Birth of Canola Oil

Overcoming Palatability and Nutritional Barriers through Breeding

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Outline

- What is Canola?
- History of Rapeseed in Canada
- Development of Low Erucic Rapeseed
- Development of Low Erucic/Low Glucosinolate Rapeseed
- Birth of “Canola”
- The “Fathers of Canola”
- Canadian and US Canola
- Canola Oil Utilization
- Trans Fat Issue
- High Stability Canola
- Omega-9 Canola

What is Canola?

Canola refers to seeds of the genus Brassica (*Brassica napus*, *Brassica rapa* or *Brassica juncea*)

A. with less than 30% erucic acid in its fatty acid profile and less that 2 micromoles of glucosinolates/gm of meal

B. with less than 2% erucic acid in its fatty acid profile and less than 10 micromoles of glucosinolates/gram of meal

★ C. None of the above

What is Canola?*

Seeds of the genus Brassica (*Brassica napus*, *Brassica rapa* or *Brassica juncea*) from which

- the oil shall contain less than 2% erucic acid in its fatty acid profile and
- the solid component shall contain less than 30 micromoles of any one or any mixture of:

  3-butenyl glucosinolate

  4-pentenyl glucosinolate

  2-hydroxy-3-butenyl glucosinolate, and

  2-hydroxy-4-pentenyl glucosinolate

  per gram of air-dry, oil-free solid

* Official Definition from Canola Council of Canada

History of Rapeseed in Canada*

- Oil extracted from rapeseed had been used in Asia for thousands of years as a cooking and lamp oil

- With advent of steam engines in the 18th century, it was found that rapeseed oil, with its high levels of erucic acid (C22:1), would adhere to metal surfaces of steam engines better than other oils

- Prior to WW II, Europe and Asia supplied the North American demand for rapeseed oil for use as a marine lubricant

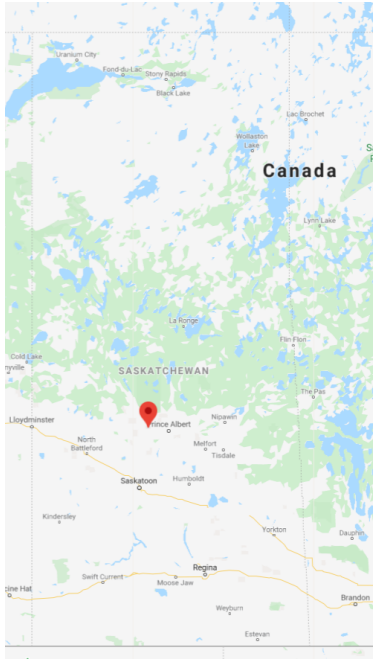
* Downey, R. K., et al. (1970). “Rapeseed, Canada’s Cinderella Crop.” Publication No. 8. Rapeseed Association of Canada. Winnipeg, Manitoba

History of Rapeseed in Canada

- The first rapeseed (*Brassica rapa*) grown in Canada was planted in 1936 by a Polish farmer at Shelbrook, SK in a garden plot

- This species became know as Polish rapeseed in Canada based on its source

- Agronomic research in the 30’s and 40’s showed that rapeseed was well adapted for growing in western Canada



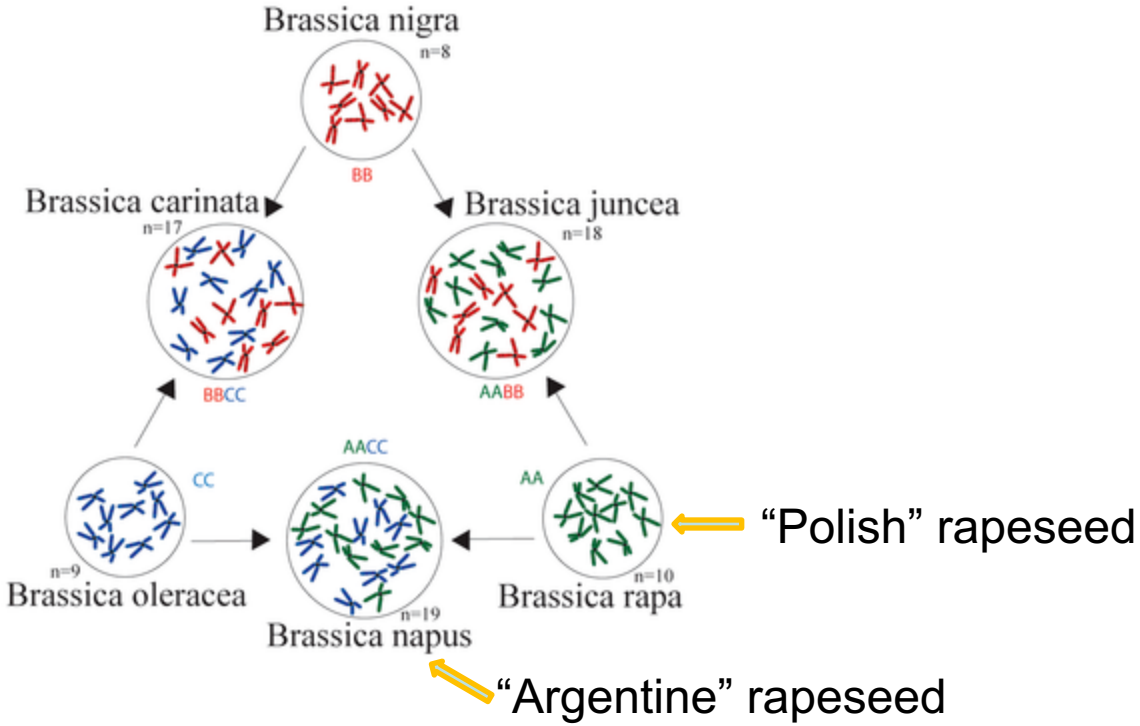
History of Rapeseed in Canada

- During WW II European and Asian supplies of rapeseed were cut off and Canada's need for domestically produced rapeseed became apparent

- T.M. Stevenson of the Canada Dept of Agriculture acquired seed of rapeseed (*Brassica napus*) from sources within Canada and the USA for planting about 3,000 acres in 1943

- As this seed originally came from Argentina, this species became known as Argentine rapeseed in Canada

Relationship of *Brassica* species



- The "triangle of U"* diagram, showing the genetic relationships among six species of the genus Brassica. Chromosomes from each of the genomes A, B and C are represented by different colors.

Source: https://en.wikipedia.org/wiki/Triangle_of_U

*Woo Jang-choon a.k.a. Nagaharu U
1st published in 1935

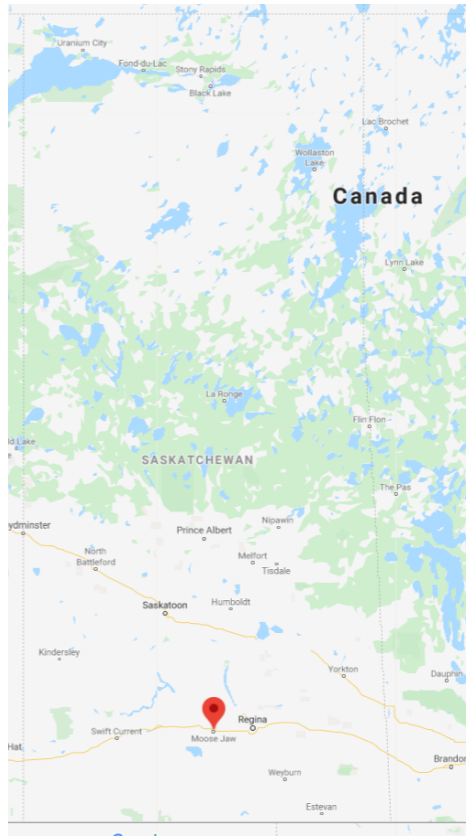
History of Rapeseed in Canada

- The rapeseed acreage increased to 11,000 acres in 1944 and 12,500 acres in 1945

- The first crushing plant in western Canadian, Prairie Vegetable Oils at Moose Jaw SK, opened in 1945

- In 1948, the rapeseed acreage peaked at about 80,000 acres

- However by 1950 the rapeseed acreage decreased to a meager 500 acres due to the removal of the blockades that were present during WW II and the shift from steam engines to diesel engines



History of Rapeseed in Canada

- During the war years, Dr William White had started a rapeseed breeding program at the Dominion Forage Lab in Saskatoon
- Dr Henry Sallans of the National Research Council Oilseeds Lab in Saskatoon worked on the chemistry of rapeseed
- Through their combined efforts the **first** variety of *Brassica napus* rapeseed, “Golden”, was released in 1954
- Golden was a selection from the original Argentine seed stock which was more uniform, earlier in maturity, and higher in seed yield and oil content than the generic seed previously available

History of Rapeseed in Canada

- In the 1960's, breeding programs at Agriculture Canada in Saskatoon and at the University of Manitoba in Winnipeg released a series of rapeseed varieties mostly based on selection and reselection from the original Argentine and Polish seed stocks

Brassica napus

Nugget	1961	Ag Cda	Seln from Argentine
Tanka	1963	U of M	Seln from Golden
Target	1966	U of M	Seln from Tanka

Brassica rapa

Arlo	1958	Sv	Variety from Sweden
Echo	1964	Ag Cda	Seln from Polish
Polar	1969	U of M	Seln from Polish

History of Rapeseed in Canada

- A dedicated group of scientists consisting of Dr Henry Sallans, Dr Burton Craig, Dr Clare Young, Dr Les Wetter and Dr Milton Bell along with their technical teams believed in the potential of the rapeseed crop in western Canada

- They continued to work on finding alternate uses for rapeseed oil to boost the sagging demand

- As a result of these efforts, rapeseed acreage increased from 6,000 acres in 1951 to 760,000 acres by 1960

History of Rapeseed in Canada

- Early canola researchers used distillation techniques for analyzing rapeseed oil composition but this required liters of oil and was labor intensive

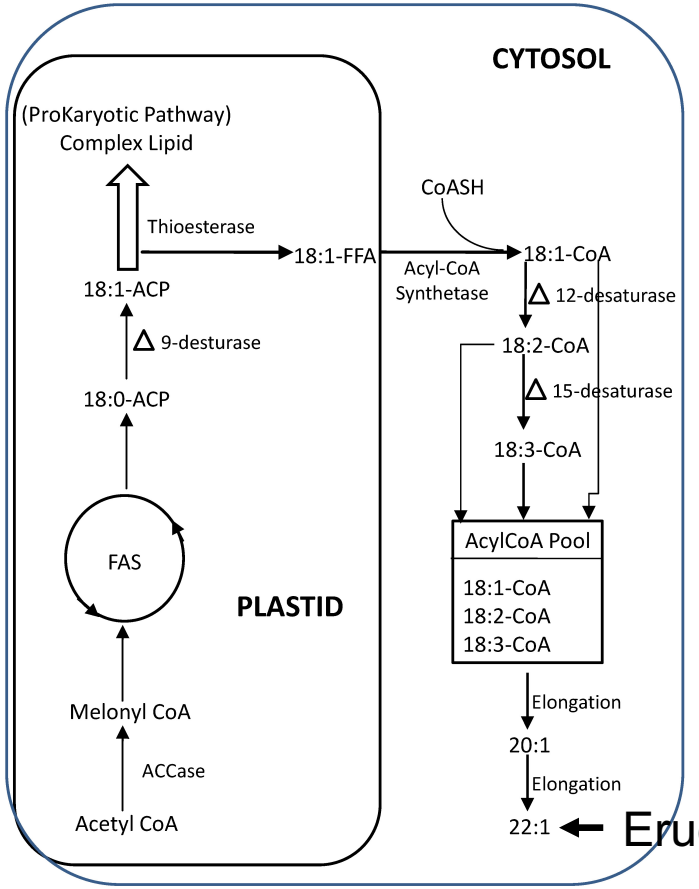
- The application of Gas Liquid Chromatography for analysis of the fatty acid profile of rapeseed oil provided a breakthrough and made it possible for breeders to more effectively make improvements in rapeseed oil composition

- Further refinements in the application of GLC technology to handle smaller sample sizes made it possible to analyze single seeds and eventually a half-seed technique was developed that is still being used by canola breeders today

Challenges to Rapeseed's Future in Canada

- Animal feeding studies being conducted with rapeseed oil suggested a link between erucic acid (C22:1) and fat accumulation around the hearts, skeletal muscle and adrenals of lab rats prompting Health Canada to call for a switch to low erucic acid rapeseed varieties as quickly as possible

- Animal feeding studies had also confirmed that rapeseed meal was goitrogenic when fed to non-ruminant farm animals due to the presence of glucosinolates making it essential that the levels of glucosinolates be reduced in rapeseed meal if it was to be able to compete with soybean meal



Cellular and molecular mechanism of biosynthesis of fatty acids in *Brassica napus* utilizing ACP substrates in the plastid and subsequent reactions on CoA substrates occurring in the cytoplasm (adapted from Slabas *et al.* 2001; Nath 2008). ACCase: acetyl-CoA carboxylase, ACP: acyl carrier protein, FAS: fatty acid synthetase, CoASH: activated CoA. From: Plant Breed. Biotech. 2016 (May) 4(2):123~134

Plant Breeding to the Rescue

- Two Canadian scientists were at the forefront of rapeseed breeding in Canada:
  - Dr Keith Downey at the Canada Agriculture Research Station in Saskatoon SK
  - Dr Downey took over responsibility for the breeding program in 1957

  - Dr Baldur Stefansson at the University of Manitoba in Winnipeg MB
  - Dr Stefansson started at the University of Manitoba in 1952 initially breeding soybeans

Plant Breeding to the Rescue

- Both breeding programs had access to germplasm which had the traits needed to develop varieties with reduced the levels of erucic acid and glucosinolates:
  - Low erucic acid had been identified in the *Brassica napus* line “Liho” in 1959
  - Low glucosinolates were identified in the Polish *Brassica napus* line “Bronowski” in the late 1960’s
- A friendly competition existed between Dr Downey and Dr Stefansson to develop the first low erucic acid rapeseed variety and the first low erucic acid / low glucosinolate rapeseed variety

Development of Low Erucic Acid Rapeseed

- Dr Downey's breeding program at Agriculture Canada in Saskatoon **was the first** to successfully develop a series of low erucic acid cultivars of in both species of rapeseed:

Brassica napus

Oro	1968	Seln from Nugget X Liho
Zephyr	1971	Seln from Oro
Midas	1973	Seln from Target x low C22 line

Brassica rapa

Span	1971	Low erucic selns from Polish & Arlo
Torch	1973	Seln from Span

Development of Low Erucic Acid Rapeseed

Comparative Analysis of Fatty Acid Contents of High / Low Erucic Acid Rapeseed Oils

Oil Type	Major Fatty Acids (%)				
	Palmitic C16:0	Oleic C18:1	Linoleic C18:2	Linolenic C18:3	Erucic C22:1
Polish rapeseed	3.0	32	19	10	23.5
Argentine rapeseed	3.5	22	12	7	40.0
Low erucic acid	**3.0**	**57**	**26**	**11**	**Trace**

Source: https://www.canolacouncil.org/canola-encyclopedia/crop-development/history-of-varietal-development/

Development of Low Erucic/Low Glucosinolate Rapeseed

- Dr Baldur Stefansson's breeding program at the University of Manitoba focused on developing **the first** low erucic acid/low glucosinolate cultivars of *Brassica napus* rapeseed:

Brassica napus			
Tower	1974	U of M	Seln from /Turret/Turret x Liho/ x /Turret/Turret x Bronowski/
Regent	1977	U of M	Same as Tower
Westar	1982	Ag Cda	/SD x S68-2895/Midas/Tower/F4

- The Ag Saskatoon breeding program successfully developed **the first** low erucic acid/low glucosinolate cultivar of *Brassica rapa* rapeseed:

Brassica rapa		
Candle	1977	Seln from crosses between lo C22 *B. rapa*, *B. juncea* and *B. napus* "Bronowski"

Birth of “Canola”

- The industry needed a new name to distinguish the improvements present in low erucic acid / low glucosinolate rapeseed to differentiate it from rapeseed being grown in the rest of the world

- The term “**canola**” (combination of “Canadian” and “oil”) was trademarked in 1978 by The Western Canadian Oilseed Crushers’ Association to distinguish the superior edible products derived from low erucic acid / low glucosinolate rapeseed varieties

- The “**canola**” trademark was transferred to the Canola Council of Canada in 1980

The “Fathers of Canola”

- Through their very significant research efforts, Downey and Stefansson earned themselves the title of the “Fathers of Canola”

Rapeseed

AAFC Saskatoon

Low Erucic Acid Rapeseed (LEAR)
Oro (1968)

University of Manitoba

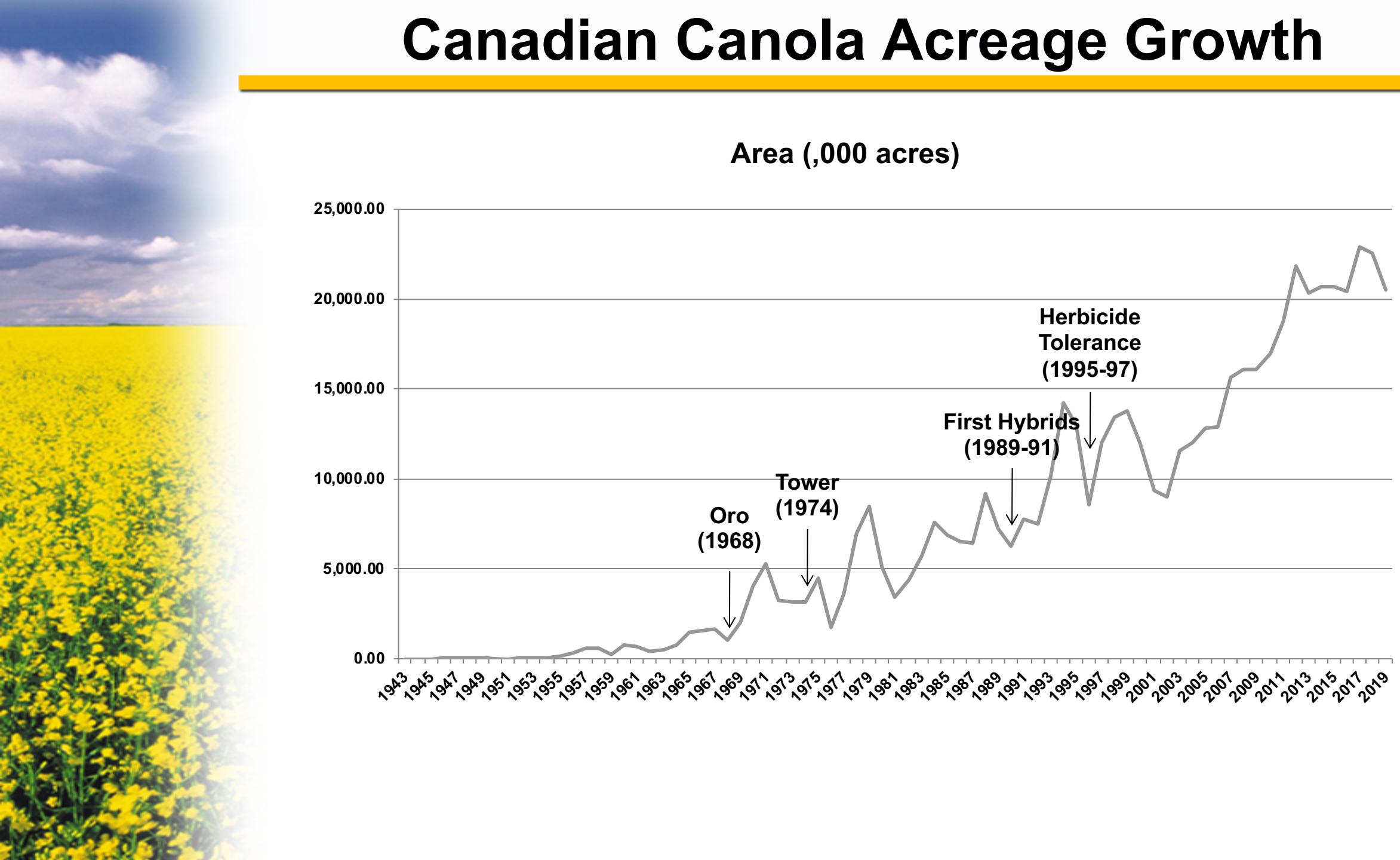
Low Erucic Acid/Low Glucosinolate Rapeseed (Canola)
Tower (1974)

The “Fathers of Canola”

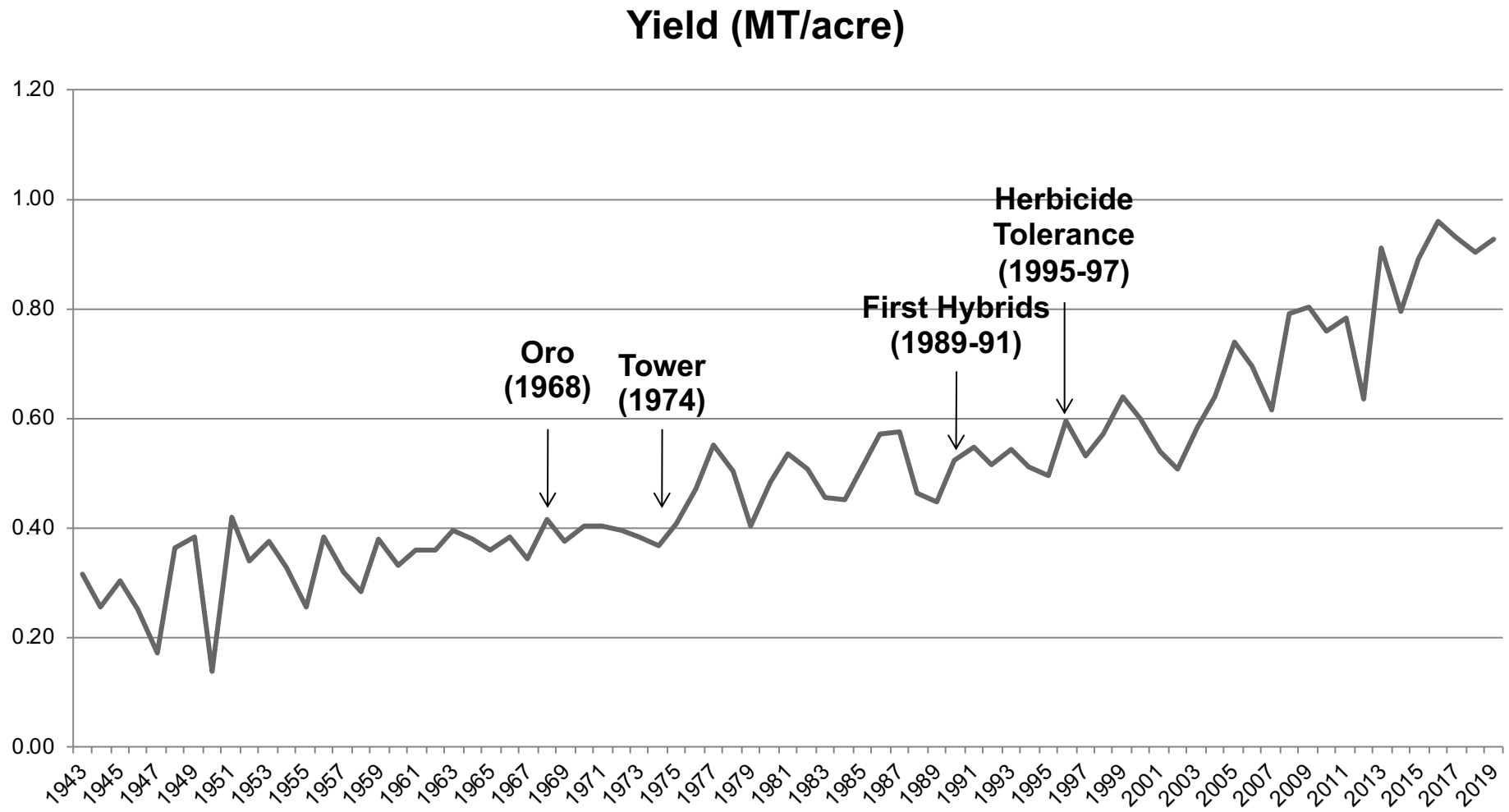
Keith Downey

Baldur Stefansson

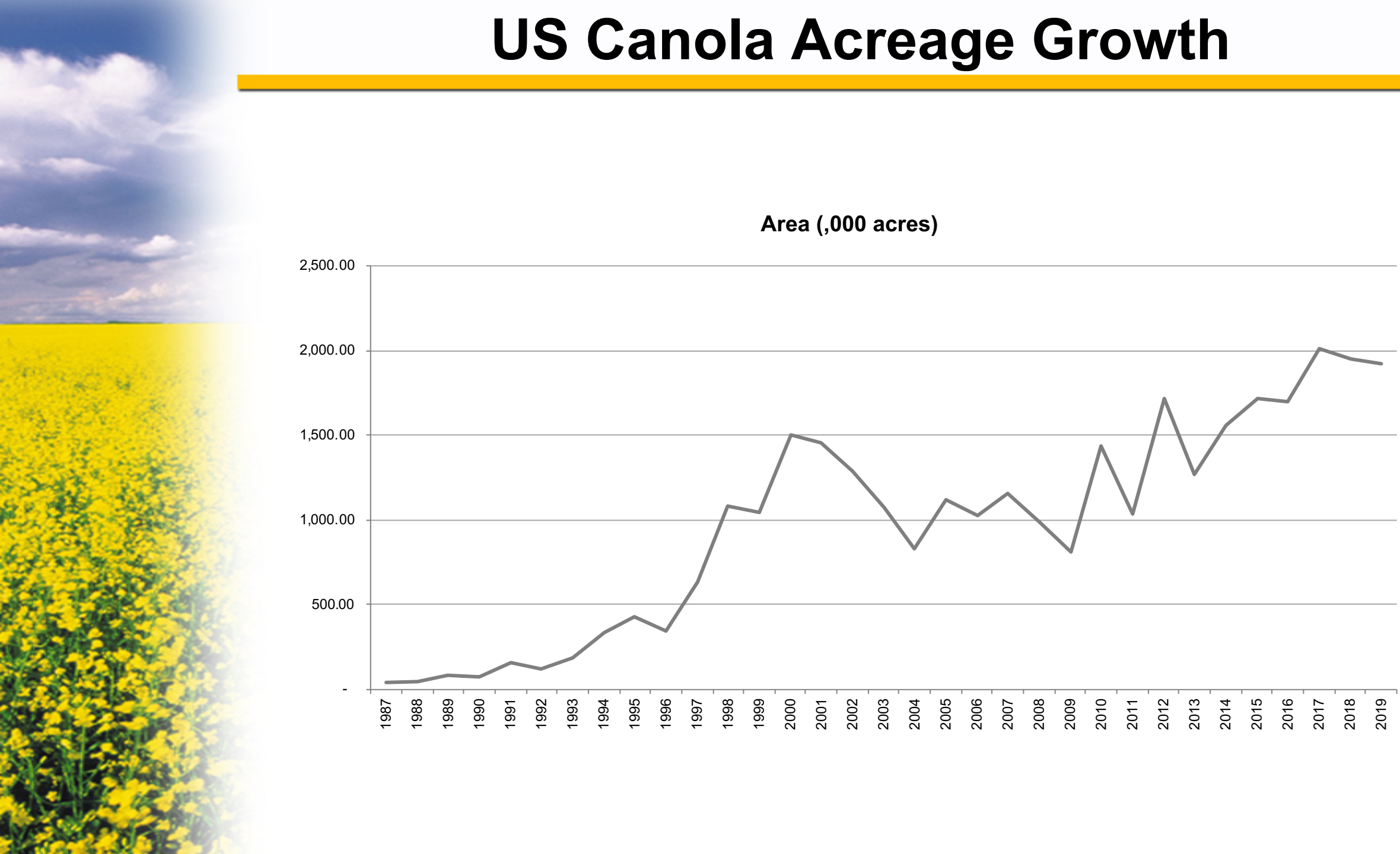
Canadian Canola Acreage Growth



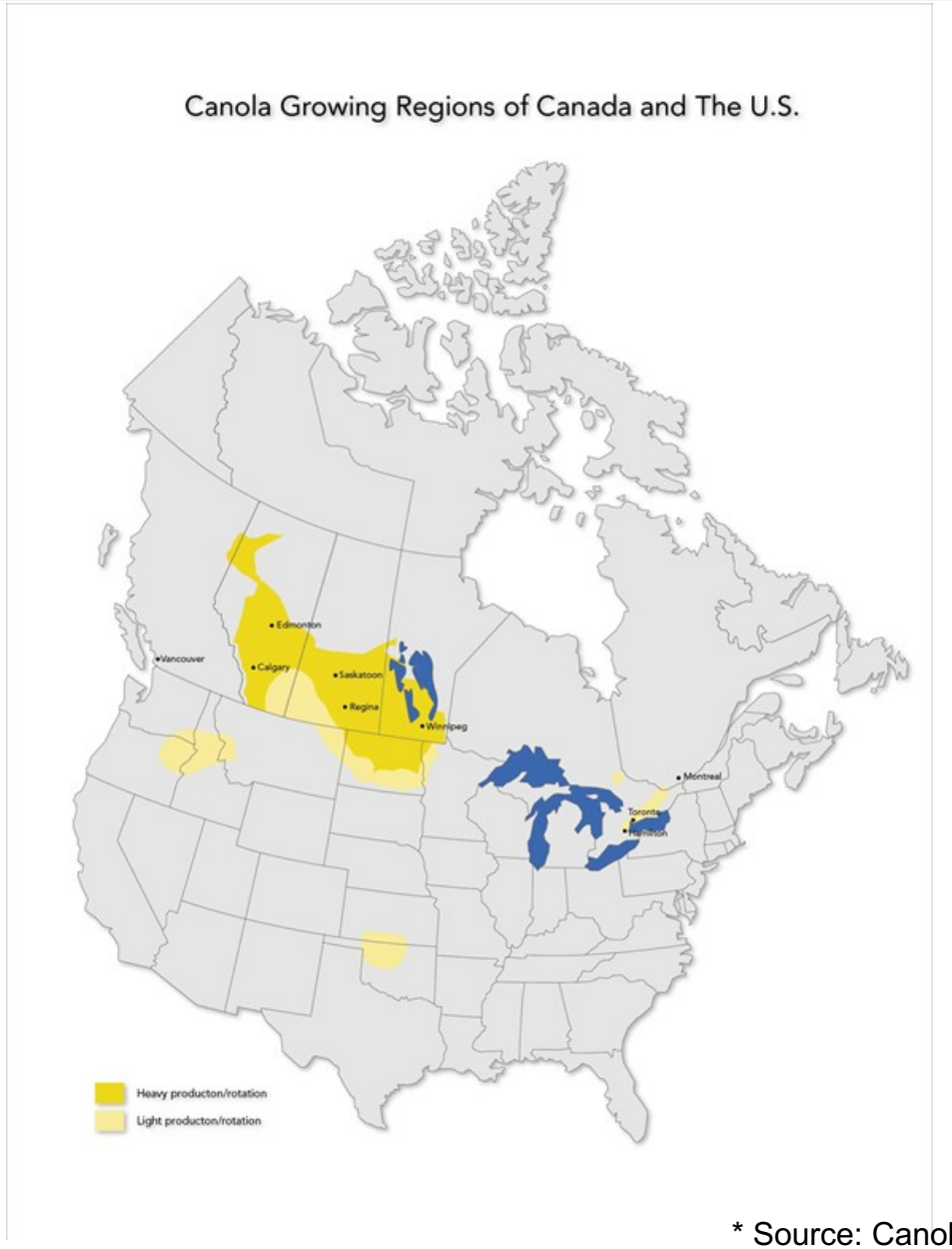
Yield Advancement in Canola



US Canola Acreage Growth



Canola Production Regions in North America



* Source: Canola Council of Canada

Canola Oil Utilization

- Healthy, versatile and light, **canola oil** is highly recommended by chefs, nutritionists and busy homemakers

- It is low in saturated fat, a good source of omega-3 fatty acids and rich in vitamin E

- Because of its light color and taste, canola oil performs equally well in cooking, baking, salads and marinades

Canola Oil Utilization

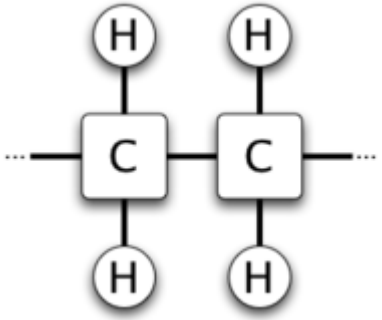
- In October 2006, the U.S. Food and Drug Administration authorized a qualified health claim for canola oil:

  "*Limited and not conclusive scientific evidence suggests that eating about one and a half tablespoons (19 grams) of canola oil daily* ***may reduce the risk of coronary heart disease due to the unsaturated fat content in canola oil****. To achieve this possible benefit, canola oil is to replace a similar amount of saturated fat and not increase the total number of calories you eat in a day."*

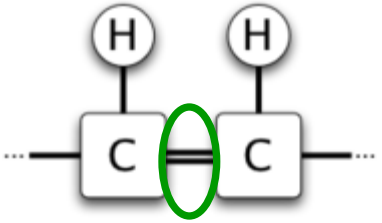
Trans Fat Issue

- Canola oil is a very healthy oil but due to the 10-12% linolenic acid (C18:3) in canola oil it is not well suited for restaurant and food service frying applications which require oils with higher oxidative stability

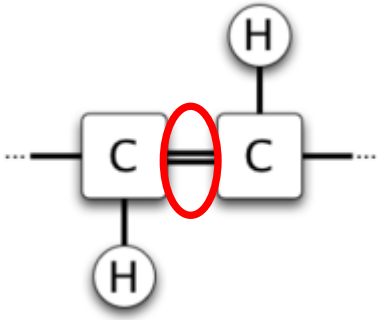
- For these applications, Canola oil was being partially hydrogenated to reduce the level of C18:3 but this process results in the production of trans fatty acids



Saturated fat (mostly in tropical oils and animal fats)



Cis-unsaturated fatty acid (in liquid oils from crops such as soybean, sunflower, canola)



Trans-unsaturated fatty acid (produced by partial hydrogenation of liquid oils)

Trans Fat Issue

- Health studies conducted during the 1990's began to identify the adverse health effects of trans fats in our diets
- Trans fats have been shown to raise LDL (bad) cholesterol and also lower HDL (good) cholesterol
- High LDL along with low HDL levels can cause cholesterol to build up in arteries which increases the risk for heart disease and stroke
- On July 11, 2003, the Food and Drug Administration (FDA) published a final rule in the Federal Register that amended its regulations on food labeling to require that trans fatty acids be declared in the nutrition label of conventional foods and dietary supplements (68 FR 41434).
- This rule went into effect on January 1, 2006.

PHOs and Trans Fats

- In 2015, FDA released its final determination that Partially Hydrogenated Oils (PHOs) are NOT Generally Recognized as Safe (GRAS)
- PHOs are the primary dietary source of artificial trans fat in processed foods. Removing PHOs from processed foods can prevent thousands of heart attacks and deaths each year.
- For the majority of uses of PHOs, June 18, 2018, was the date after which manufacturers could not add PHOs to foods. For products produced prior to June 18, 2018, the FDA extended the compliance date to January 1, 2020 to allow them to work their way through distribution.

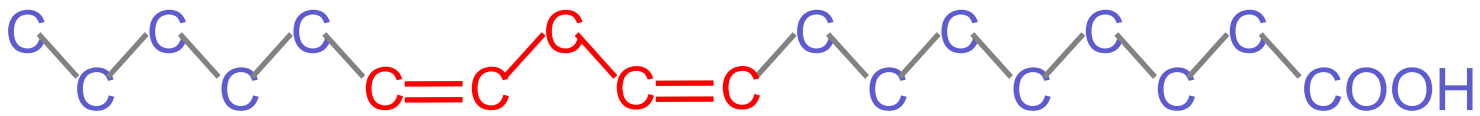
Plant Breeding to the Rescue Again

- To produce a naturally stable canola oil, the level of monounsaturated fatty acids had to be increased and the levels of polyunsaturated fatty acids, especially linolenic acid, had to be reduced

Oleic acid (C18:1) monounsaturate (Omega 9)

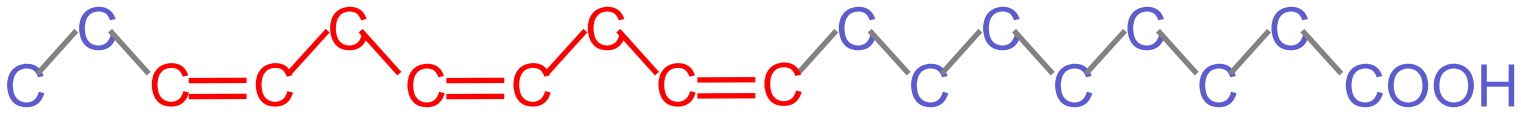
Most Stable Unsaturated Fatty Acid

1X



Linoleic acid (C18:2) polyunsaturate (Omega 6)

45X less stable



Linolenic acid (C18:3) polyunsaturate (Omega 3)

98X less stable

Omega-9 Canola Oil

- Omega-9 canola oil from Dow AgroSciences (now Corteva Agriscience) is one such oil that was developed to meet this need for a canola oil with higher oxidative stability based on mutagenesis and conventional breeding*

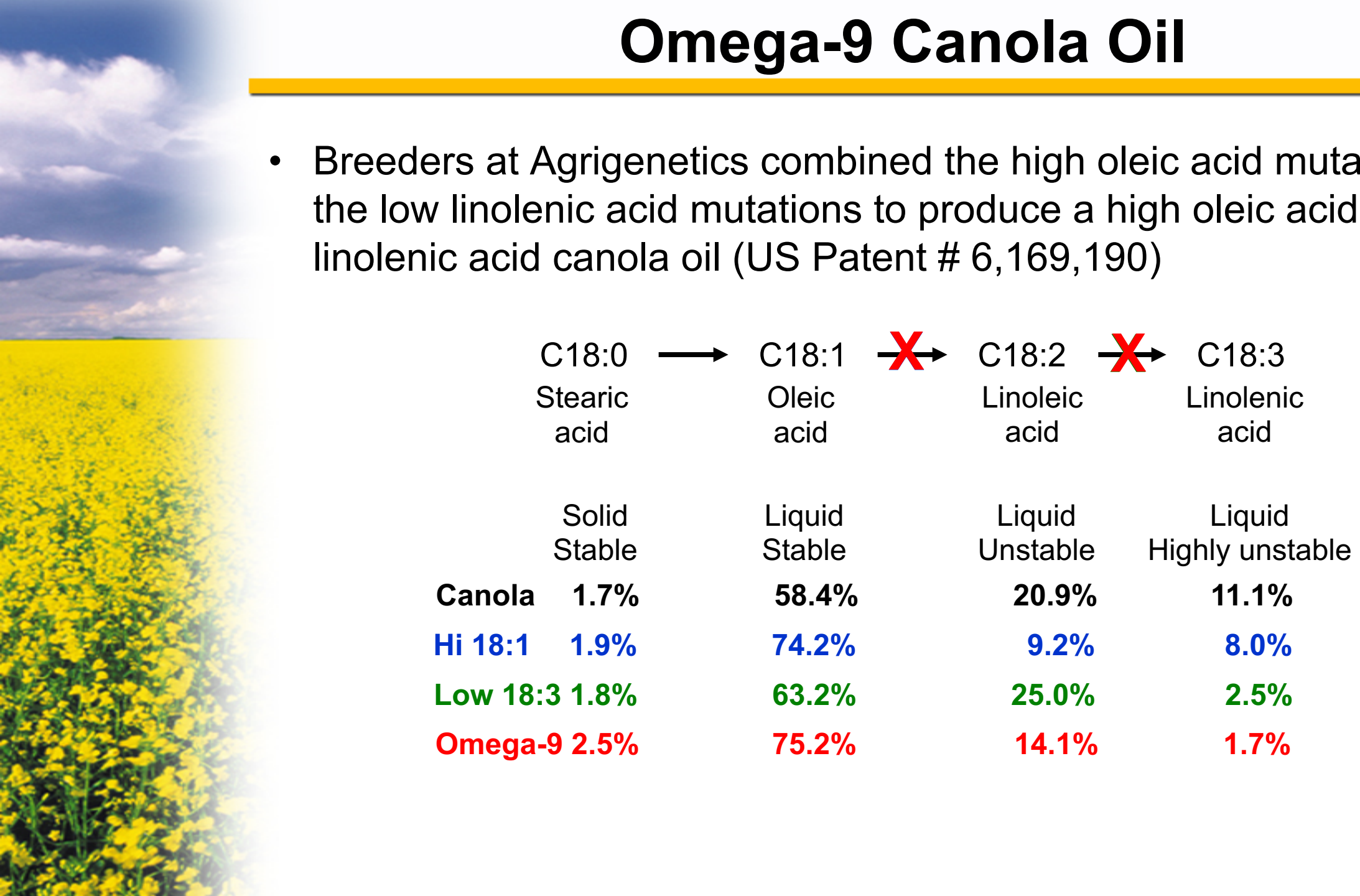
- Dr Gerhard Rakow in Germany had developed mutations blocking the desaturation of linoleic acid to linolenic acid in *Brassica napus*

- Researchers at SunGene Technologies / Agrigenetics / Lubrizol developed a mutation in *Brassica napus* which reduced the desaturation of oleic acid to linoleic acid

* Cargill also markets a high stability canola oil under their Clear Valley Oils brand which is based on mutation work done at DNA Plant Technologies

Omega-9 Canola Oil

- Breeders at Agrigenetics combined the high oleic acid mutation with the low linolenic acid mutations to produce a high oleic acid / low linolenic acid canola oil (US Patent # 6,169,190)



	C18:0 Stearic acid	C18:1 Oleic acid	C18:2 Linoleic acid	C18:3 Linolenic acid
	Solid Stable	Liquid Stable	Liquid Unstable	Liquid Highly unstable
Canola	**1.7%**	**58.4%**	**20.9%**	**11.1%**
Hi 18:1	**1.9%**	**74.2%**	**9.2%**	**8.0%**
Low 18:3	**1.8%**	**63.2%**	**25.0%**	**2.5%**
Omega-9	**2.5%**	**75.2%**	**14.1%**	**1.7%**

Omega-9 Canola Oil

Great Taste, Superior Performance, & Outstanding Health

Oil	OSI	Oleic C18:1	Linoleic C18:2	Linolenic C18:3	Total Sats	Total Trans	Trans + Sats
Omega-9 Canola Oil	OSI 17	73%	15%	<3%	<7%	1%	<8%
Omega-9 Sunflower Oil	OSI 20	87%	5%	0%	9%	<1%	<10%
PH Canola	OSI 10	79	8	<1	11	19	30
Canola	OSI 7	62	20	9	7	2	9
Low Linolenic Canola	OSI 12	64	24	4	7	1	8
PH Soybean	OSI 10	50	31	2	16	20	36
Soybean	OSI 6	23	54	8	15	2	17
Low Linolenic Soybean	OSI 8	26	55	3	16	2	18
Extra Virgin Olive Oil	OSI 12	60	15	1	20	<1	<21

PH = Partially Hydrogenated

- High stability (OSI)
- High Omega-9 (oleic acid) content
- Low linolenic acid content
- Low in saturates and trans fat

Omega-9 Oils™
Canola • Sunflower
Healthier Oils. Healthier Business.™

Omega-9 Canola Oil

- Dow AgroSciences acquired the Agrigenetics breeding program and did an initial production in 1999

- Production was limited in the initial years as market demand was being created but when the required labeling of trans fat came into effect on January 1, 2006, the demand for Omega-9 canola oil and acreage increased substantially

- In 2020, Corteva Agriscience is contracting 1.2 mm acres of their Nexera canola hybrids to meet the demand for Omega-9 canola oil*

* Source: Tyler Groeneveld, Commercial Grains and Oils Leader for North America at Corteva Agriscience

Health Benefit of High Oleic Oils

- On November 19, 2018, the FDA allowed a qualified health claims for oils containing high levels of oleic acid:

  "Supportive but not conclusive scientific evidence suggests that daily consumption of about 1½ tablespoons (20 grams) of oils containing high levels of oleic acid, when replaced for fats and oils higher in saturated fat, may reduce the risk of coronary heart disease. To achieve this possible benefit, oleic acid-containing oils should not increase the total number of calories you eat in a day."

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