



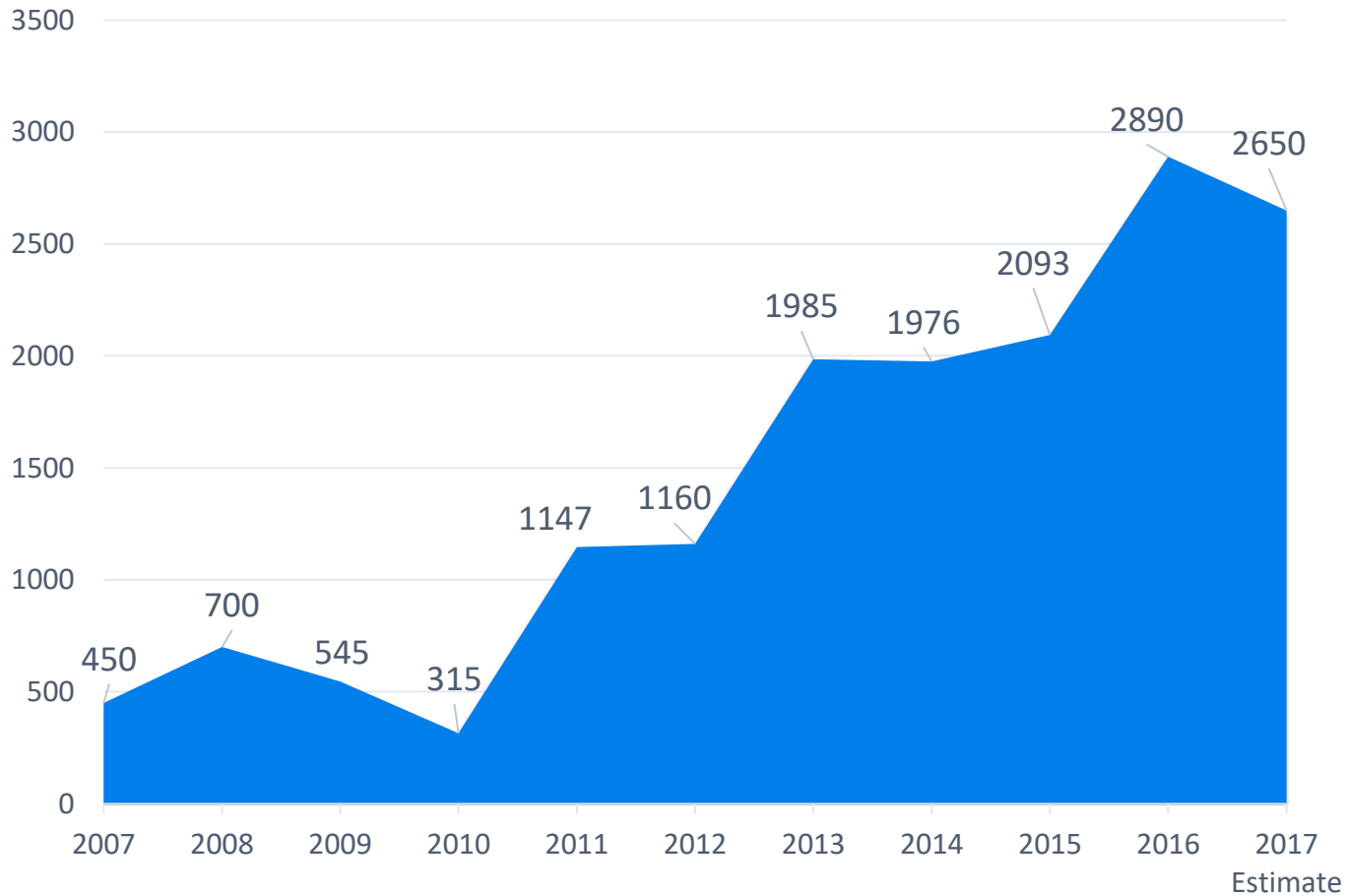
Biodiesel Feedstock Overview

Steven A Howell
September 2018

U.S. Biodiesel & Renewable Diesel Market

(millions of gallons)

Source: EPA EMTS*



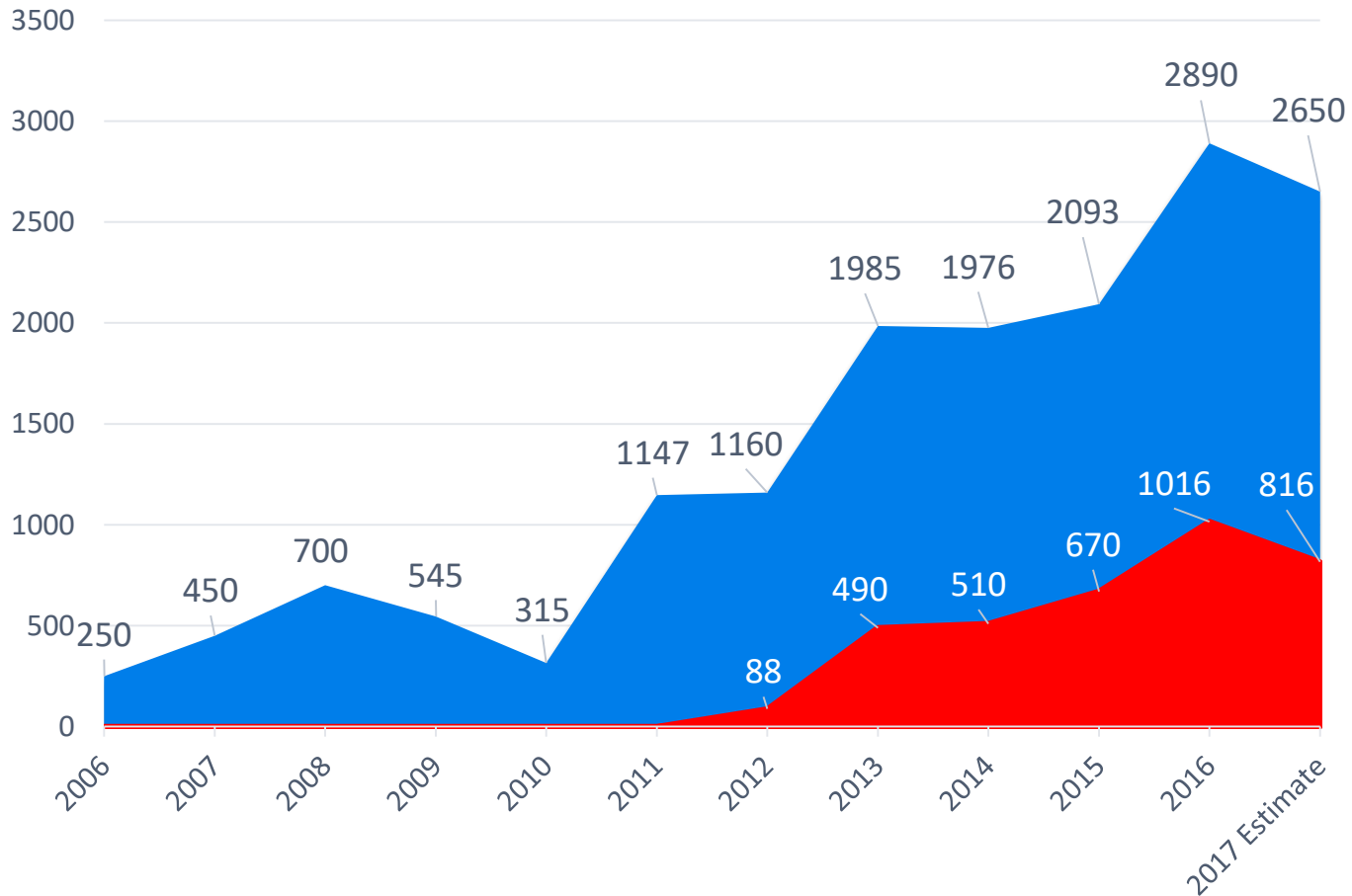
■ Biodiesel and Renewable Diesel

*Volumes reported under the RFS in the D4, D5, and D6 categories.

U.S. Biodiesel & Renewable Diesel Market

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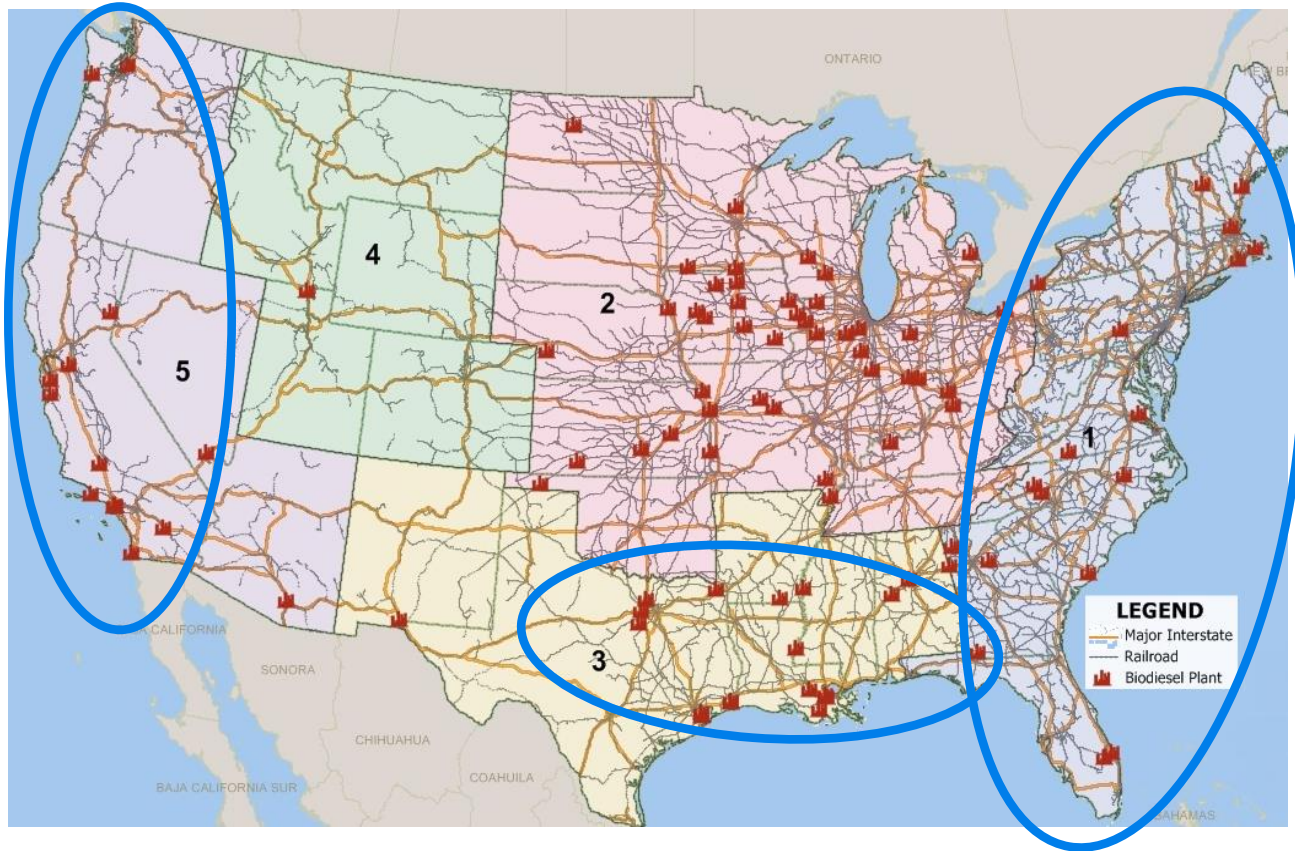
■ Biodiesel and Renewable Diesel

■ Imported fuel

*Volumes reported under the RFS in the D4, D5, and D6 categories.

Biodiesel Has Expanded and Diversified Production Capacity

- Biodiesel production has expanded beyond the Midwest
- New capacity closer to other markets uses diversified feedstocks



Feedstock Options

EPA approved pathways



Distillers Corn Oil



Animal Fats



Soybean Oil



Yellow Grease



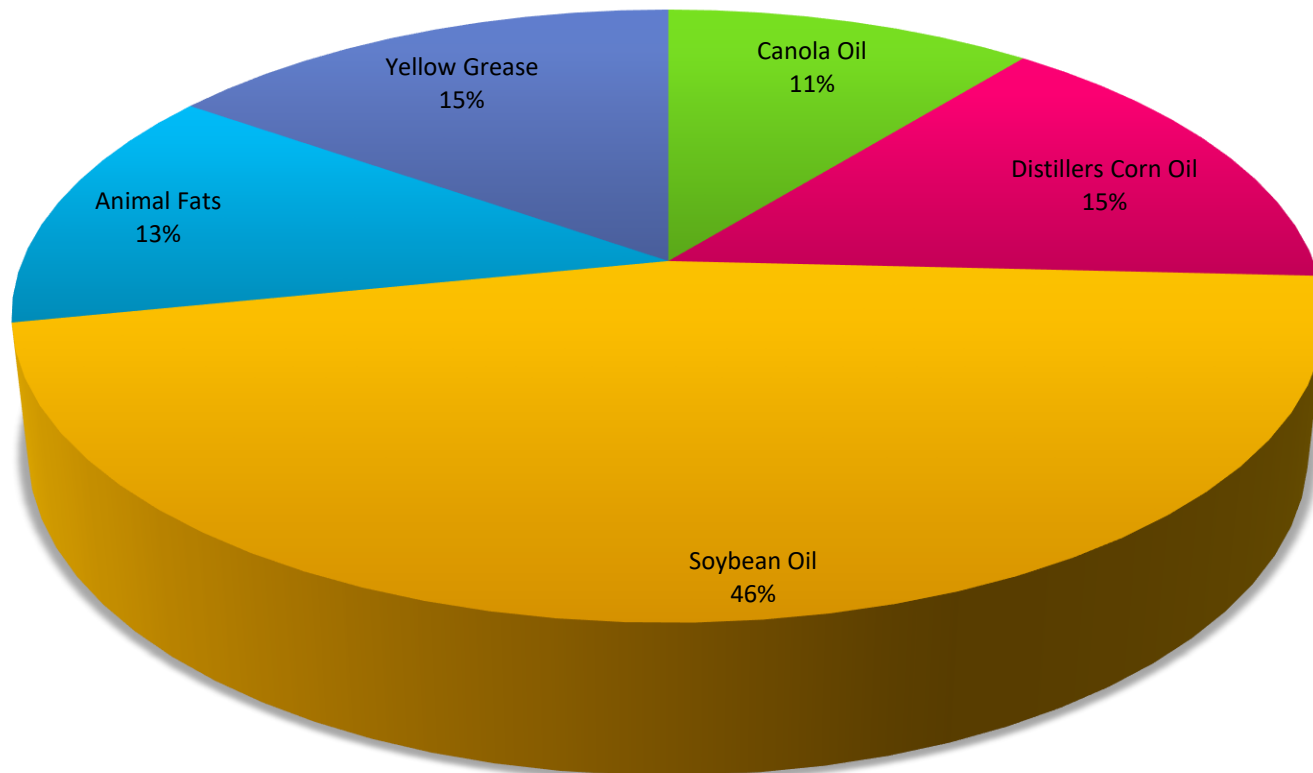
Camelina



Canola Oil

2017 Fats & Oils Use

Biomass-based Diesel



Feedstock Options

EPA approved pathways



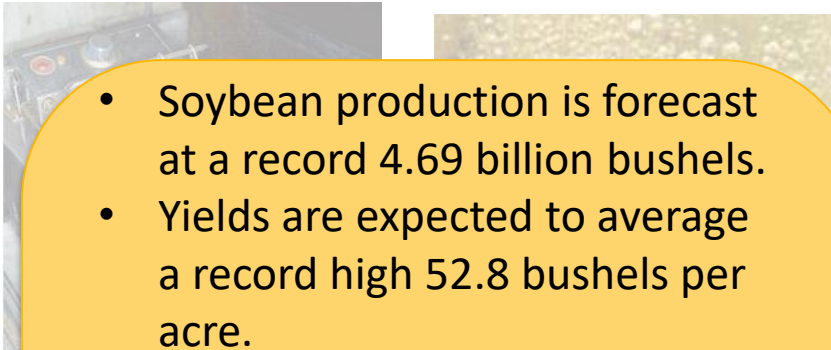
Distillers Corn Oil



Animal Fats



Soybean Oil

- 
- Soybean production is forecast at a record 4.69 billion bushels.
 - Yields are expected to average a record high 52.8 bushels per acre.
 - Soybean yields consistently above trend line.
 - Project ending stocks this marketing year are 450 million bushels greater than ending stocks last year. This equates to a potential of 675 million gallons of additional biodiesel from the oil in those additional beans alone.

Feedstock Options

EPA approved pathways

- LMC international projects that the global waste oil supply will grow from 29.0 million metric tons in 2017 to 31.9 million metric tons in 2020. 31.9 million metric tons of waste oil would be enough to create 9.6 billion gallons of biomass-based diesel.
- Changing consumer demand for vegetarian fed meat has decreased feed demand for yellow grease and UCO. Industry indicates this trend is forecasted to continue.



Yellow Grease



Camelina



Canola Oil

Feedstock Options

EPA approved pathways



Distillers Corn Oil



Animal Fats

- Prior to commercialization of the biodiesel market, DCO was not generated in the US in significant quantities.
- DCO output saw rapid growth between 2010 and 2017, as most ethanol plants invested in extraction capacity and improvements in technology increased yields.
- LMC International estimates output reached almost 4 billion pounds in 2017 and is expected to exceed 4.4 billion pounds in 2018 (over 500 million gallons).



Camelina



Feedstock Options

EPA approved pathways



Distillers Corn Oil



Animal Fats

- USDA's Economic Research Service reported the pork industry has been setting quarterly inventory records almost since 2015.
- This trend exists for the beef and poultry industry as well.
- Animal fat supplies are directly correlated with meat production and US processing capabilities.
- Longer term, the National Renderers Association projects rendered fat supplies (animal fats and used cooking oil) to increase by 14% over the next decade.



Camelina



Feedstock Options

EPA approved pathways



Distillers Corn Oil



Yellow Grease



Camelina



Animal Fats

- Continues to be an important feedstock for biodiesel production. Some expansion of acreage in Great Plains.
- US Canola Association goal to reach more than 3.5 million acres vs. ~2 million currently.



Canola Oil

Feedstock Options

EPA approved pathways



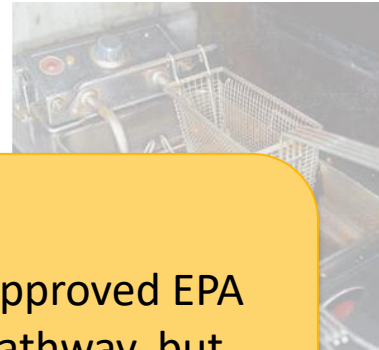
Distillers Corn Oil



Animal Fats



Soybean Oil



Approved EPA
pathway, but
limited
commercial use.



Camelina



Canola Oil



Looking Beyond Current Supplies

Feedstock Options

Pathways with Petitions



Corn Oil from Wet Milling



Cottonseed Oil



Brassica carinata



Field Pennycress

New Winter Annuals

Field Pennycress

- **Significant Opportunity**
 - As a winter annual, could be planted on millions of acres in the Midwest typically left underutilized during the winter.
 - Key will be harvest window and yield impact on the following soybean crop.
- **Key Research Questions**
 - Risk management by producers
 - Line improvement (yield)



New Winter Annuals

Brassica carinata

- *Brassica carinata* (also called Ethiopian mustard), is closely related to rapeseed and prefers cooler weather, making it a suitable crop to grow during the winter months in the southeast US.
- Carinata grain is approximately 45% oil, and the seed meal is approximately 43-46% protein with a low fiber content.
- Per acre production goals are 3,500 pounds of seed.
- Future goals for acreage expansion are ~850,000+ acres in the Southeast United States by 2022 with early maturity and frost tolerance.





Future Innovation

Private Equity Investment in Yield Technology

*Significant that soybean
yields have been above trend
line the past five years.*



Dow AgroSciences



150 Years
Science For A Better Life

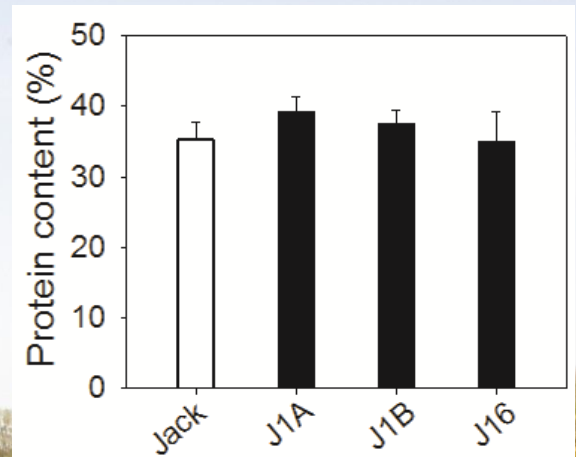
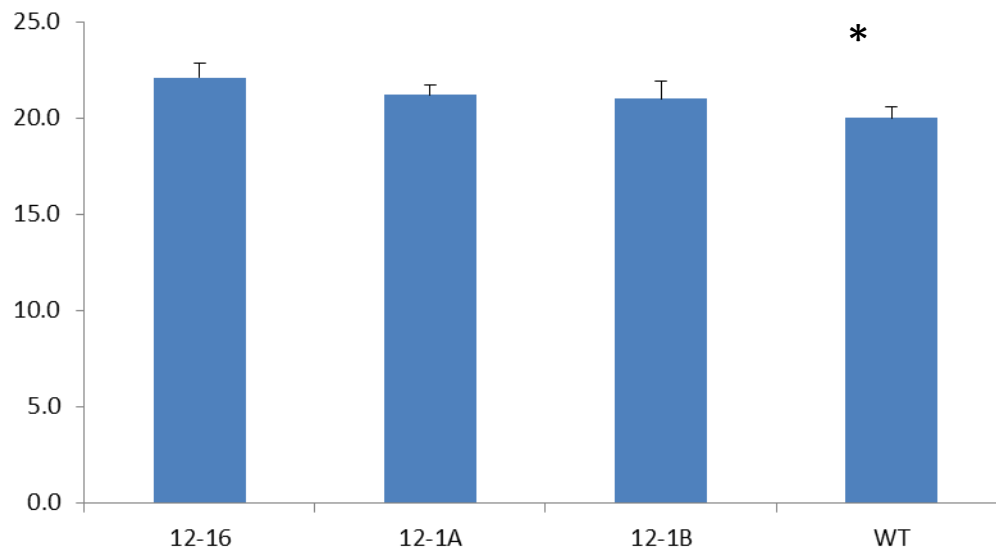


Lipid Content in Soy?

Oil content (%)

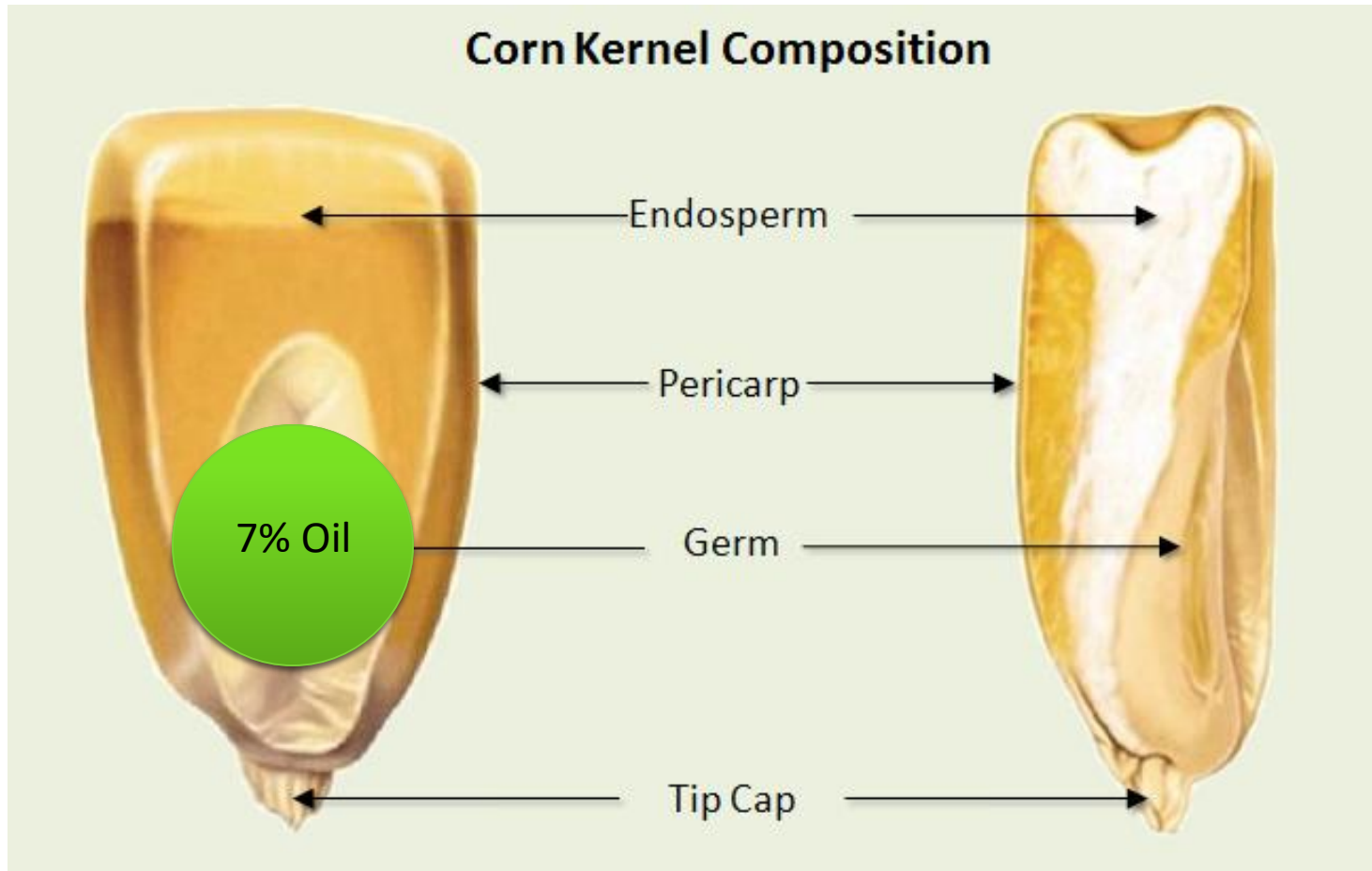
* represent significant differences.

Values are means $\pm$ se (n=12, $P \leq 0.05$)



Soy protein content (%)
quantified by N content.

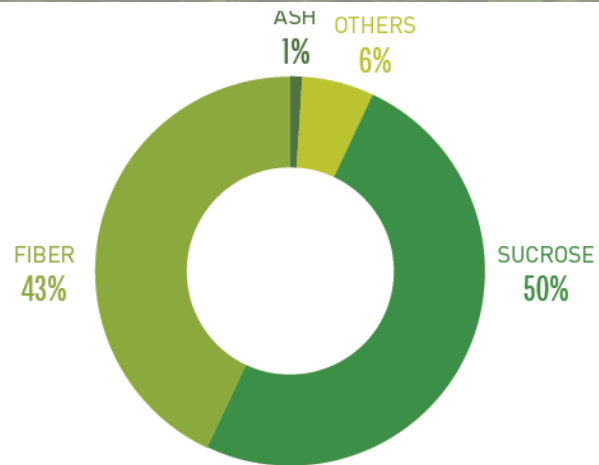
Lipid content in corn?



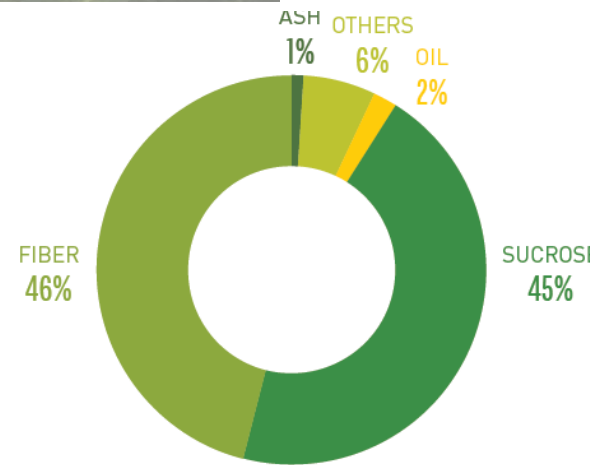


PETROSS

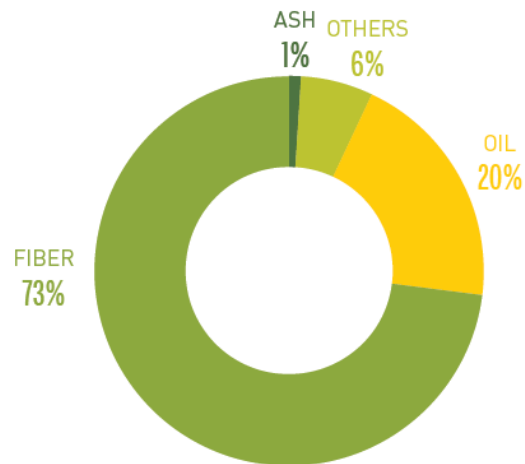
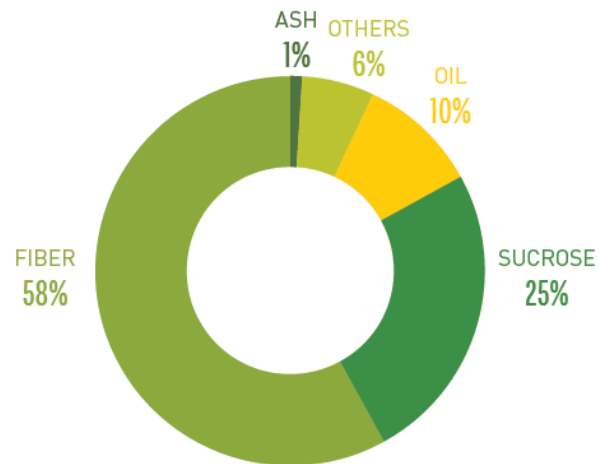
GENETICALLY ADVANTAGED
OIL-PRODUCING
SUGARCANE & SWEET SORGHUM



0% LIPID,
CONVENTIONAL SUGARCANE



2% LIPID CANE



Future Sources & Innovation

- Algal production
- Lipids in leaves
- Interceptor Grease
- Lipids from by-products (meat/bone meal)
- Lipids as co-product of integrated cellulosic bio-refinery process
- Others?????

Near-term Goals



Biodiesel Goes High-Stake with Ten Year Vision – Biodiesel.org

http://biodiesel.org/news/biodiesel-news/news-display/2013/02/05/biodiesel-goes-high-stake-with-ten-year-vision

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Feb 05, 2013
Industry Bets on New 10X22 Goal

NEWS

FOR IMMEDIATE RELEASE

February 5, 2013 **Contact:** Kaleb Little / NBB – (573) 645-3260

(LAS VEGAS) – It's Vegas, and the winning bet is on growth for biodiesel, America's advanced biofuel. American job the industry pushes towards its new 10-year vision: 10 percent of the on-road diesel market by 2022.

"It is not about replacing every drop of petroleum; it is about continuing to diversify transportation energy so we can m sustainably," said National Biodiesel Board CEO Joe Jobe. "Biodiesel will play an increasing role to help protect fuel from unstable energy markets that are grossly distorted by political factors in the most politically unstable region in the companies of totalitarian regimes."

Eight years ago NBB set a goal to be 5 percent of the diesel fuel supply by 2015, a goal then viewed as aggressive. V 2011 and 2012, the biodiesel industry is well on its way to achieve that goal and possibly hit it earlier than expected.

"No one could have predicted the changes and challenges of this industry, but we have been deliberate and intentional as we map our potential," Jobe



4 Billion Gallons by 2022

Steve Howell
ASTM Fellow
AOCS Fellow
M4 Consulting

