  - 13 oil blends
- Palm stearin: 60 – 90%
- Palm kernel oil: 10 – 40%
- Fish oil: 0 – 10%

Model fitting

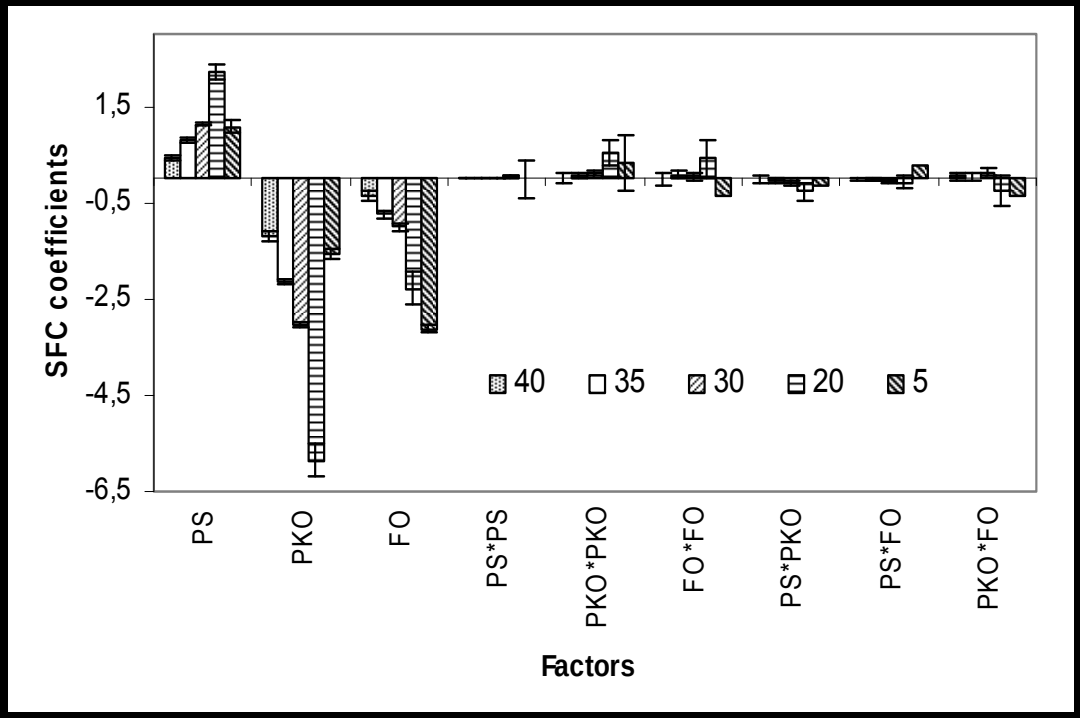
$$Y = \beta_0 + \sum_{i=1}^{3} \beta_i X_i + \sum_{i=1}^{3} \beta_{ii} X^2{}_i + \sum_{i=1}^{2} \sum_{j=i+1}^{3} \beta_{ij} X_i X_j$$

where Y is response variables, β0 intercept, βi first-order model coefficients, βii quadratic coefficients for the *i*th variable, βij interaction coefficients for the interaction of variables i and j, and Xi are independent variables

R^2: > 0.95

ANOVA: No lack of fit

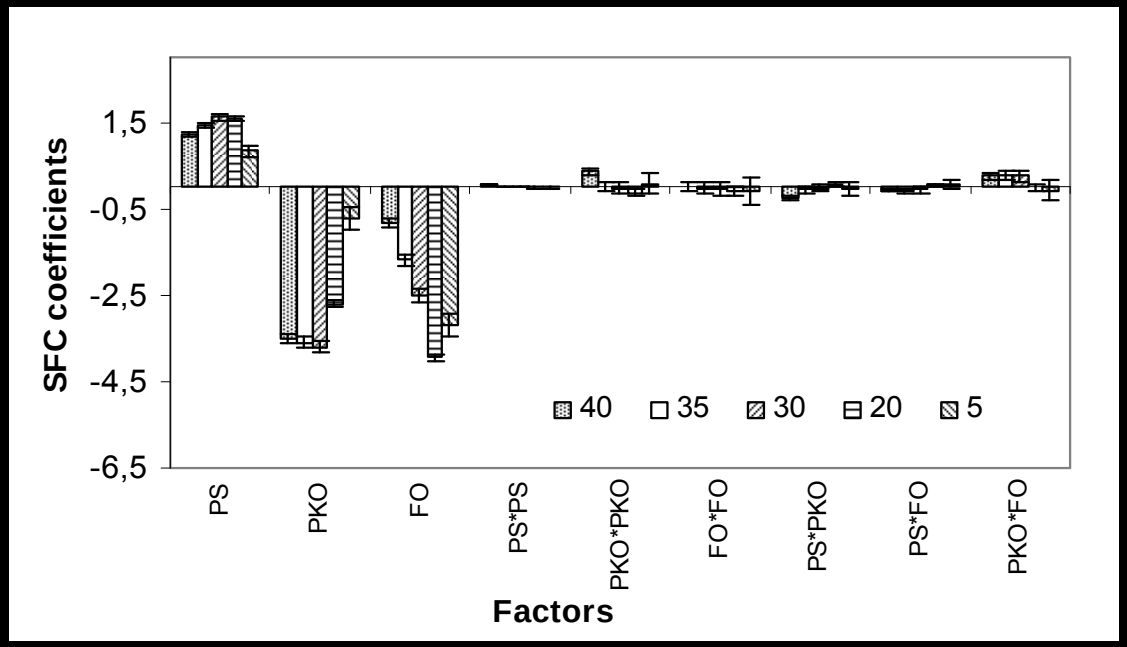
Effect of oils on SFC in blends



Coefficient plot:

- **FO supresses the increase of SFC due to high PUFA content**
- **Major impact at 5 °C**
- **As temperature increases, effect of FO become diminished**

Effect of oils in EIE products



- **FO has major impact at 5 and 20 °C**
  - **Rearrangement of fatty acids led to change in crystallization behaviour**
- **Positive interaction between FO and PKO at 30-40 °C**
  - **FO and PKO led to an increase of SFC in interesterified product**

Conclusion

- Interaction between FO and PKO contributed to the increase of the SFC of the interesterified product
- Interesterification process reduced the SFC
- Even though FO content was only 10%, it has strong influence on the melting profile
- Melting characteristic of the EIE margarine is comparable to the commercial n-3 margarine
- It is possible to produce n-3 margarine hardstock via enzymatic process, but a suitable flavour must be added to mask the fishy odour and taste

Structural Modification of Palm Stearin by Enzymatic Routes to Produce High Valued Oil Products

Siew Wai Lin

Nuzul Amri Ibrahim

Objectives

- Interesterification of double fractionated palm stearin and canola oil by lipozyme TL IM.
- To determine the physico-chemical properties of the products.

Material Preparation

- Hard palm stearin was melted and mixed with canola oil (CO) in proportions ranging from 20 to 80% palm stearin, in 10% increments (w/w).
- Six blends of the mass ratio of hard palm stearin to canola oil (PS:CO) were prepared: 20:80, 30:70, 40:60, 50:50, 60:40 and 70:30.
- 100g of PS:CO blends were reacted with 10% (w/w) of conditioned immobilized enzyme and 10% (w/w) of molecular sieves batch system at 60°C and 25 rpm/min for 24 hours.

Analysis

Chemical

- Free fatty acid
- Triglyceride profile
- FA composition
- Regiospecific analysis

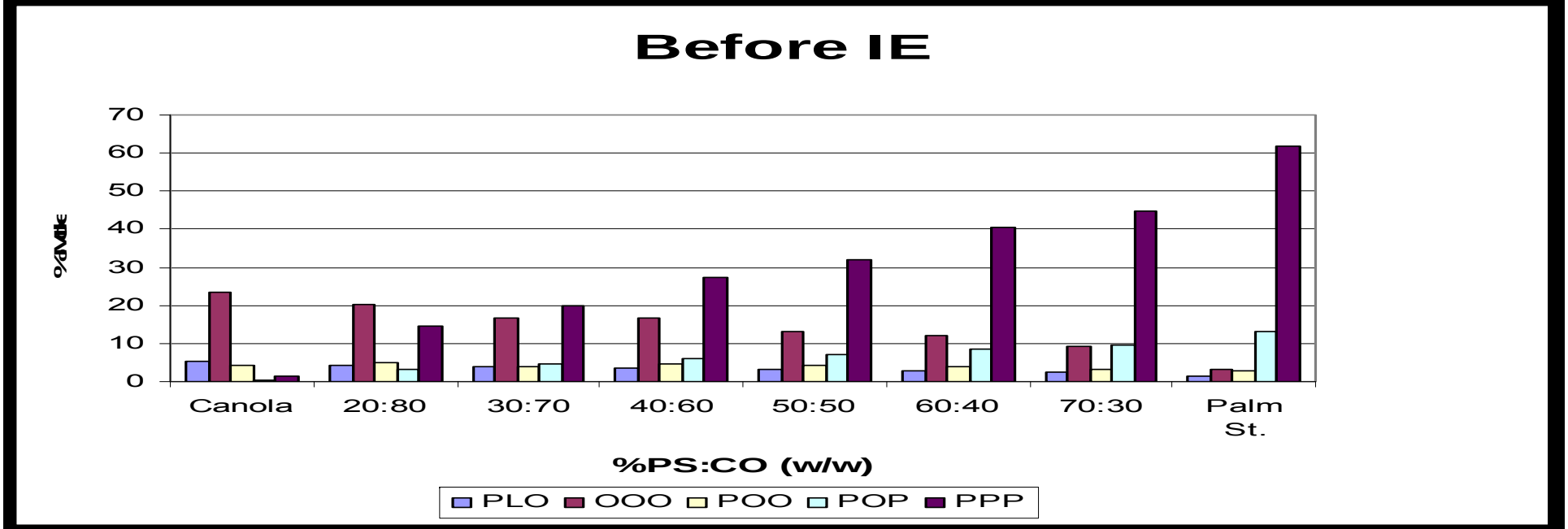
Physical

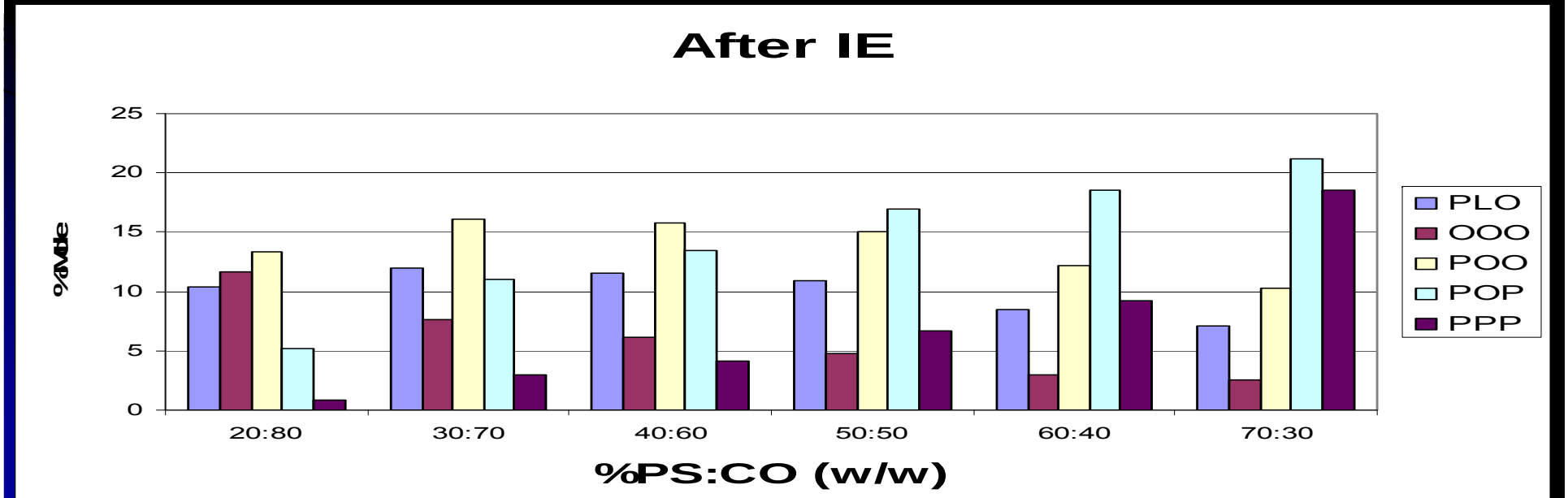
- Slip melting point
- Solid fat content
- DSC analysis
- Polymorphism

RESULTS & Discussion

Chemical Analysis

TAG Profile


Before IE
70
60
50
40
30
20
10
0
Canola
20:80
30:70
40:60
50:50
60:40
70:30
Palm St.
%PS:CO (w/w)
PLO
OOO
POO
POP
PPP


After IE
25
20
15
10
5
0
20:80
30:70
40:60
50:50
60:40
70:30
%PS:CO (w/w)
PLO
OOO
POO
POP
PPP

TAG Profile

- **The interesterified blends showed a decrease of PPP and OOO (high melting and low melting TAGs) but an increase of POP, POO and PLO content.**

- **The blend of PS:CO 30:70 exhibited the highest increment of POO (12.3 mol %) after interesterification by TLIM lipase.**

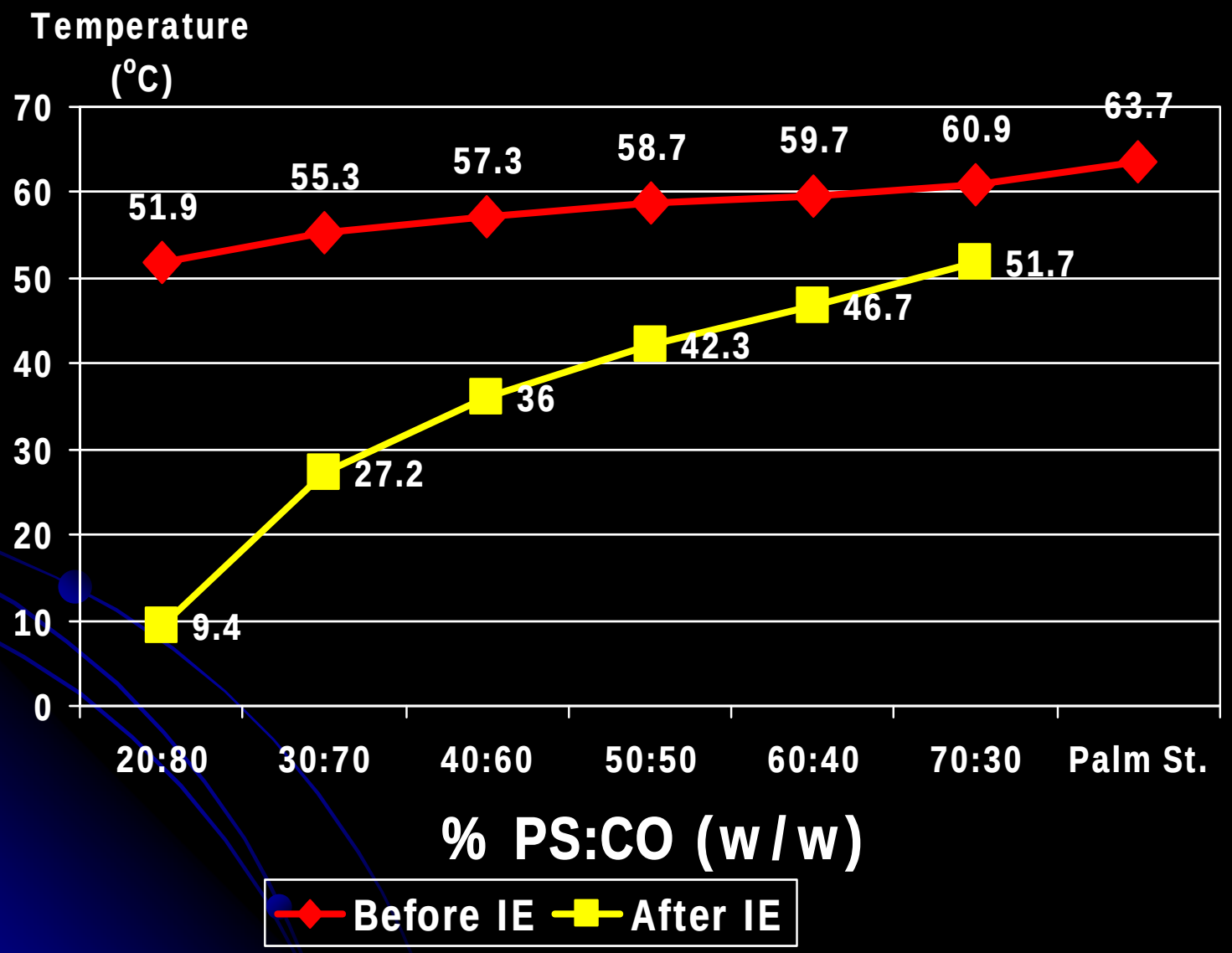
Fatty Acid Ratio

- Dietary intake (WHO) suggested that the n-6 to n-3 fatty acid ratio should not exceed 5 to 1 for a healthy balance.
- All the experimental PS:CO blends had optimal n-6 to n-3 fatty acid ratio below 5:1

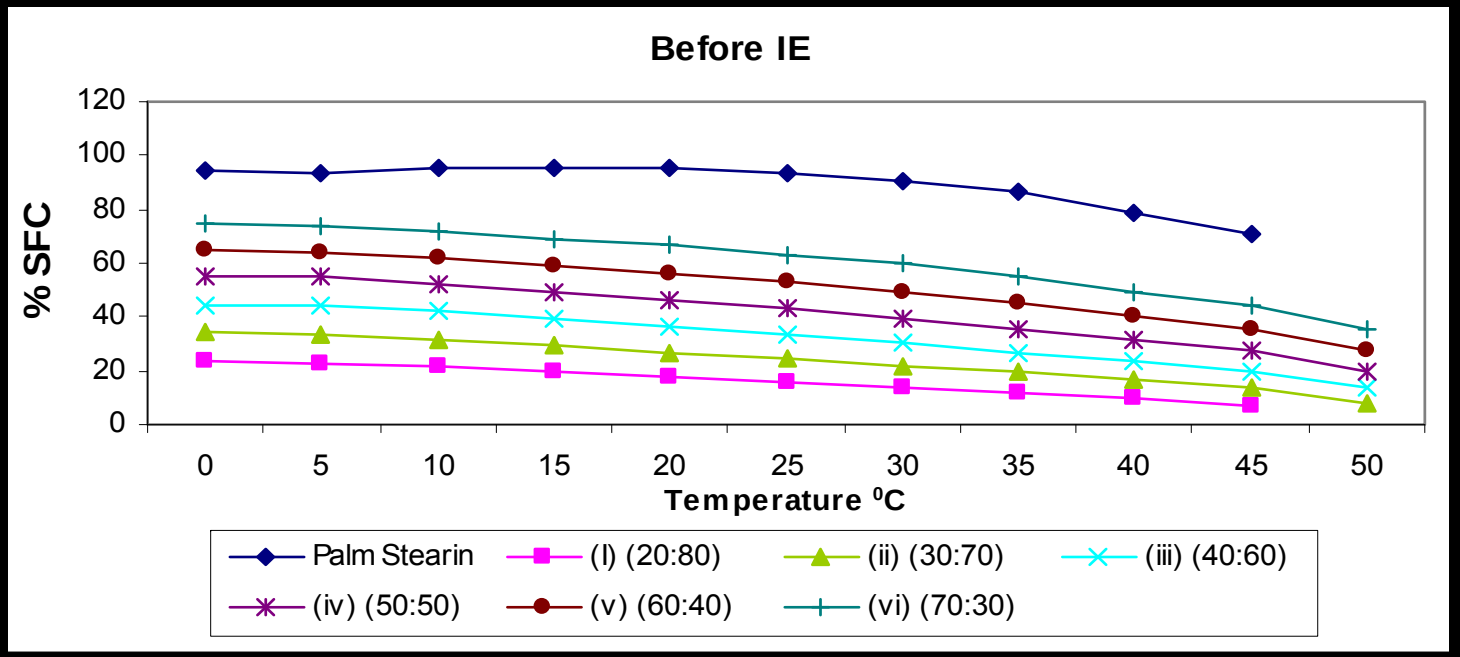
RESULTS & Discussion

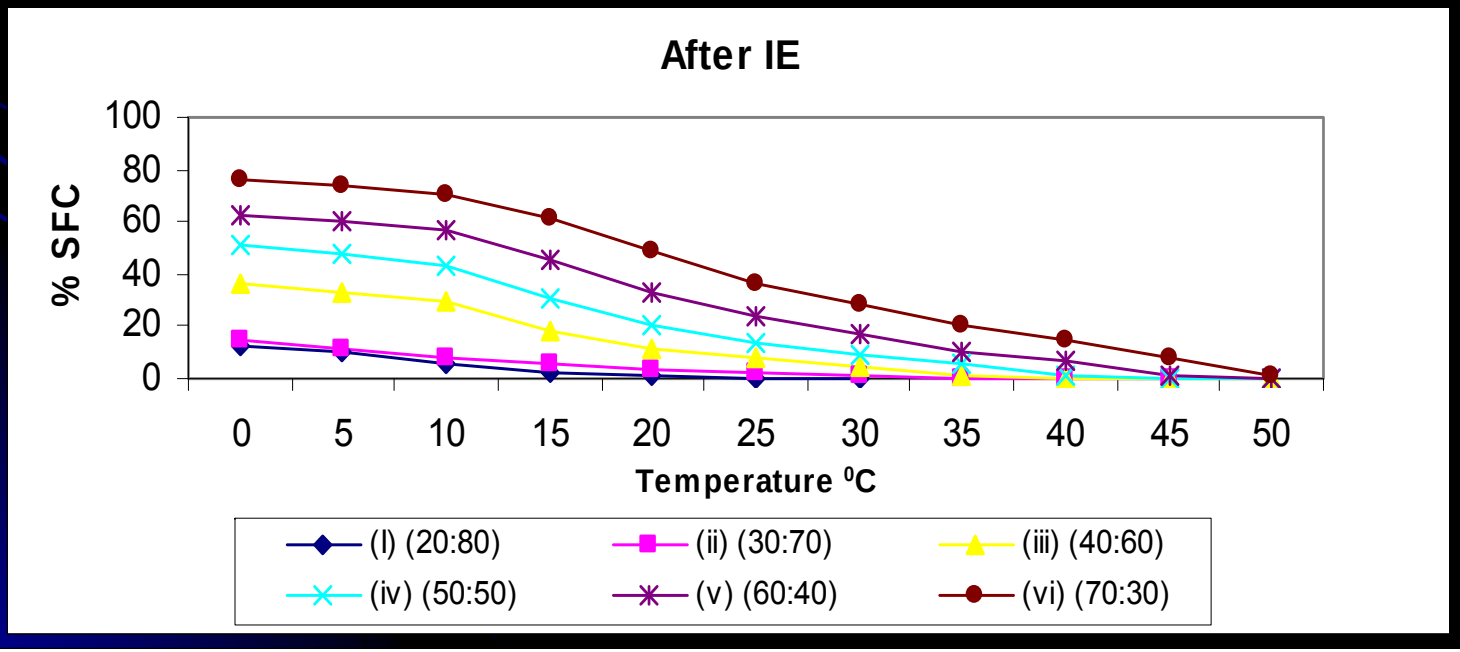
Physical Analysis

Slip Melting Point (SMP)



Solid Fat Content



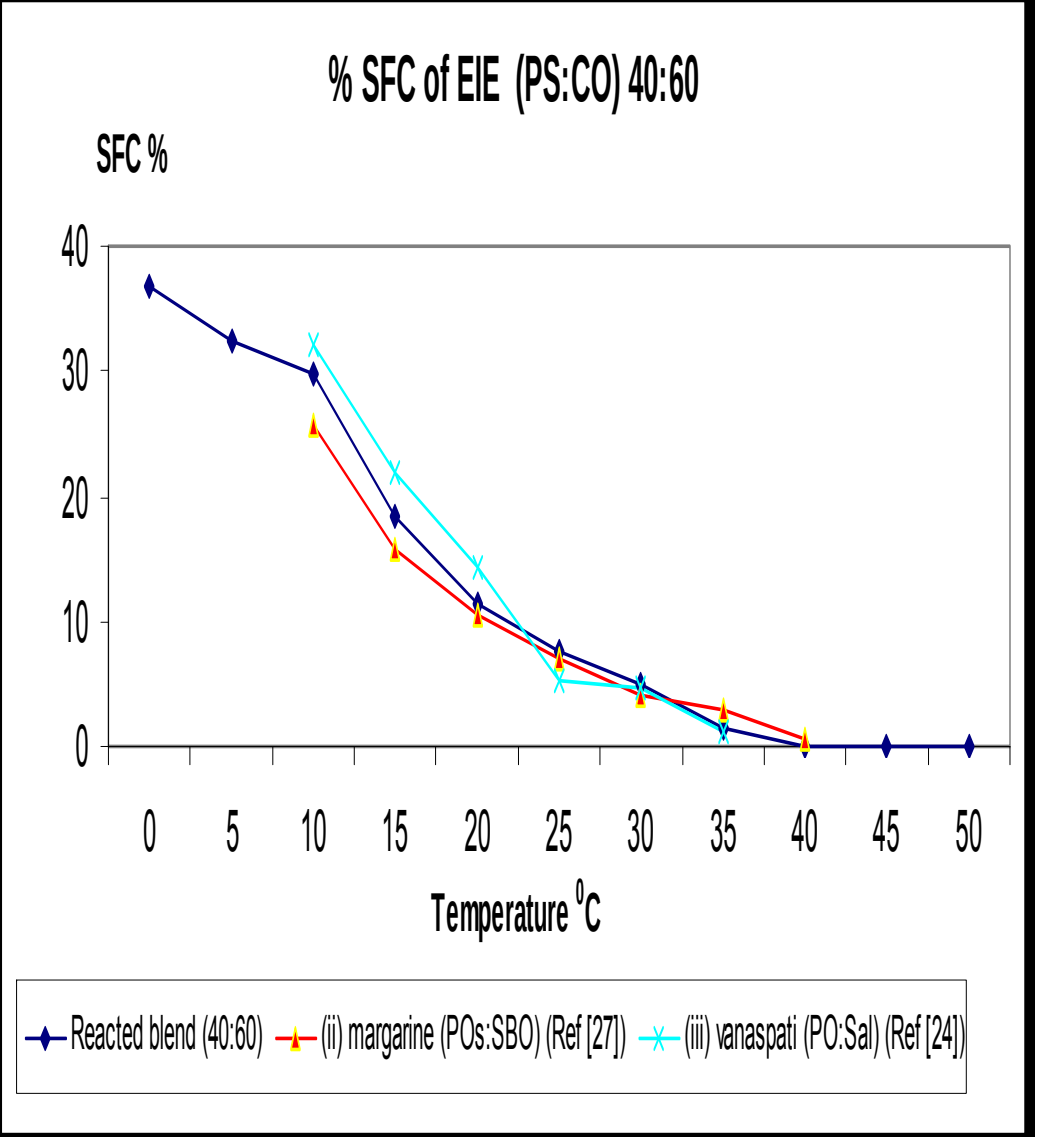


Solid Fat Content (SFC)

- The SFC of margarine at 35°C should be below 5% in order to show complete melting in the mouth without leaving a waxy coating on the palate.
- The IE PS:CO blends of 20:80 (0%), 30:70(0.2%), 40:60(1.4%) which have lower than 5% of solid fat at 35°C, are all meeting this requirement.

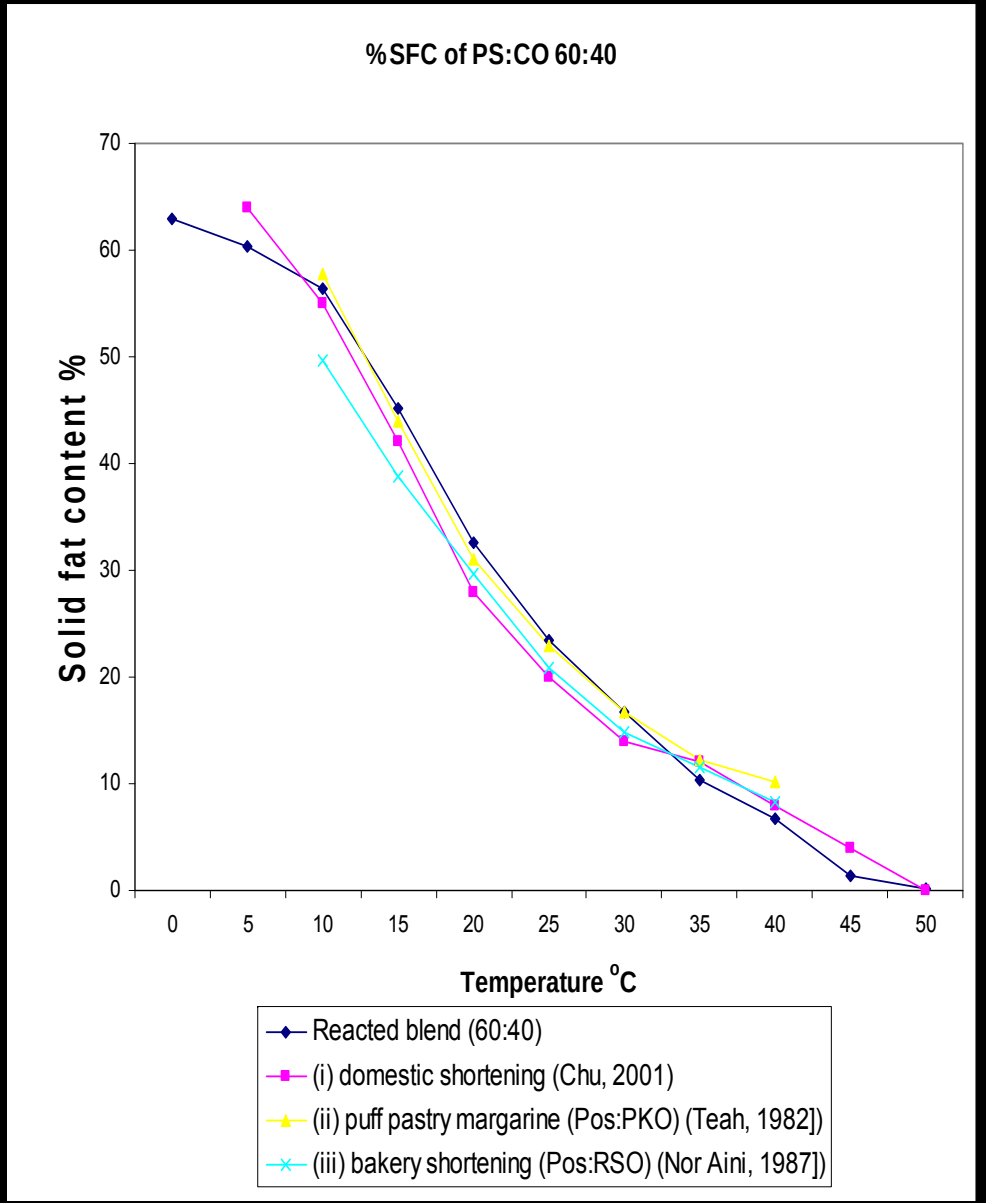
Sample vs Fat Products (SFC)

Fat Blend	FB 1	FB 2 margarine	FB 3 vanaspati
Palm St	40	50	
Canola	60		
SBO		50	
PO			80
Sal			20
% SFC			
10°C	29.8	25.8	32.2
15°C	18.3	15.9	21.9
20°C	11.3	10.6	14.2
25°C	7.5	7.0	5.3
30°C	5.1	4.1	4.7
35°C	1.4	2.8	1.3
40°C	0	0.5	
SMP	36.0		38.5°C



Sample vs Fat Products

Fat Blend	FB 1	FB 2	FB 3
Palm St	60	80	70
Canola	40		
PKO		20	
Rapeseed			30
% SFC			
10°C	56.3	57.8	49.7
15°C	45.1	43.9	38.8
20°C	32.6	31.1	29.7
25°C	23.5	22.9	20.9
30°C	16.8	16.8	14.9
35°C	10.3	12.2	11.5
40°C	6.7	10.1	8.2
SMP	46.7°C		43.5°C



Polymorphic Crystallization

- Increased of β´ polymorphs after IE, not sufficient for margarine and shortening application.
- β crystal is desired in pastry margarine meant for piecrust making to produce stiff and hard product consistency.
- The formation of β crystals can be suppressed by adding sorbitan tristearate about 0.3-0.5% into the fat blends.

% PS:CO	Polymorphic form (s)	
	Before IE	After IE
20:80	β	β > β´
30:70	β	β > β´
40:60	β	β = β´
50:50	β	β = β´
60:40	β	β = β´
70:30	β	β = β´
Palm stearin	β	

Conclusion

Chemical aspect

- Interesterification process had caused some changes in chemical composition of PS:CO blends that determines the physical and nutritional value of palm stearin.
- The nutritional properties of palm stearin has been increased by incorporation of canola oil to produce high percentage of essential fatty acids and low trans-fatty acid potential for fat spread application.

Conclusion

Physical aspect

- Based on SMP and SFC results, some of the IE blends are suitable for margarines and shortenings.
- Improvements are however required for attaining suitable polymorphism and other required characteristics.

The Palm Oil EVENT OF THE YEAR is back!

The Malaysian Palm Oil Board is organizing

INTERNATIONAL PALM OIL CONGRESS

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PIPOC 2011

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15-17 November 2011

Kuala Lumpur Convention Centre

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Kuala Lumpur
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15-17 November