QUALITY AND USE OF SUNFLOWER OIL AND SUNFLOWER WAX IN THE FOOD INDUSTRY

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NCAUR, Peoria, IL

National Center for Agricultural Utilization Research

- Research Units
  - Bacterial Foodborne Pathogens
  - Bioenergy
  - Bio-oils
  - Crop Bioprotection
  - **Functional Foods Research**
  - Plant Polymer
  - Renewable Product Technologies

1950

2013

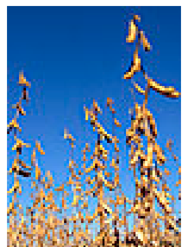
https://www.ars.usda.gov/midwest-area/peoria-il/national-center-for-agricultural-utilization-research/

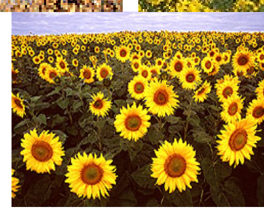
Improving Quality, Stability, and Functionality of Oils and Bioactive Lipids

Project # 5010-44000-052-00D

USDA-Agricultural Research Service

National Center for Agricultural Utilization Research





Research to improve oils- From the field to the kitchen table

Project Objectives

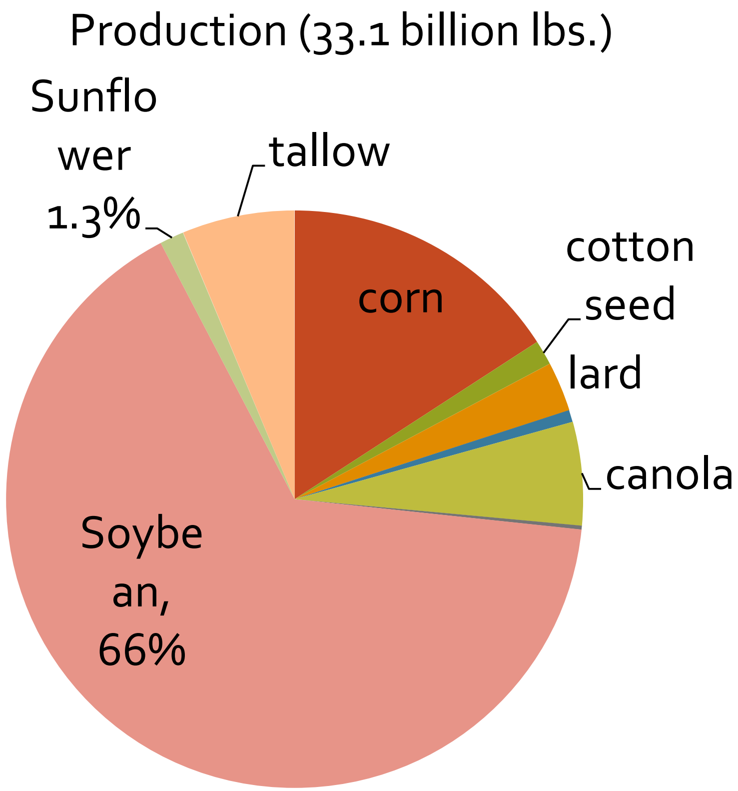
- Increase the value of edible oils produced in the U.S. through the **development of technologies to replace trans fats and saturated fats** while overcoming stability and functionality shortcomings

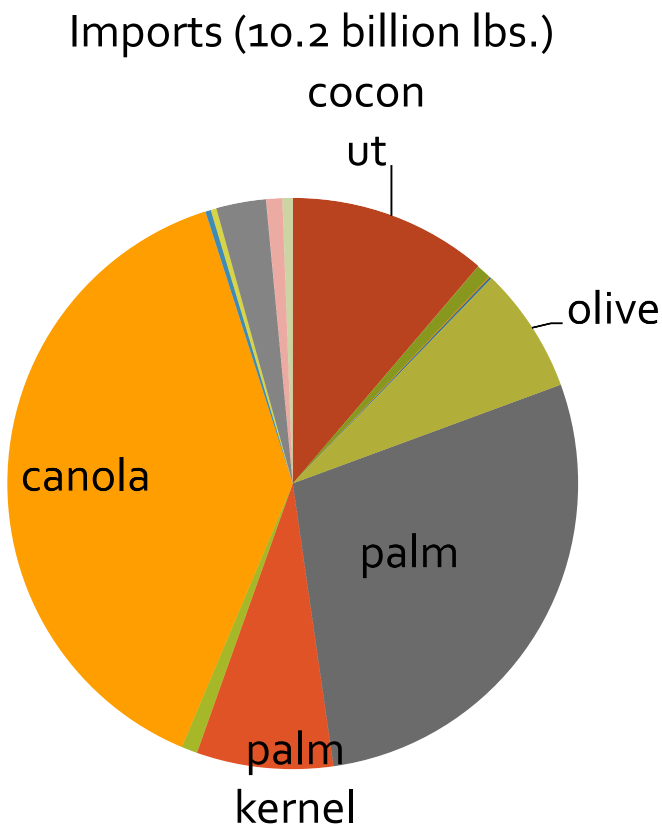
- Increase the value-added potential of agricultural and food processing coproducts through **discovery of bioactive ingredients and antioxidants**

Outline

- Edible oils in the U.S.
- Stability and functionality of edible oils
- Research on sunflower oil and sunflower wax

Production and Import of Edible Oils and Fats in the U.S.

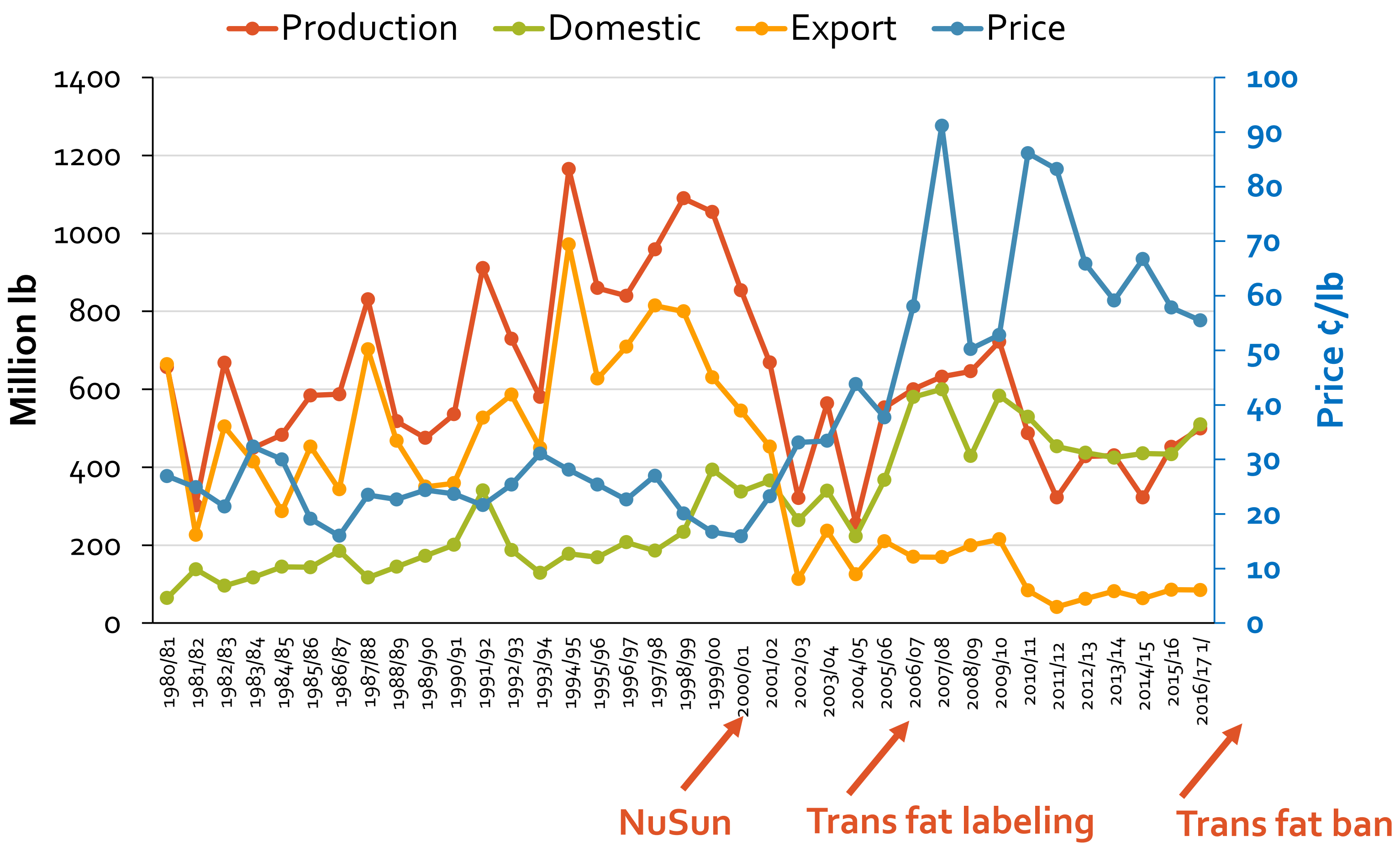




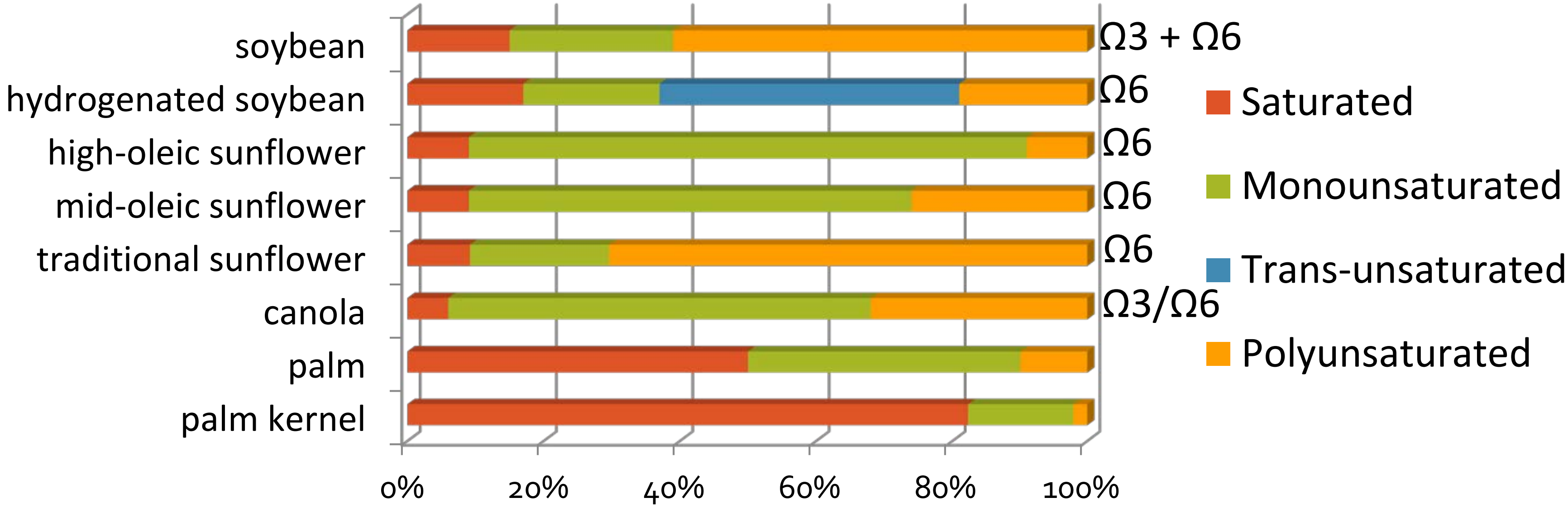
Why are alternatives to lipid structuring needed?

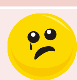
- 2006: FDA requires food companies to label the content of trans-fatty acids
  - Food industry responded by replacing partially hydrogenated oils with palm oil and palm kernel oil (↑ saturated fat)
- 2013: FDA releases preliminary ruling that hydrogenated oils containing trans fatty acids would not longer be considered GRAS (Generally Recognized as Safe)
- 2018: U.S. food industry required to phase out all partially hydrogenated oils
- Goal: zero trans fats, low saturated fats

Impact of quality improvements: Production, Consumption, and Price of Sunflower oil



Fatty acid composition of common vegetable oils and effect on healthfulness, stability and functionality



	Healthfulness	**Stability** to oxidation or frying	**Functionality**
Saturated	★	★★★	★★★
Trans-unsaturated		★★	★★★
Monounsaturated	★★★	★★	★★
Polyunsaturated	★★★	★	★

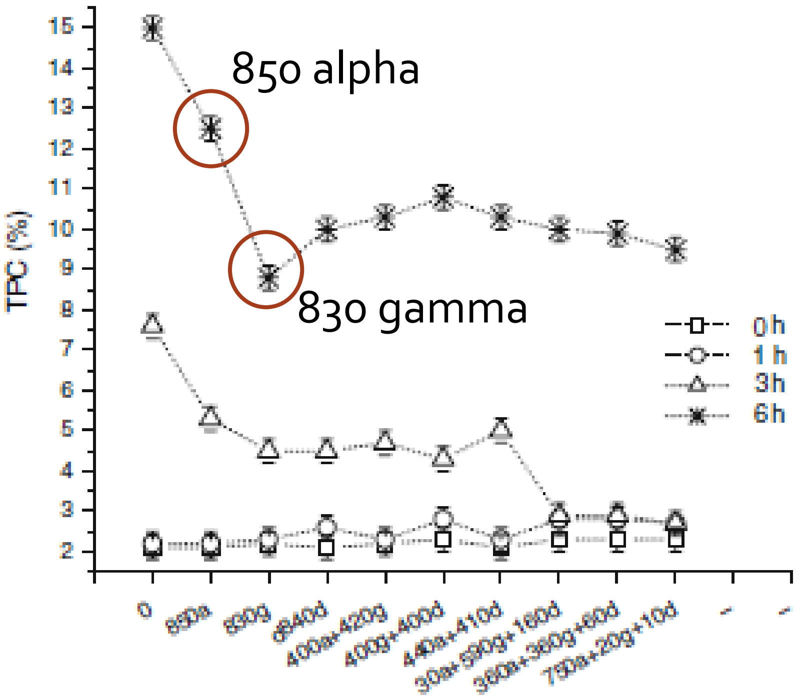
Advantages of Sunflower Oil

- Mid-to-high levels of oleic acid
- Low in saturated fats (< 10 %)
- Zero trans fats
- High in Vitamin E (alpha tocopherol)

- High stability
  - Frying oil
  - Salad oil
  - Long shelf-life
- High smoke point
  - Frying
- Neutral flavor
- Non-GMO
  - Organic
  - Expeller pressed

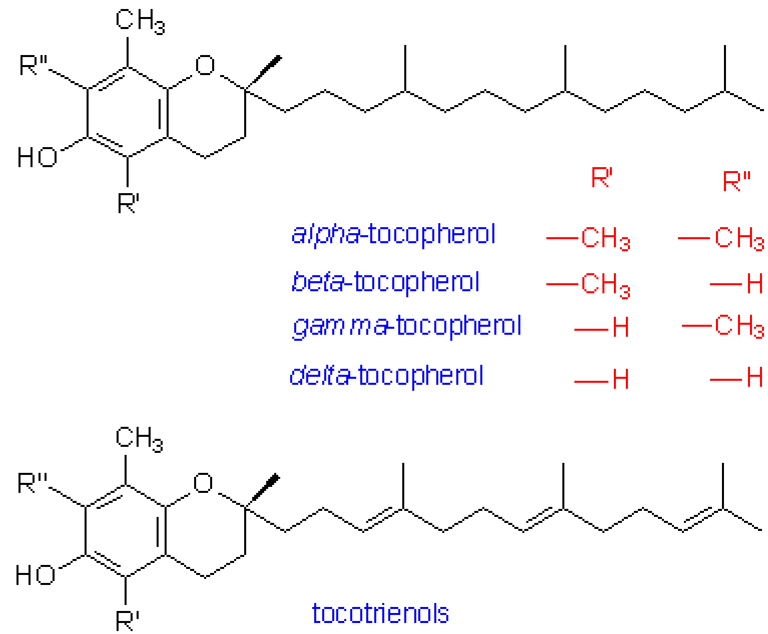
Tocopherol profile

Effect of different tocopherols on stability of mid-oleic sunflower oil during frying



J Am Oil Chem Soc (2009) 86:1199–1207

Vitamin E: Tocopherol and tocotrienol structures



J Am Oil Chem Soc (2008) 85:529–533
DOI 10.1007/s11746-008-1212-3

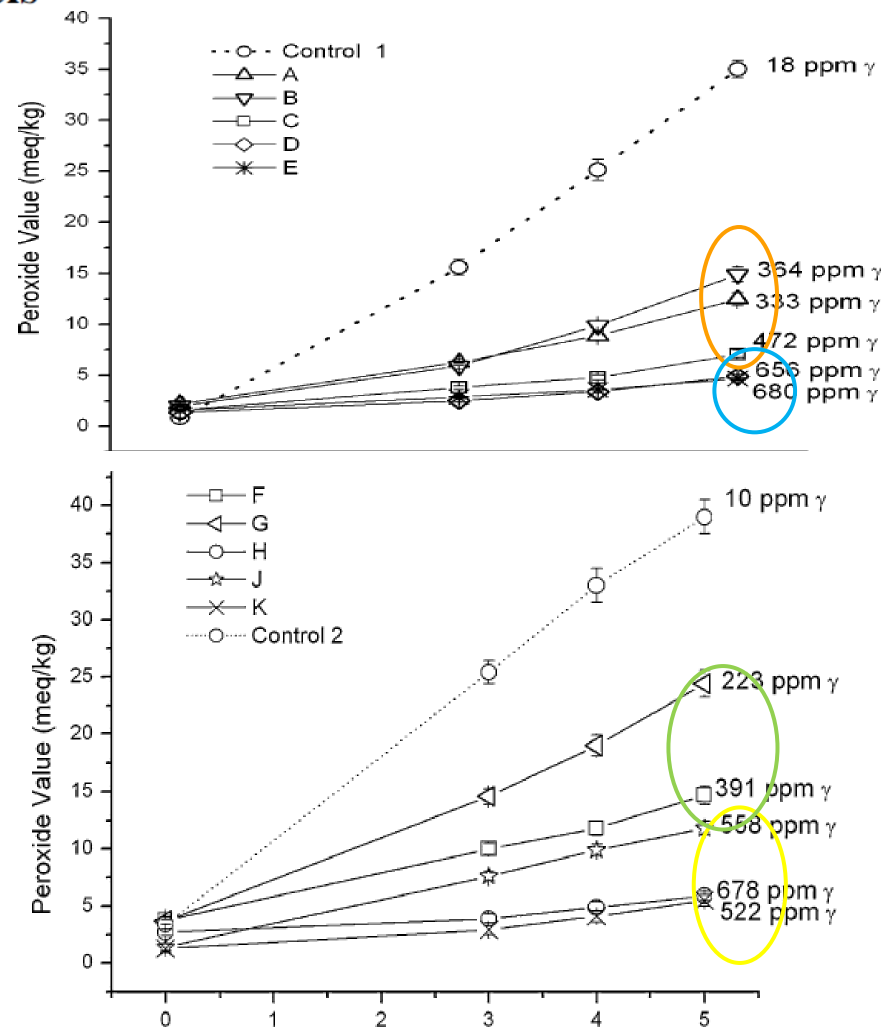
ORIGINAL PAPER

Oxidative Stability of Crude Mid-Oleic Sunflower Oils from Seeds with High γ- and δ-Tocopherol Levels

K. Warner · Jerry Miller · Y. Demurin

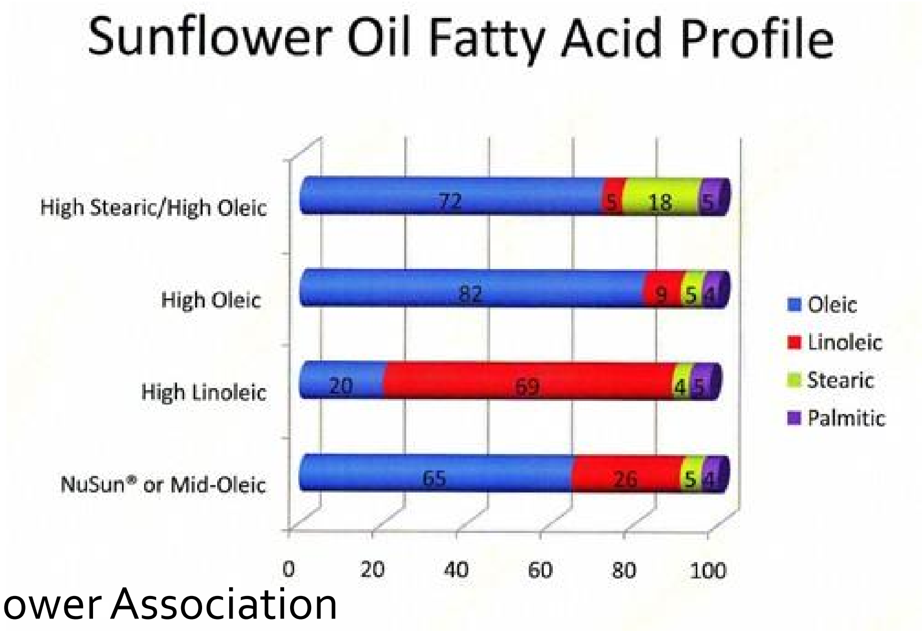
Table 2 Tocopherol compositions (ppm) of extracted crude sunflower oils

	Alpha	Beta	Gamma	Delta
Set 1				
Mid-oleic				
A	393 a	82 a	333 a	64 a
B	356 b	78 a	364 b	68 a
C	289 c	56 b	472 c	95 b
D	69 d	24 c	680 d	221 c
E	33 e	12 d	656 d	188 d
Control 1	909 f	34 e	18 e	3 e
Set 2				
High-oleic				
F	365 a	109 a	391 a	120 a
G	512 b	79 b	223 b	42 b
H	44 c	8 c	678 c	140 c
J	52 c	9 c	558 d	135 c
K	308 d	47 d	522 e	121 a
Control 2	779 e	34 e	10 f	2 d



Addressing functionality

- Saturated and/or trans fats (straight chains) are needed for higher melting point (fat *vs* oil)
  - Blending with fats
  - Interesterification (blend and move fatty acids around)
  - Development of new breeds higher in saturates



Source: National Sunflower Association

Oleogel approach:
How can liquid oils be turned into semi-solids for replacement of *trans* and saturated fats?

- Organogels[1]
  - <10% w/w molecular weight gelator
    - Phytosterols + oryzanol, waxes, hydrocarbons, fatty acids, hydroxy fatty acids, ethylcellulose, monoglycerides
  - Crystallizes upon cooling
  - Forms thermo-reversible network to entrap large volumes of liquid oil
- "Oleogels"-specifically using edible oils

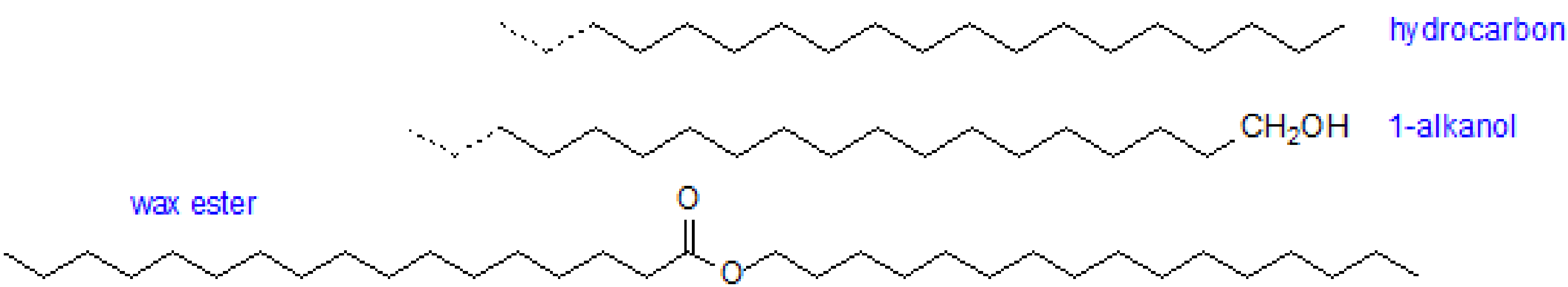


[1]Blake and Marangoni, Food Biophysics, 2015, 10:403-415

Sunflower wax

- Mainly from seed hull (2-2.5%)
- Oil wax content 0.02% - 0.35 %
- Removed by winterization
  - *Clear oil, no turbidity*
- Purified wax
  - Long chain wax esters

- Waxes: history of use in food in coatings & confectionary ingredients, as well as in cosmetics
  - Approved food additives
  - GRAS



Images from AOCS Lipid Library (lipidlibrary.aocs.org)

Wax based organogels

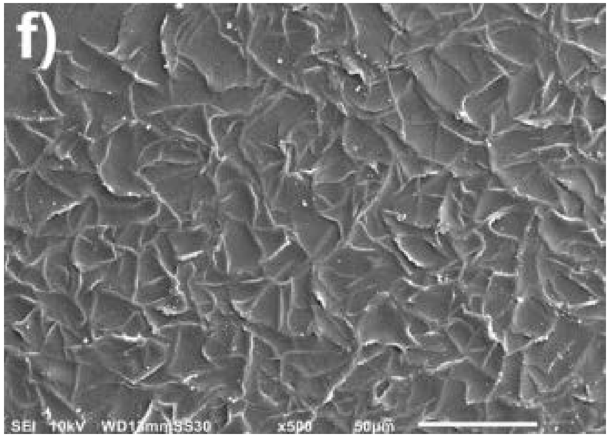
Wax type	Composition (1)	Melting point	Minimum gelation (2)
Rice bran	WE(94%), FFA (6%)	82	0.5 – 5%
Sunflower	96% WE 3% FFA	77	0.5%
Beeswax	58% WE 27% HC 9% FFA 6% FAL	64	2 – 3%
Candelilla	73% HC 16% WE 10% FFA 2% FAL	65	1 – 2%

1. Doan et al.(2017) Food Chemistry 214:717-725
2. Hwang et al. (2012) J. Amer. Oil Chem. Soc. 89: 639-647

Properties of wax organogels[1]

- Minimum gelation levels
  - 0.5-5% w/w
  - Wax type
  - Purity
  - Oil
- Increased melting point with ↑ wax %
- Increased firmness with ↑ wax %
- Decreased crystal size with ↑ cooling rate
  - Increased firmness
  - Denser networks

- Sunflower wax
  - Thin, plate-like crystals
- Products made with wax oleogels
  - Spreads (soft margarine)
  - Shortening/margarine replacement in cookies, cakes

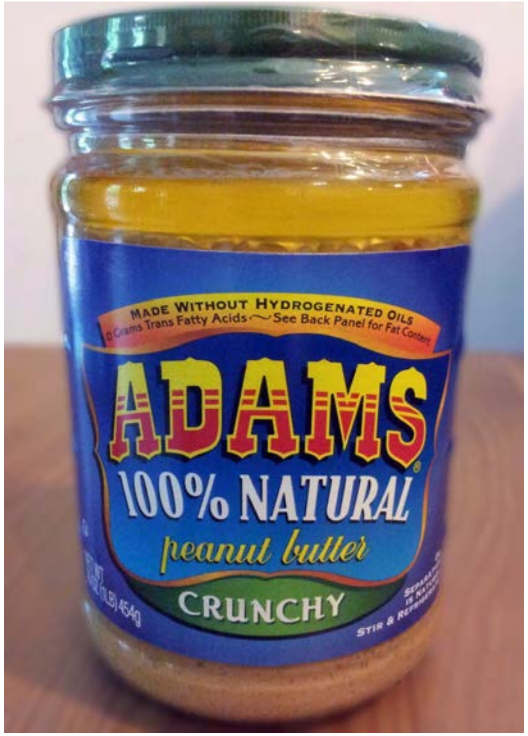


5% sunflower wax in SBO with fast cooling, from reference 4 on last slide

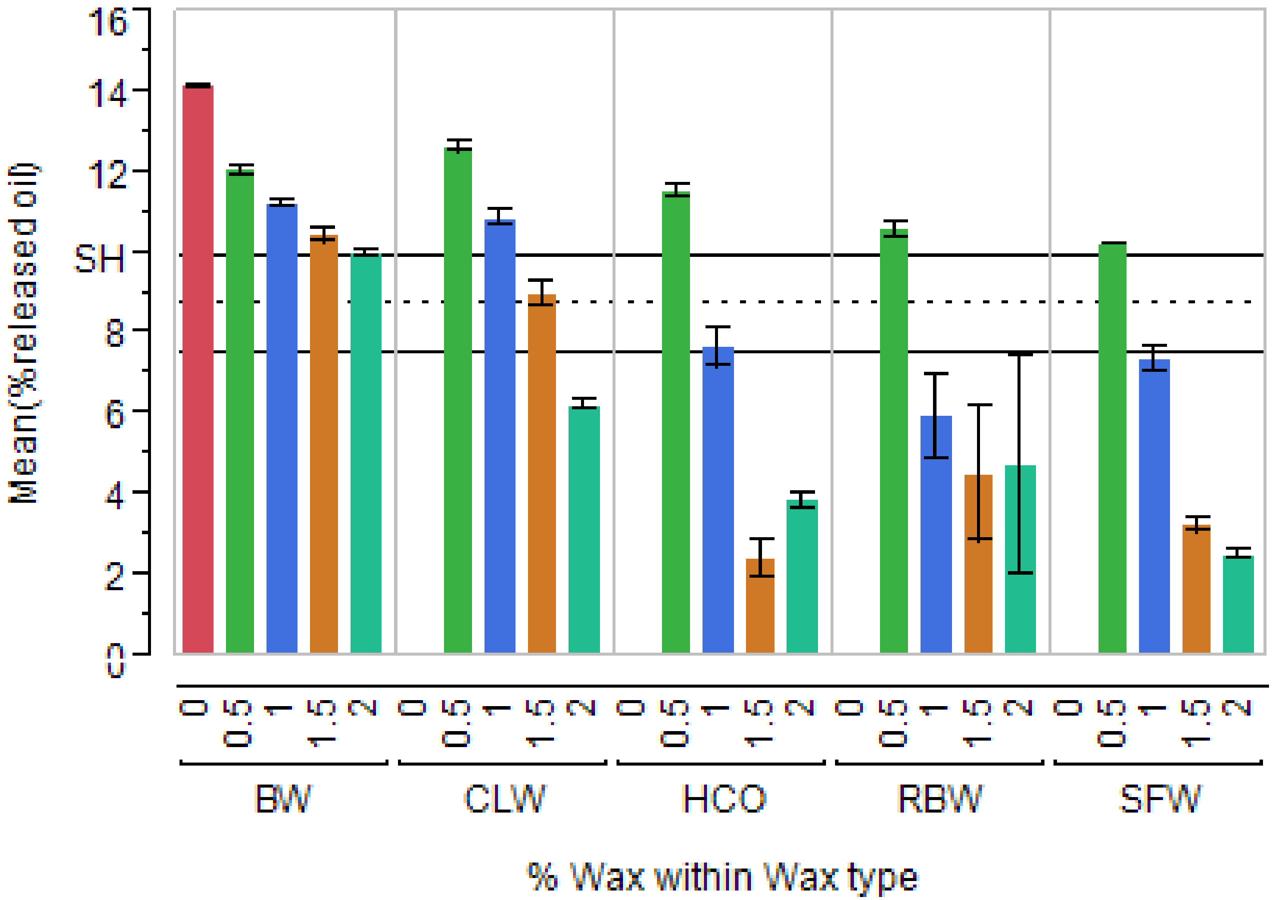
References listed on last slide

Example: Peanut butter

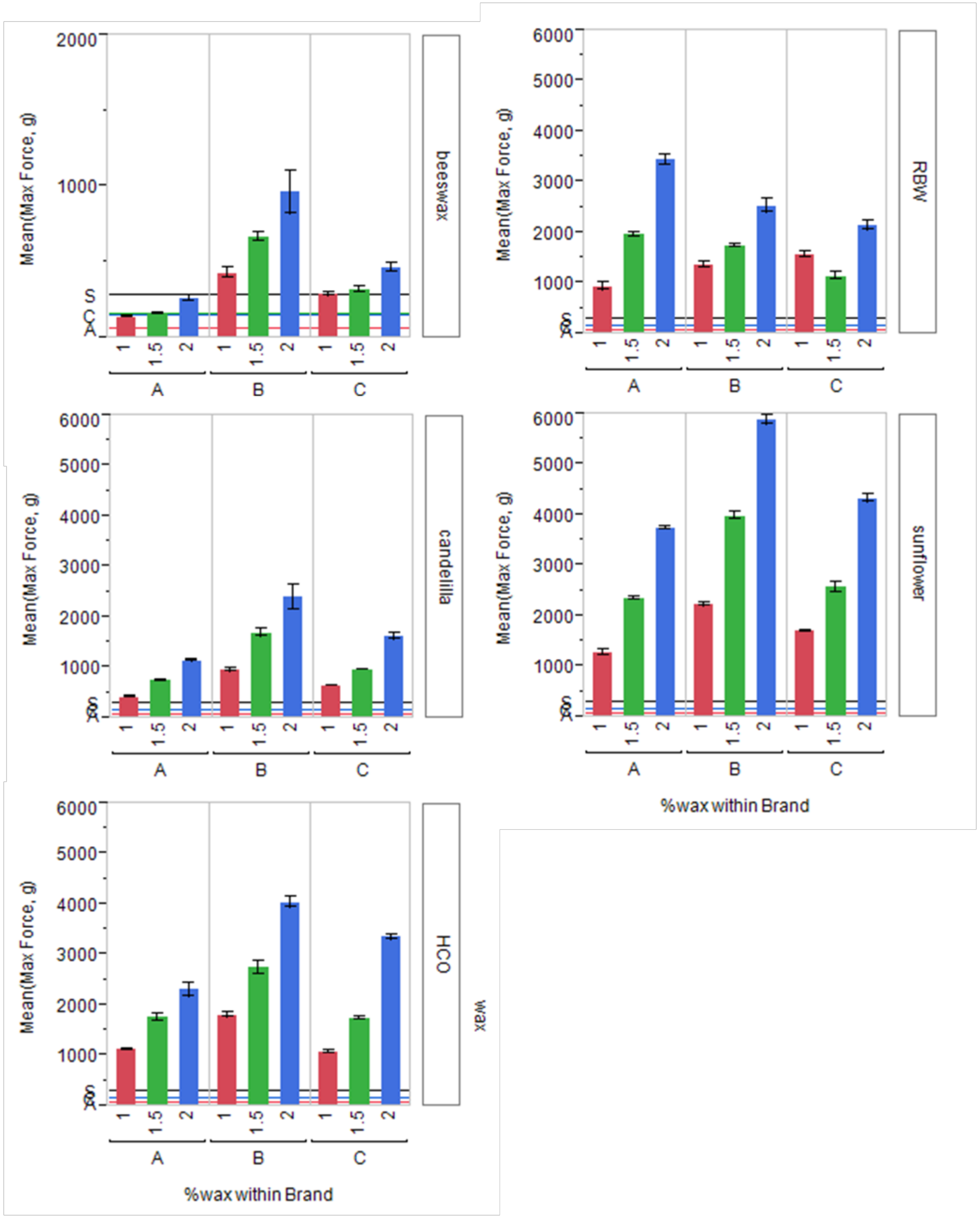
- Hydrogenated oils or palm oil are added to peanut butter to bind excess oil and to improve texture and spreadability
- Four waxes studied for oil binding capacity and texture analysis in peanut butter
  - Beeswax
  - Candelilla wax
  - Rice bran wax
  - Sunflower wax
  - Hydrogenated cottonseed oil –control/reference



Oil binding in peanut butter

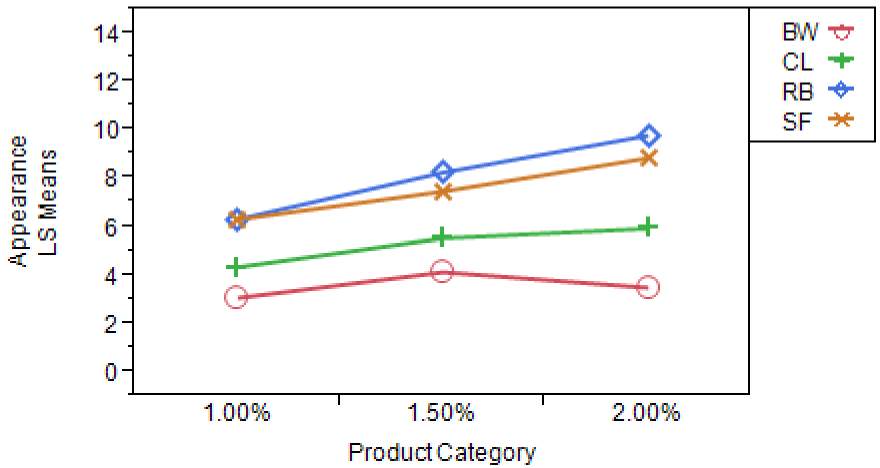


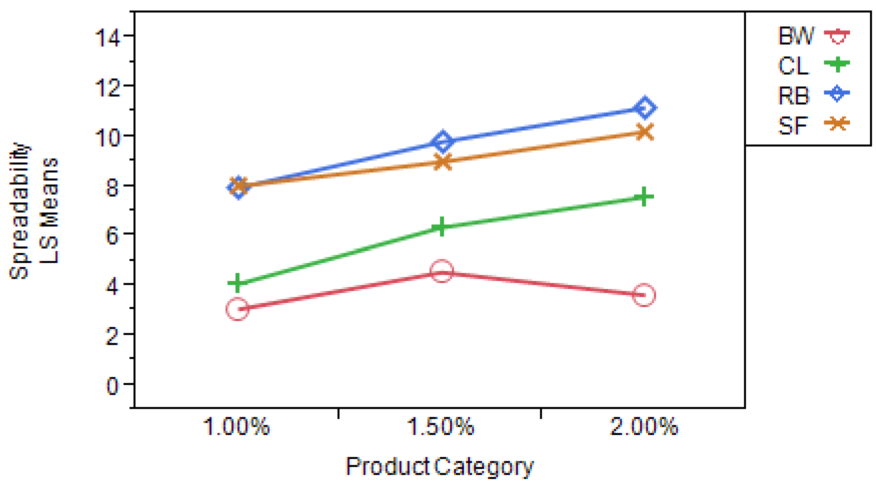
Sunflower wax had the best oil binding property, was not significanntly different from the control



- Measured firmness was higher with sunflower wax and rice bran wax, similar to the control

Sensory Panel: Appearance & Spreadability





Sunflower wax and rice bran wax were less ‘oily’ in appearance

Sunflower wax and rice bran wax had increased spreadability (Skippy)

Challenges and Opportunities

- Excellent oil binding capacity
  - Networks (sunflower, rice bran) do not recover after stirring
  - Interaction with food ingredients
- Sharp melting curve
- High melting point- waxy mouthfeel
- Hydrocarbons and other wax components may have off-flavors of their own
- Residual oil off-flavors/odors-minimize levels
- Availability
- → Minimize wax concentrations
- Opportunities-broaden the physical properties and profiles of wax-based oleogels by combining waxes

Conclusions

- Sunflower oil with increased oleic acid content (NuSun, high oleic) are premium oils for use in the food industry
- New sunflower varieties with altered tocopherol profiles may have improved oxidative stability
  - Frying
- Sunflower wax may be a promising new ingredient for improving functional properties of oils without adding saturated and trans fats.

Thank You !

References not provided on slides

(1) Hwang, H. S.; Kim, S.; Singh, M.; Winkler-Moser, J. K.; Liu, S. X., Organogel formation of soybean oil with waxes. *JAOCS, Journal of the American Oil Chemists' Society* **2012,** *89*, 639-647.

(2) Hwang, H. S.; Singh, M.; Bakota, E. L.; Winkler-Moser, J. K.; Kim, S.; Liu, S. X., Margarine from organogels of plant wax and soybean oil. *JAOCS, Journal of the American Oil Chemists' Society* **2013,** *90*, 1705-1712.

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(5) Hwang, H. S.; Singh, M.; Lee, S., Properties of Cookies Made with Natural Wax-Vegetable Oil Organogels. *J. Food Sci.* **2016,** *81*, C1045-C1054.

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(7) Kim, J. Y.; Lim, J.; Lee, J.; Hwang, H. S.; Lee, S., Utilization of Oleogels as a Replacement for Solid Fat in Aerated Baked Goods: Physicochemical, Rheological, and Tomographic Characterization. *J. Food Sci.* **2017,** *82*, 445-452.

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