PHO Alternatives

TIA Technical Conference

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Overview:

- **Basics / PHO Timeline**
- **Stable Oils – trait enhanced / naturally stable**
- **Solid Fat Functionality – interesterification, blending**
- **Industry Trends**

Why Oils and Fats

- ➢ Concentrated sources of energy (9 cal/g).
- ➢ Source of essential fatty acids (C18:2/C18:3).
- ➢ Carrier for fat soluble vitamins.
- ➢ Contribute to texture and flavor (lubricity, cohesiveness, aeration, oiliness).
- ➢ Serve as a heat transfer medium.

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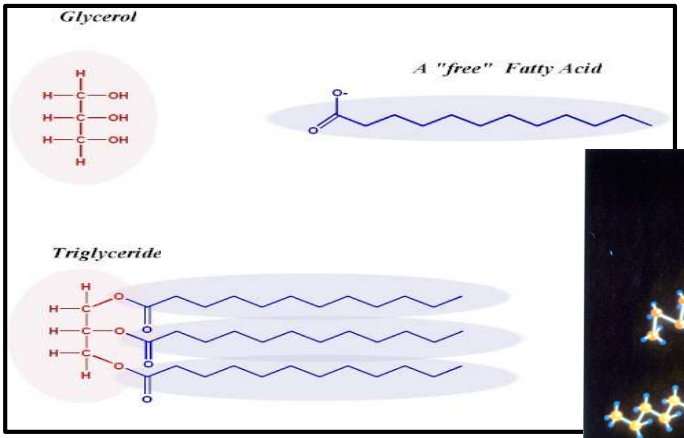
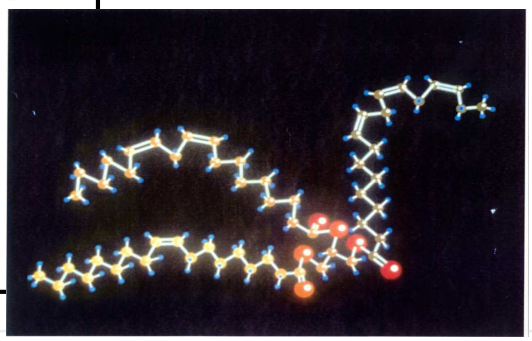
Triglycerides

- Oils and fats are made up of triglycerides.
- Triglycerides are made up of various fatty acids.
- Fatty acids can vary in chain length and degree of unsaturation.





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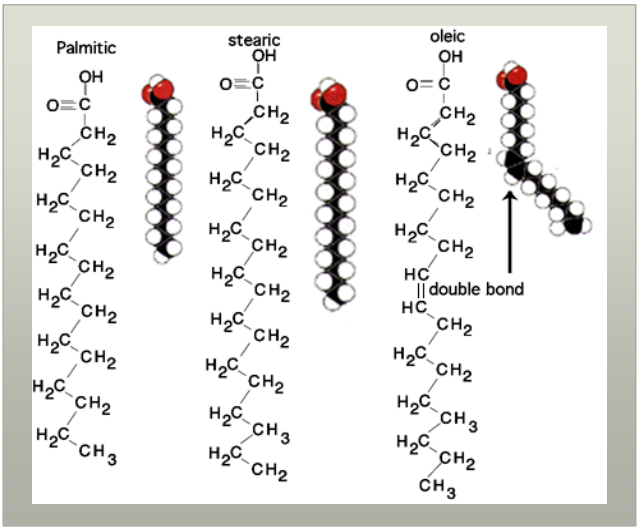
Fatty Acids



Butyric	C4:0
Caproic	C6:0
Caprylic	C8:0
Capric	C10:0
Lauric	C12:0
Myristic	C14:0
Palmitic	C16:0
Palmitoleic	C16:1
Stearic	C18:0
Oleic	C18:1
Linoleic	C18:2
Linolenic	C18:3
Arachidic	C20:0
Behenic	C22:0
Lignoceric	C24:0

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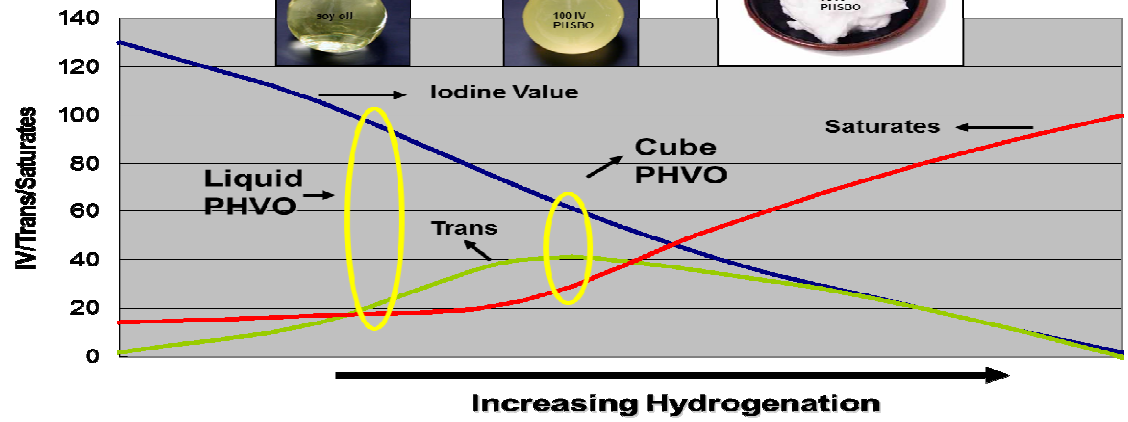
Partial Hydrogenation & Full Hydrogenation (soybean oil)

	Iodine Value	% Trans	% Saturates
No hydrogenation / salad oil	130	<1.5	15
Partial hydrogenation	105	14	17
	70	40	23
	40	34	54
	20	20	80
Full hydrogenation	2	<2	>98



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PHO's

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Typical Trans Levels

Cubed Frying Shortening = 43%
Par-frying Medium = 43%
All Purpose Shortening = 32%
Cracker Spray Oil = 35%
Donut Frying Shortening = 43%
Dairy Creamer Fat = 45%
Creamy Liquid Frying Shortening = 15%
Icing Shortening = 32%
Cocoa Butter Replacer = 45%
Non hydrogenated Foodservice Frying Medium = <1.5%
Industrial Table Grade Margarine = 25%
Tub Margarine Base = 13%
Stick Margarine Base = 22%
Partially Hydro Winterized Soybean Oil = 9%

All functional and oxidatively stable

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PHO's:

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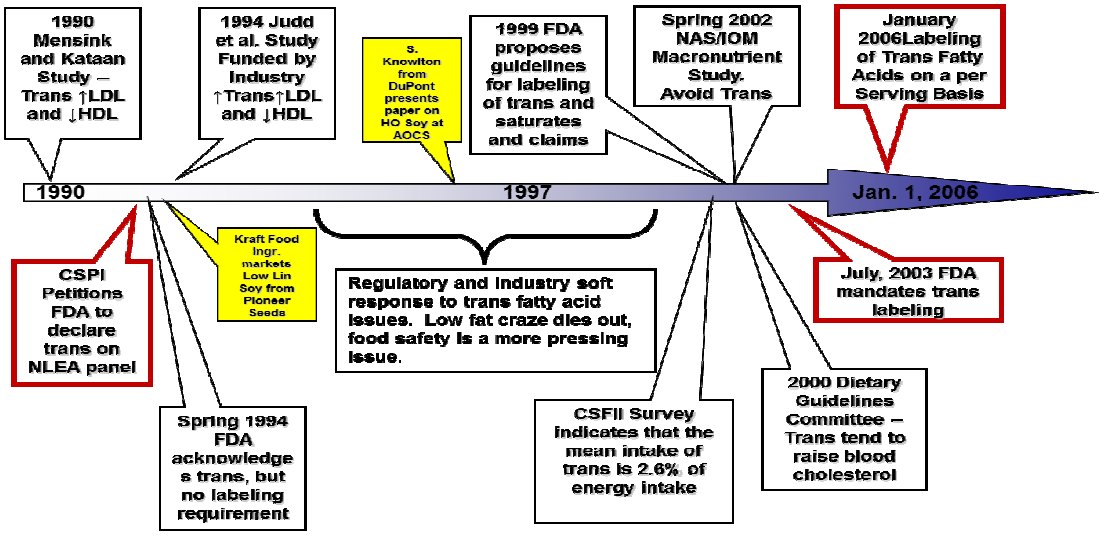
The Trans / PHO Timeline



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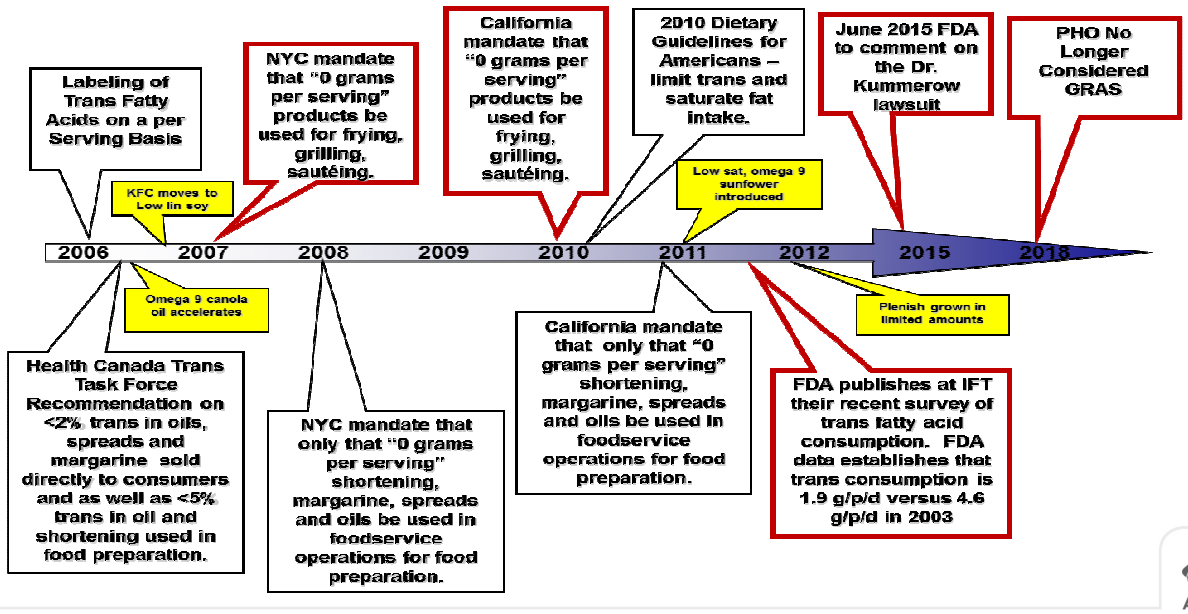
PHO's: The Trans / PHO Timeline



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FDA Final Determination Regarding PHO's

PHO's are not GRAS for any use in human food.

Food Additive Petitions may be sought for one or more specific uses of PHO's with data showing no harm for the attended use.

Fully hydrogenated oils are defined as those fats and oils that have been hydrogenated to complete or near complete saturation with and IV of less than 4.

FDA is establishing a compliance date of June 18th, 2018.

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Overview:

- **Basics / PHO Timeline**
- **Stable Oils – trait enhanced / naturally stable**
- **Solid Fat Functionality – interesterification, blending**
- **Industry Trends**

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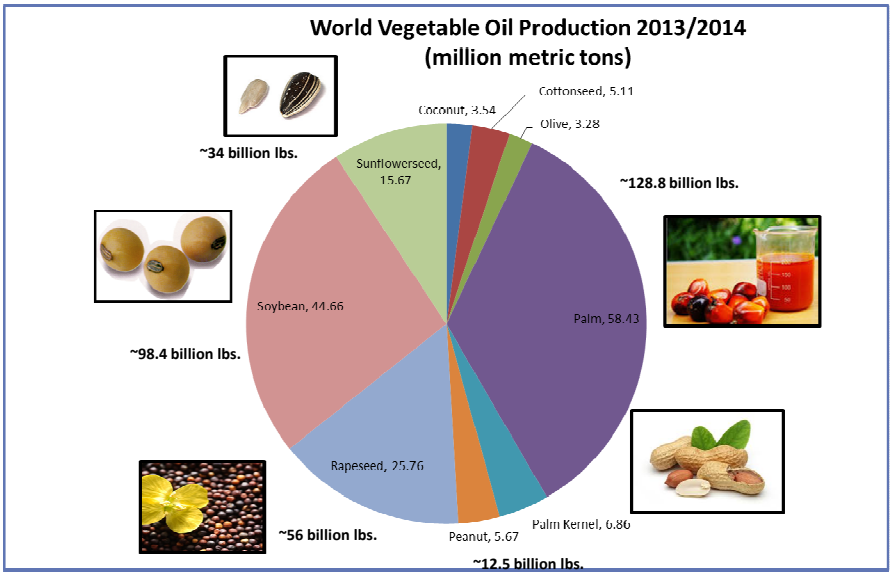
Palm and Soybean Oil Dominate



Source: USDA ERS

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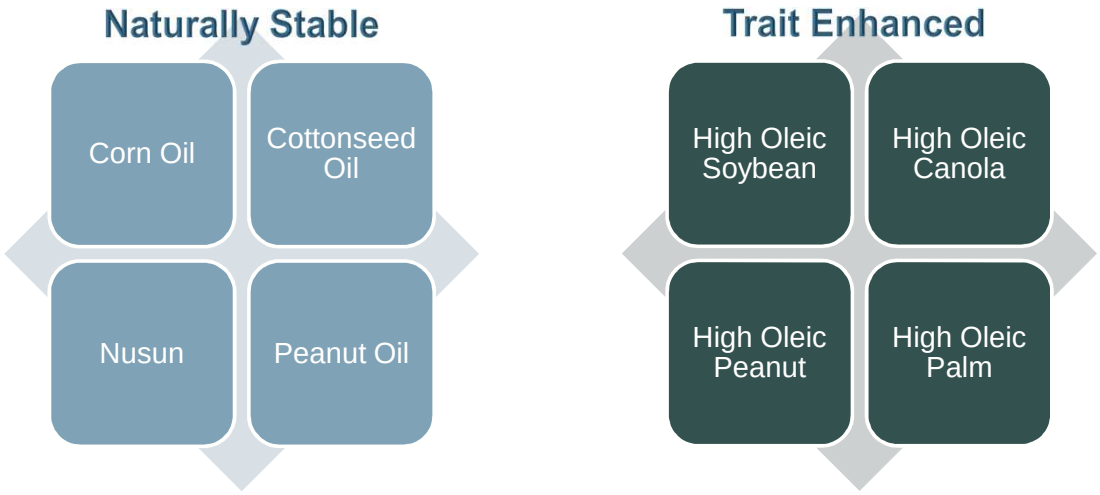
Stability – The Need for Stable Oils



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The Need for Trait Enhanced Oils

Trans Fat Regulation:
-The 2006 FDA labeling of trans mandate, thus alternative for PHO's.
-Geographic / Municipal regulations indicating that for foodservice all products must meet "0 grams trans per serving".

Increase Oxidative Stability:
-As partial hydrogenation is phased out ***stable*** oils are needed.
-Industrial demand for a ***stable*** oil.
-Foodservice / QSR demand for ***stable*** oils.

Improve Profile:
-Reduction on erucic acid (HEAR to LEAR).
-Increase in Oleic and decrease in PUFA's to increase oxidative stability.
-Reduction in saturates (push from NGO's and Health Authorities).
-Increase in Stearic Acid (neutrality of the saturated fatty acid).
-Increase the long chain PUFA content.

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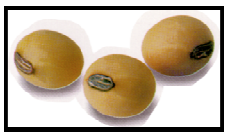
The Need for Stability

High Oleic Soy - Opportunities

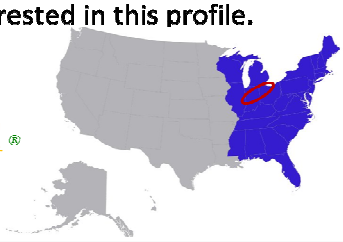
- Work began in the early 1970's to improve soybean oil traits.
- Food processing & QSR sector disappointed by low C18:3 soy.
- HO Soy will offer greater oxidative stability.
- HO Soy will offer lower saturate profiles.
- HO Soy will provide a suitable base oil for blending or inter-esterification to produce low tans shortenings.
- Both food and industrial users are interested in this profile.

Fatty Acid	Soybean Oil	High Oleic Soybean Oil
C16:0	10.3	5.9
C18:0	4.3	4.5
cis C18:1	22.4	75
cis C18:2	53.9	7.8
cis C18:3	7.5	2
OSI (hrs @ 110 C)	7	30



Plenish®

Vistive Gold®



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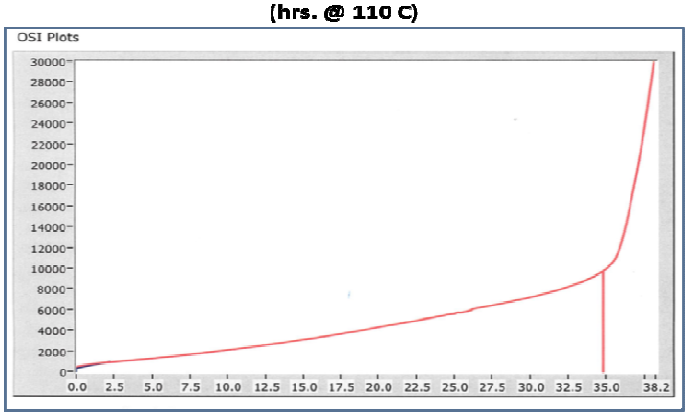
High Oleic Soybean Oil Profiles

Analysis	Vistive ®	Plenish®
Myristic C14:0	0.03	0.05
Palmitic C16:0	2.79	5.97
Stearic C18:0	3.43	4.45
Total C18:1 trans FA	0.04	0.06
Total C18:1 cis FA	71.80	75.75
Total C18:2 trans FA	0.19	0.00
Total C18 2 cis FA	17.18	7.70
Total C18:3 trans FA	0.23	0.07
Total C18:3 cis FA	2.56	1.97
Arachidic C20:0	0.32	0.44
Behenic C22:0	0.34	0.44
Lignoceric C24:0	0.10	0.15
Total Trans FA	0.46	0.12
Total Saturated FAs	7.09	12.35
Total Monos	71.84	75.81
Total PUFAs	20.16	9.74

OSI Time of High Oleic SBO (hrs. @ 110 C)



According to the FDA these oil are to be labeled as "high oleic soybean oil:.

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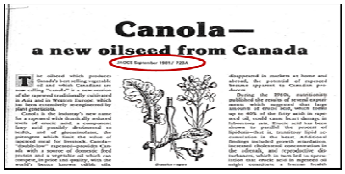
The Need for Stability

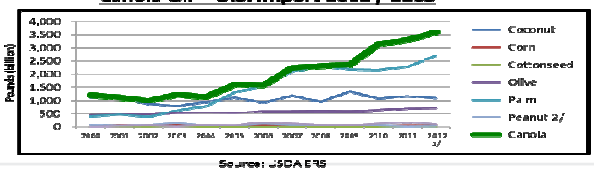
Canola Developments

- Canola oil was developed to move from HEAR to LEAR & lower levels of glucosinolates in the early 70's.
- Early 1990's work on low C18:3 canola oil .
- Mid 1990's work on high lauric canola oil.
- Plans to introduce canola that produces DHA.
- Late 1990's to today life science companies expand high oleic / low linolenic canola production.



Fatty Acid	Canola Oil	High Oleic Canola
C16:0	4.13	3.72
C18:0	1.86	1.84
cis C18:1	63.83	72.3
cis C18:2	18.72	14.89
cis C18:3	7.99	2.3
C20:0	0.57	0.63
C20:1	1.19	1.31
C22:0	0.32	0.37
OSI (hrs @ 110 C)	9	16

Canola Oil – U.S. Import 2012 / 2103



Source: USDA ERS

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The Need the Stability

Mid Oleic Sunflower Oil Development

- **1996 – Industry decision to 'change oil'**
- **1997 – Initial 'fry' test**
- **1997 –NuSun™ defined**
  - **55-75% monounsaturated (oleic acid)**
  - **13-35% polyunsaturated (linoleic acid)**
  - **Less than 10% saturates**
- **1999 first commercial production**

	Refined Sunoil
OSI @ 110C (hrs)	4.90
Palmitic C16:0	6.10
Palmitoleic C16:1	0.12
Stearic C18:0	3.55
Total C18:1 trans FA	0.00
Total C18:1 cis FA	29.19
Total C18:2 trans FA	0.70
Total C18:2 cis FA	58.03
Total C18:3 trans FA	0.00
Total C18:3cis FA	0.18
Gadoleic C20:1n9 c s	0.20
Behenic C22:0	0.76
Lignoceric C24:0	0.54
Total Saturated FAs	11.40
Calc. IV	127.57

	Nusun	HOSUN
OSI	10.33	22.58
Palmitic C16:0	4.46	3.22
Stearic C18:0	3.54	3.17
Total C18:1 trans FA	0.21	0.39
Total C18:1 cis FA	61.83	85.73
Total C18:2 trans FA	0.67	0.18
Total C18:2 cis FA	26.96	5.12
Total C18:3 trans FA	0.09	0.00
Total C18:3cis FA	0.22	0.15
Arachidic C20:0	0.27	0.28
Behenic C22:0	0.78	0.80
Total Saturated FAs	9.42	7.69
Total trans FA	0.97	0.57
Total Monos	62.14	86.22
Total Polys	27.94	5.45

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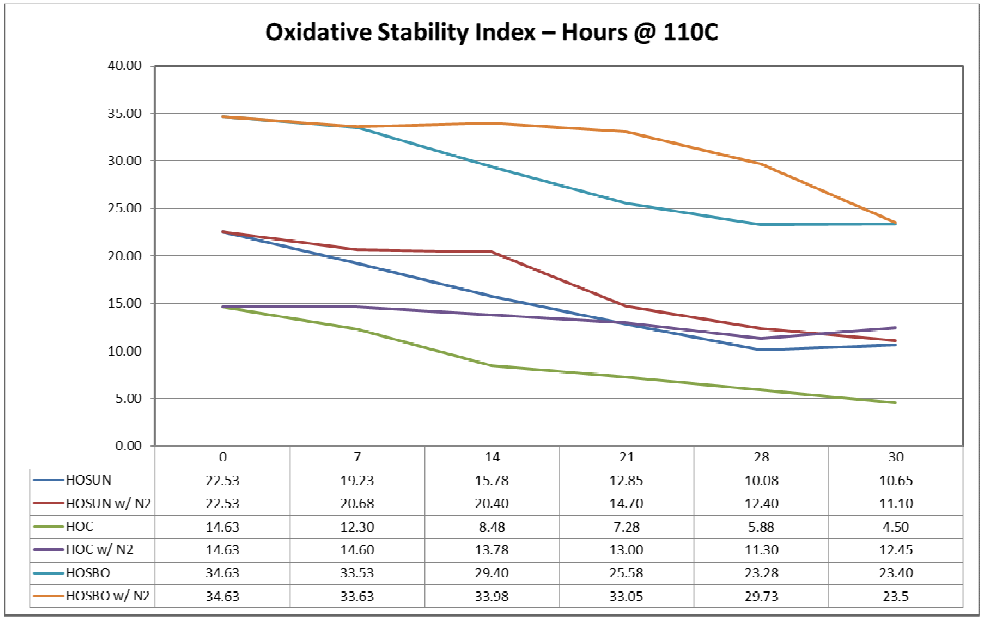
High Oleic Oils – Accelerated Shelf Life



	0	7	14	21	28	30
HOSUN	22.53	19.23	15.78	12.85	10.08	10.65
HOSUN w/ N2	22.53	20.68	20.40	14.70	12.40	11.10
HOC	14.63	12.30	8.48	7.28	5.88	4.50
HOC w/ N2	14.63	14.60	13.78	13.00	11.30	12.45
HOSBO	34.63	33.53	29.40	25.58	23.28	23.40
HOSBO w/ N2	34.63	33.63	33.08	33.05	29.73	23.5

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Overview:

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- **Solid Fat Functionality – interesterification, blending**
- **Industry Trends**

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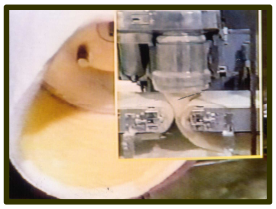
Functionality – The Need for Solids



Interesterified Fats and Oils:

- Can provide shortening from soybean oil source
- Low *trans*
- Saturated fat from a stearic acid
- Saturate range 33-48% (current soy based products)
- Can provide hard stocks from palm fractions, palm kernel source and palm / palm kernel blends

Palm Products:

- Low *trans*
- Fractions are suitable for blending with liquid oils
- Saturated fat from palmitic acid
- Whole palm ≈50% saturates

Blending:

- An array of options for solids or liquids

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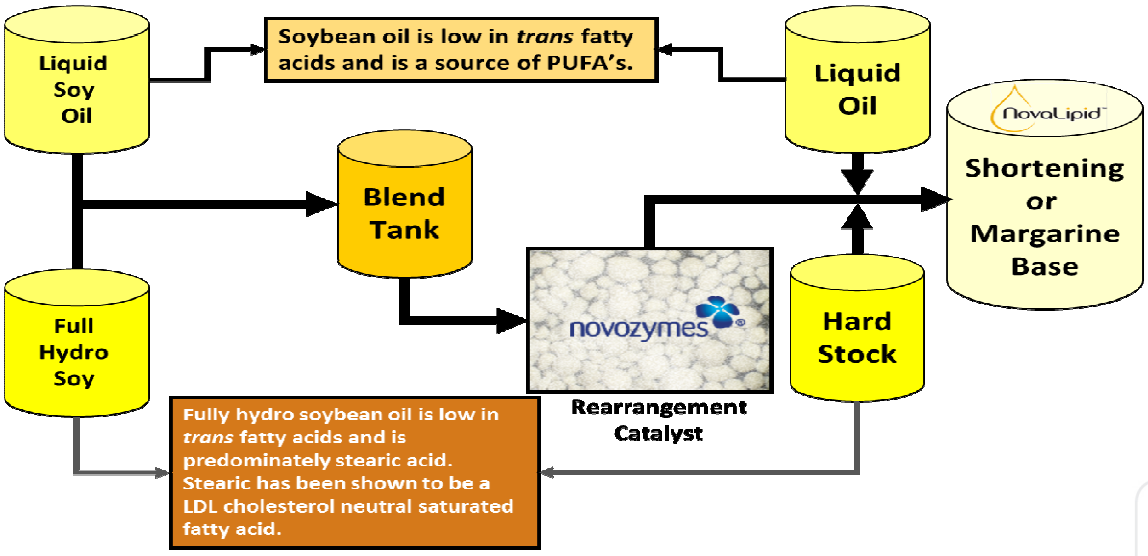
Producing Soybean Oil based Low *trans* Solid Fats



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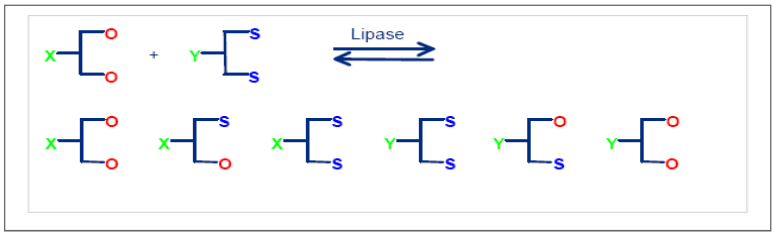
Interesterified Basestocks

- **Chemical Interesterification:**

-rearrangement catalyst
-oil loss
-waste water treatment
-random distribution

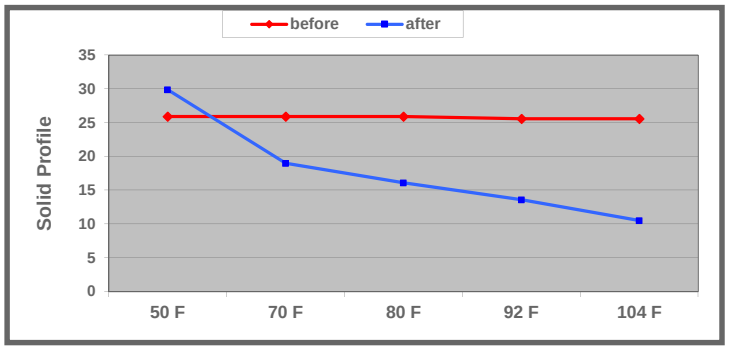
- **Enzymatic Interesterification:**

-continuous process
-minimal oil loss
-minimal waste
-milder processing conditions
-1,3 specific lipase



- **Soybean Oil / Fully Hydrogenated Soybean Oil:**

Melt Point before = 146 F
Melt Point after = 119 F



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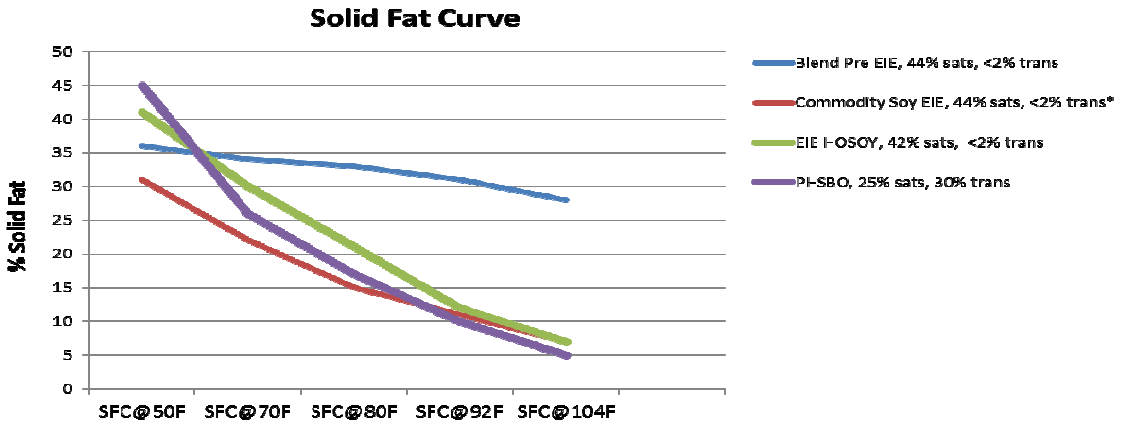
Replacements for Partially Hydrogenated Oils
Enzymatic Interesterification of HO Soy / FHSBO



- Using HOSOY in interesterification produces sharper SFC curves.
- Using HOSOY in interesterification improves oxidative stability.

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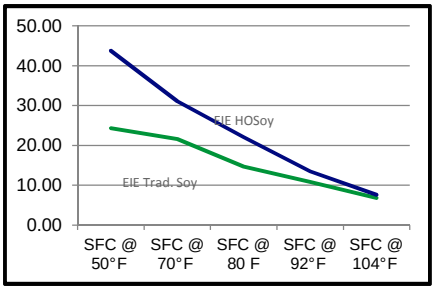
HO Soy Enzymatic Interesterification

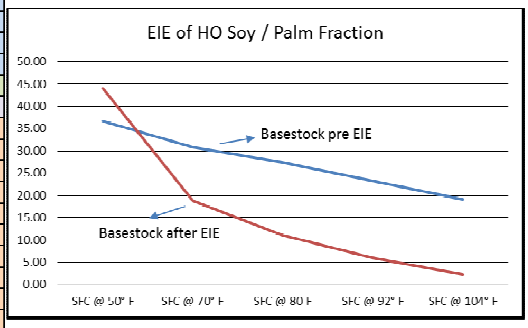
	SBO	HOSBO
	EIE Trad. Soy	EIE HOSoy
MDP (F)	122.5	118.4
SFC @ 50° F	24.30	43.75
SFC @ 70° F	21.61	31.06
SFC @ 80 F	14.65	22.09
SFC @ 92° F	10.87	13.46
SFC @ 104° F	6.85	7.61
OSI @ 110℃ (hrs)	10.63	61.43
Myristic C14:0	0.08	0.07
Palmitic C16:0	10.39	7.92
Stearic C18:0	30.51	32.96
Total C18:1 trans FA	0.30	0.09
Total C18:1 cis FA	15.18	51.00
Total C18:2 trans FA	0.32	0.02
Total C18 2 cis FA	35.74	3.95
Total C18:3 trans FA	0.62	0.07
Total C18:3cis FA	5.36	1.13
Arachidic C20:0	0.43	0.45
Behenic C22:0	0.36	0.39
Lignoceric C24:0	0.11	0.12
Total trans FA	1.23	0.19
Total Saturated FAs	42.10	42.55

- Comparison of traditional EIE soy vs. EIE with HO SBO.
- Very similar saturate profile.
- SFC curve is sharp, more solids at the lower SFC temperatures. More “palm” like.
- OSI time is very good for a low trans alternative.



HO Soy Enzymatic Interesterification (no hydrogenation)

Analysis	Basestock HO Soy / Pst 5233-50	EIE HO Soy / Pst 5233-50
Mettler Drop Point (F)	129.2	100.8
SFC @ 50° F	36.62	44.14
SFC @ 70° F	30.84	18.72
SFC @ 80 F	27.43	11.03
SFC @ 92° F	23.29	5.94
SFC @ 104° F	19.16	2.27
OSI @ 110℃ (hrs)	55.65	49.18
Total Tocopherols	784	435
Lauric C12:0	0.21	0.19
Myristic C14:0	0.53	0.53
Palmitic C16:0	32.02	31.91
Stearic C18:0	4.22	4.22
Total C18:1 trans FA	0.09	0.10
Total C18:1 cis FA	54.57	54.56
Total C18:2 trans FA	0.00	0.11
Total C18 2 cis FA	4.69	4.73
Total C18:3 trans FA	0.03	0.12
Total C18:3cis FA	1.22	1.12
Arachidic C20:0	0.39	0.36
Gadoleic C20:1n9 cis	0.19	0.19
Behenic C22:0	0.26	0.26
Total trans FA	0.12	0.32
Total Saturated FAs	38.23	38.17



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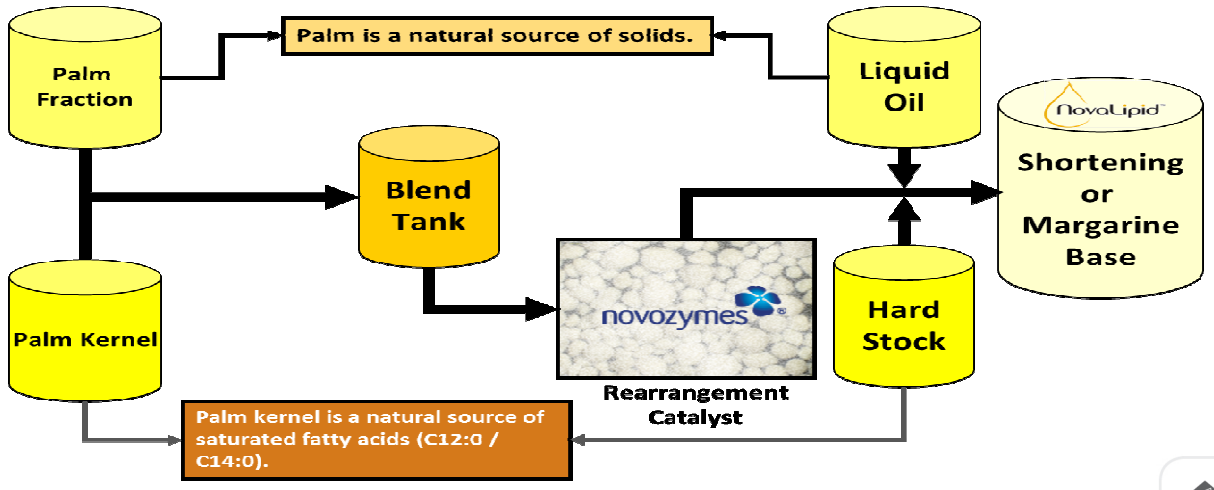
Producing Palm based Low *trans* Solid Fats



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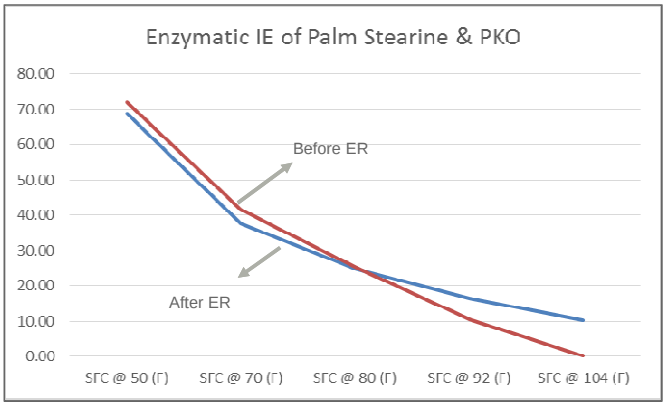
Enzymatic Rearrangement of Palm and PK

Analysis	Basestock PS:PKO 5233-1	EIE Deod PS:PKO 5233-1
MDP (F)	121.0	102.0
SFC @ 50 (F)	68.71	72.05
SFC @ 70 (F)	37.60	41.71
SFC @ 80 (F)	24.96	25.44
SFC @ 92 (F)	16.38	10.49
SFC @ 104 (F)	10.26	0.17
Total Saturated FAs	71.49	71.47



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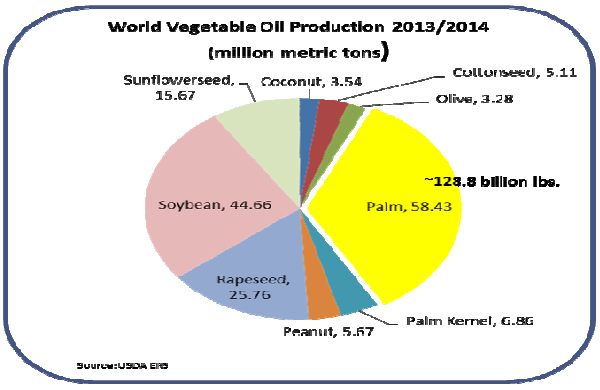
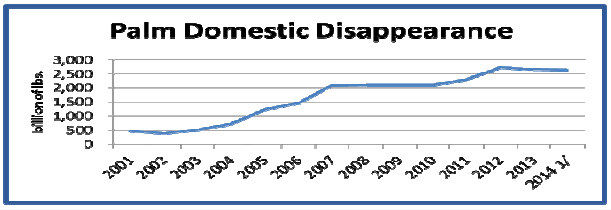
Palm Oil



	Palm Olein	Palm Oil
MDP (F)	74.3	104.0
IV by GC	56.2	52.8
SFC @ 50 (F)	39.37	52.60
SFC @ 70 (F)	4.30	23.62
SFC @ 80 (F)	0.53	13.06
SFC @ 92 (F)	0.02	7.37
SFC @ 104 (F)	0.00	3.80
Total C12:0	0.26	0.26
Total C14:0	1.04	1.04
Total C16:0	40.18	43.63
Total C18:0	4.39	4.57
Total C18:1 trans	0.12	0.32
Total C18:1 cis	40.81	37.42
Total C18:2 trans	0.40	0.47
Total C18 2 cis	11.05	10.48
Total C18:3 trans	0.10	0.11
Total C18:3cis	0.21	0.33
Total trans	0.63	0.90
Total Saturated	48.68	50.24
OSI (hrs. @ 110 C)	~ 25	~ 30



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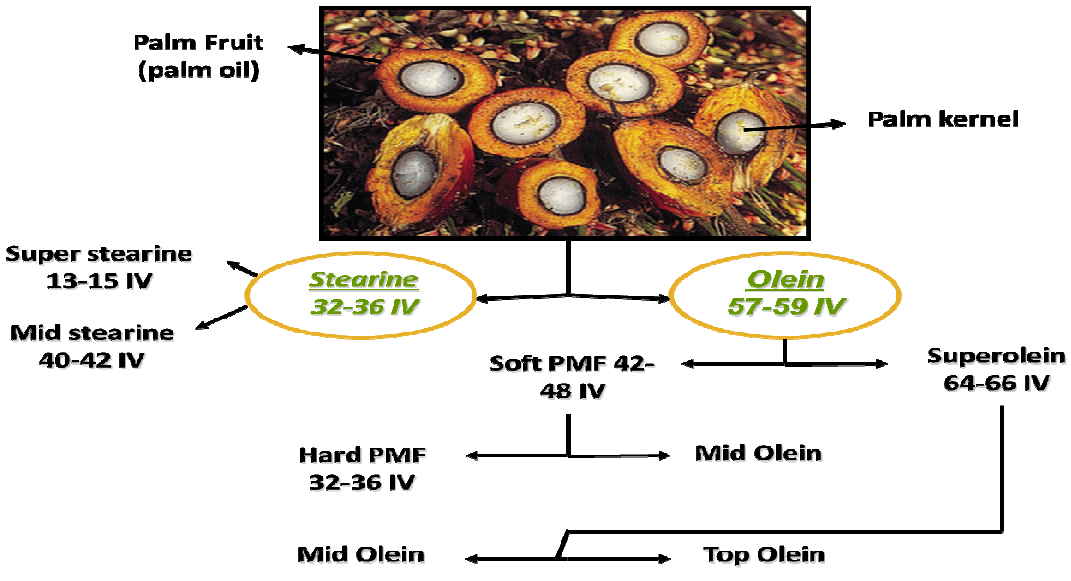
Palm Oil & Palm Fractions



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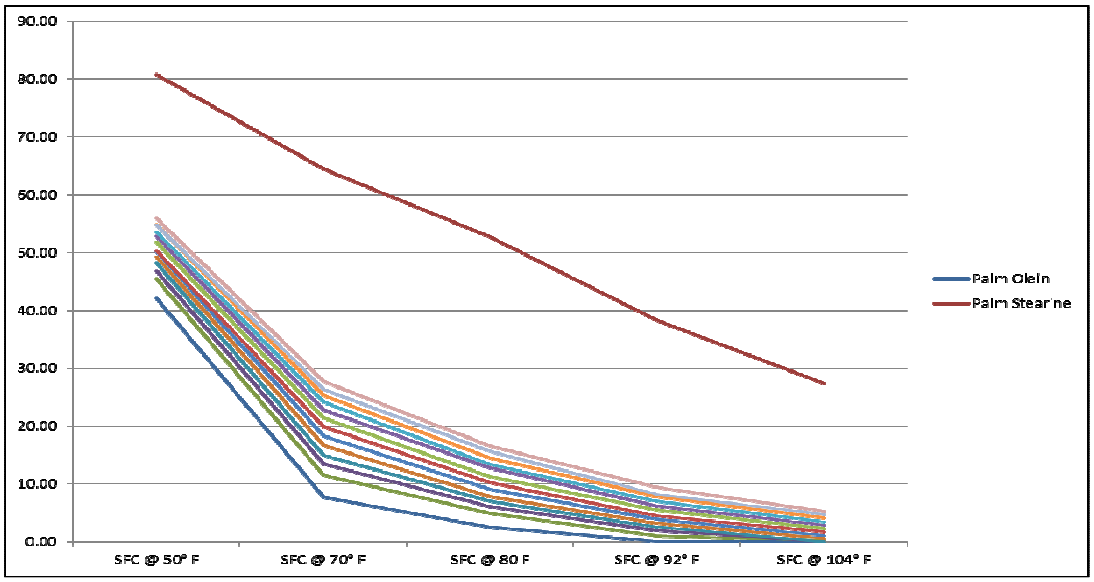
SFC's of Palm Fraction Blends



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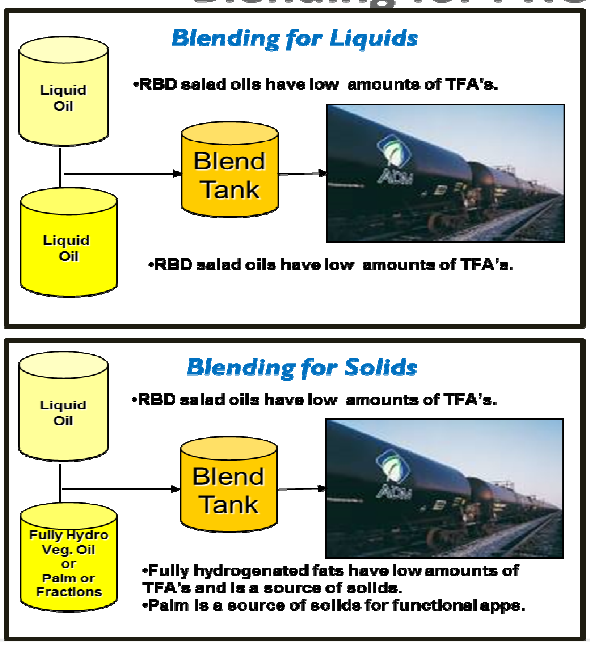
Blending for PHO Replacement



Viable approach to meet:

- Nutritional targets
- Labeling limitations
- Cost constraints
- Flavor
- Stability

Optimize components and blend ratios to produce a functional system.

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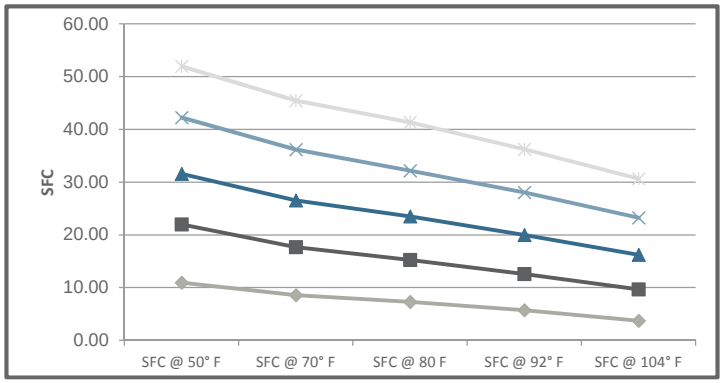
High Oleic Soy / Palm Fractions (blends)

Analytical	HOSOY / PST	HOSOY / PST	HOSOY / PST	HOSOY / PST	HOSOY / PST
Mettler Drop Point (F)	110.66	121.64	127.22	131.72	135.14
SFC @ 50°F	10.94	21.96	31.57	42.23	51.93
SFC @ 70°F	8.56	17.66	26.53	36.13	45.45
SFC @ 80 F	7.30	15.27	23.51	32.14	41.31
SFC @ 92°F	5.74	12.59	19.96	28.02	36.24
SFC @ 104°F	3.70	9.68	16.23	23.24	30.64
OSI @ 110C (hrs)	28.63	32.83	38.18	44.85	53.30
Total Saturated FAs	20.09	27.55	34.90	42.34	49.88



Lauric Products - Palm Kernel Oil & Coconut Oil

Palm kernel oil and coconut oil applications include ice cream coatings, candy centers, dairy systems as well as other applications where steep melting fats are used.

Palm Kernel Oil

Analysis	Palm Kernel Oil	Hydro Palm Kernel	Hyd Re Palm K	Hyd Re Palm K
MDP F	78-84	110-114	95-98	101-103
IV	15-21	4 max.	4 max.	4 max.
SFI 50 F	65-74	68-75	64-69	68-75
SFI 70 F	28-39	64-70	53-57	54-60
SFI 80 F	15 max.	46-52	36-42	40-45
SFI 92 F	1 max.	18-24	8-12	11-15
SFI 104 F	0	8-14	0	4 max.
Total TFA's	0.34	0.022	1.65	2.06
Total Saturates	83.81	99.59	96.31	96.53

Coconut Oil

Analysis	Coconut	H Coconut	H Coconut + H Soy	H Coconut + H Soy
MDP F	72.0-78.0	93.0-97.0	98.0-102.0	103.0-108.0
IV	7-11	1.5 max.	1.5 max.	5 max.
SFI 50 F	52-58	61-67	61-67	61-70
SFI 70 F	23-29	37-43	38-44	38-44
SFI 80 F	1 max.	9-15	9-15	---
SFI 92 F	0	4 max.	3-9	3-9
SFI 104 F		1 max.	4 max.	2-8
Total TFA's	< 2	< 2	< 2	< 2
Total Saturates	92	98	98	98

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Overview:

- **Basics / PHO Timeline**
- **Stable Oils – trait enhanced / naturally stable**
- **Solid Fat Functionality – interesterification, blending**
- **Industry Trends**

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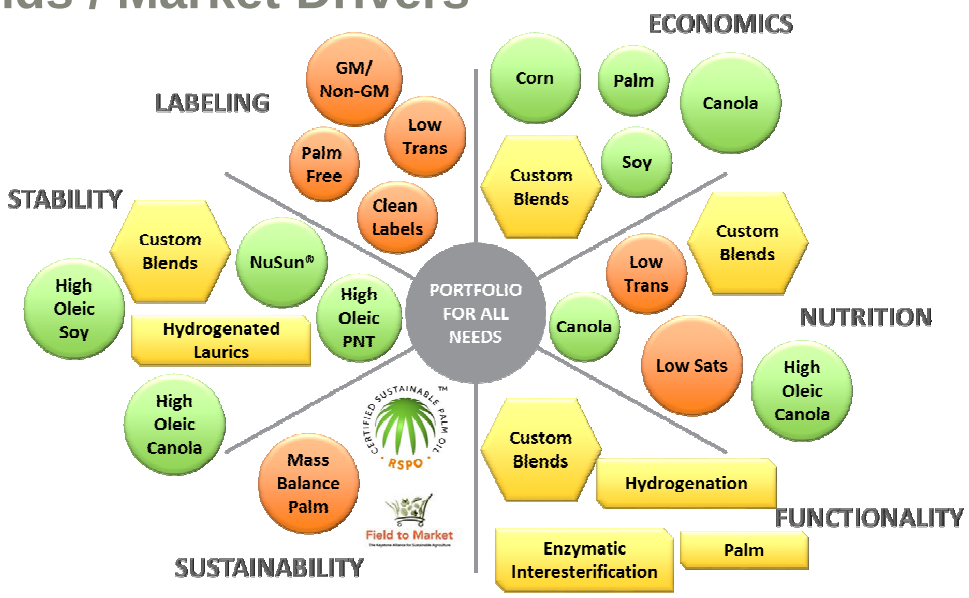
Trends / Market Drivers



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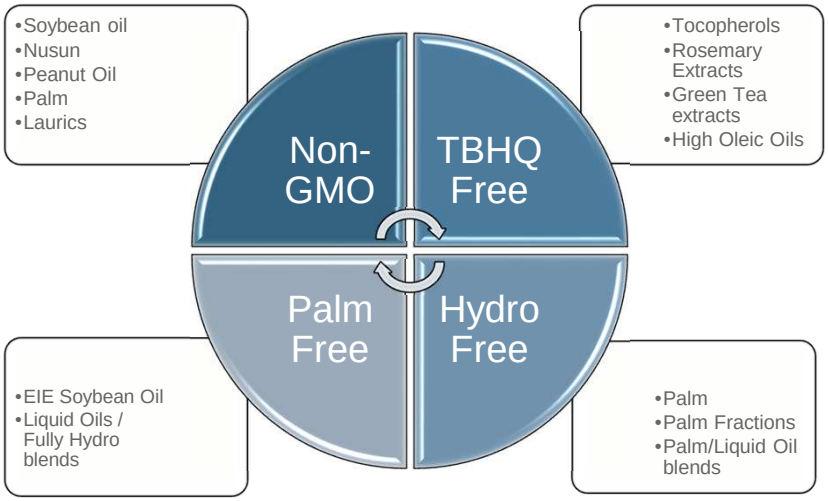
Labelling – Clean Labels Leading the Way



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Discussion

- Partially hydrogenated oils no longer considered GRAS – 6/18/2018.
- Fully hydrogenated oil <4 IV.
- Trait enhanced oils such as high oleic soybean oil will provide the industry with a stable oil for blends and interesterification.
- Interesterificiation will provide functional products for a variety of applications.
- Blending liquids, blending solids & liquids and blending various solids fats provides many solutions for PHO alternatives.
- The Edible Oils Industry continues to produce non-PHO solutions to address a variety of technical challenges.