

Plant Composition and Climate Change

Influence of climate and climate change on plant oil composition



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Fatty acid composition of selected plant oils, alphabetical order

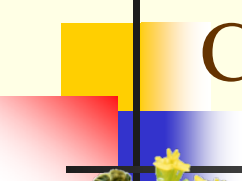
Oil	Unsat./Sat. ratio	Saturated					Mono unsaturated	Poly unsaturated	
		Capric Acid C10:0	Lauric Acid C12:0	Myristic Acid C14:0	Palmitic Acid C16:0	Stearic Acid C18:0	Oleic Acid C18:1	Linoleic Acid (ω6) C18:2	Alpha Linolenic Acid (ω3) C18:3
Canola Oil	15.7	-	-	-	4	2	62	22	10
Cocoa Butter	0.6	-	-	-	25	38	32	3	-
Coconut Oil	0.1	6	47	18	9	3	6	2	-
Corn Oil	6.7	-	-	-	11	2	28	58	1
Cottonseed Oil	2.8	-	-	1	22	3	19	54	1
Flaxseed Oil	9.0	-	-	-	3	7	21	16	53
Grape seed Oil	7.3	-	-	-	8	4	15	73	-
Olive Oil	4.6	-	-	-	13	3	71	10	1
Palm Oil	1.0	-	-	1	45	4	40	10	-
Palm Kernel Oil	0.2	4	48	16	8	3	15	2	-
Peanut Oil	4.0	-	-	-	11	2	48	32	-
Safflower Oil*	10.1	-	-	-	7	2	13	78	-
Sesame Oil	6.6	-	-	-	9	4	41	45	-
Soybean Oil	5.7	-	-	-	11	4	24	54	7
Sunflower Oil*	7.3	-	-	-	7	5	19	68	1

Fatty acid composition of selected plant oils, grouped by optimum temperature for growth

Oil	Adaptation	Unsat./Sat. ratio	Saturated					Mono unsaturated	Poly unsaturated	
	Optimum Temp. for growth		Capric Acid C10:0	Lauric Acid C12:0	Myristic Acid C14:0	Palmitic Acid C16:0	Stearic Acid C18:0	Oleic Acid C18:1	Linoleic Acid (ω6) C18:2	Alpha Linolenic Acid (ω3) C18:3
Canola	< 20°C	15.7	-	-	-	4	2	62	22	10
Safflower	< 20°C	10.1	-	-	-	7	2	13	78	-
Flaxseed	< 20°C	9.0	-	-	-	3	7	21	16	53
Sunflower	< 25°C	7.3	-	-	-	7	5	19	68	1
Grape seed	< 25°C	7.3	-	-	-	8	4	15	73	-
Corn	< 30°C	6.7	-	-	-	11	2	28	58	1
Sesame	< 30°C	6.6	-	-	-	9	4	41	45	-
Soybean	< 30°C	5.7	-	-	-	11	4	24	54	7
Olive	< 30°C	4.6	-	-	-	13	3	71	10	1
Peanut	< 30°C	4.0	-	-	-	11	2	48	32	-
Cottonseed	< 30°C	2.8	-	-	1	22	3	19	54	1
Palm	> 30°C	1.0	-	-	1	45	4	40	10	-
Cocoa Butter	> 30°C	0.6	-	-	-	25	38	32	3	-
Palm Kernel	> 30°C	0.2	4	48	16	8	3	15	2	-
Coconut	> 30°C	0.1	6	47	18	9	3	6	2	-



Climate and fatty acid composition of plant oils



Fatty acid composition of plant oils are confounded by numerous variables

Even so, there are some general rules:

Climate has effects on the fatty acid composition of plant oils

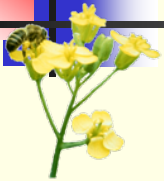
Temperature is the primary climate related variable affecting fatty acid composition of plant oils

Fatty acid composition of plant oils in warmer climates is higher in saturates and mono unsaturates and lower in poly unsaturates than for plant oils in cooler climates





Climate and fatty acid composition of plant oils



General rules continued:

Warmer climate plant oils have lower unsaturated to saturated fatty acid ratios than cooler climate plant oils

Tropical oils have unique short chain (C10:0 and C12:0) saturated fatty acids



Fatty acid composition of selected plant oils, grouped by optimum temperature for growth

Oil	Adaptation	Unsat./Sat. ratio	Saturated					Mono unsaturated	Poly unsaturated	
	Optimum Temp. for growth		Capric Acid C10:0	Lauric Acid C12:0	Myristic Acid C14:0	Palmitic Acid C16:0	Stearic Acid C18:0	Oleic Acid C18:1	Linoleic Acid (ω6) C18:2	Alpha Linolenic Acid (ω3) C18:3
Canola	< 20°C	15.7	-	-	-	4	2	62	22	10
Safflower	< 20°C	10.1	-	-	-	7	2	13	78	-
Flaxseed	< 20°C	9.0	-	-	-	3	7	21	16	53
Sunflower	< 25°C	7.3	-	-	-	7	5	19	68	1
Grape seed	< 25°C	7.3	-	-	-	8	4	15	73	-
Corn	< 30°C	6.7	-	-	-	11	2	28	58	1
Sesame	< 30°C	6.6	-	-	-	9	4	41	45	-
Soybean	< 30°C	5.7	-	-	-	11	4	24	54	7
Olive	< 30°C	4.6	-	-	-	13	3	71	10	1
Peanut	< 30°C	4.0	-	-	-	11	2	48	32	-
Cottonseed	< 30°C	2.8	-	-	1	22	3	19	54	1
Palm	> 30°C	1.0	-	-	1	45	4	40	10	-
Cocoa Butter	> 30°C	0.6	-	-	-	25	38	32	3	-
Palm Kernel	> 30°C	0.2	4	48	16	8	3	15	2	-
Coconut	> 30°C	0.1	6	47	18	9	3	6	2	-

Fatty acid composition of rapeseed oil as affected by temperature*

Nugget Oil	Adaptation	Unsat./Sat. ratio	Saturated					Mono unsaturated		Poly unsaturated	
	Temp. for growth		Capric Acid C10:0	Lauric Acid C12:0	Myristic Acid C14:0	Palmitic Acid C16:0	Stearic Acid C18:0	Oleic + Erucic Acid C18:1 C22:1	Linoleic Acid (ω 6) C18:2	Alpha Linolenic Acid (ω 3) C18:3	
Rapeseed	10°C	19.0	-	-	-	3	2	27 + 44 = 71	15	9	
Rapeseed	16°C	19.0	-	-	-	3.5	1.5	22 + 49 = 71	16	8	
Rapeseed	21°C	19.0	-	-	-	4	1	28 + 45 = 73	17	5	
Rapeseed	26°C	15.7	-	-	-	5	1	38 + 42 = 80	11	3	

* Adapted from Canvin 1965

Rapeseed fatty acid composition fairly stable over temperature

At highest temperature, saturates and mono unsaturates increase and poly unsaturates decrease

At highest temperature, unsaturates to saturates ratio decreases

Fatty acid composition of canola oil as affected by temperature*

Regent Oil	Adaptation	Unsat./Sat. ratio	Saturated					Mono unsaturated	Poly unsaturated	
	Temp. for growth		Capric Acid C10:0	Lauric Acid C12:0	Myristic Acid C14:0	Palmitic Acid C16:0	Stearic Acid C18:0	Oleic Acid C18:1	Linoleic Acid (ω 6) C18:2	Alpha Linolenic Acid (ω 3) C18:3
Canola	15°C/10°C	15.7	-	-	-	3	3	65	19	10
Canola	25°C/20°C	15.7	-	-	-	3	3	64	21	9
Canola	30°C/25°C	15.7	-	-	-	3	3	67	20	7

* Adapted from Deng and Scarth 1998

Canola fatty acid composition fairly stable over temperature

At highest temperature, mono unsaturates increase slightly
and poly unsaturates decrease slightly

Unsaturates to saturates ratio stable for this cultivar in this
temperature range

Fatty acid composition of low linolenic canola oil as affected by temperature*

Stellar Oil	Adaptation	Unsat./Sat. ratio	Saturated					Mono unsaturated	Poly unsaturated	
	Temp. for growth		Capric Acid C10:0	Lauric Acid C12:0	Myristic Acid C14:0	Palmitic Acid C16:0	Stearic Acid C18:0	Oleic Acid C18:1	Linoleic Acid (ω6) C18:2	Alpha Linolenic Acid (ω3) C18:3
Low Linolenic Canola	15°C/10°C	15.7	-	-	-	3	3	66	25	3
Low Linolenic Canola	25°C/20°C	15.7	-	-	-	3	3	62	29	3
Low Linolenic Canola	30°C/25°C	13.3	-	-	-	4	3	67	24	3

* Adapted from Deng and Scarth 1998

Low Linolenic Canola fatty acid composition fairly stable over temperature

At highest temperature, saturates increase slightly and poly unsaturates decrease slightly

At highest temperature, unsaturates to saturates ratio decreases

Fatty acid composition of transgenic high palmitic canola oil as affected by temperature*


GMO High Palmitic Oil	Adaptation	Unsat./Sat. ratio	Saturated					Mono unsaturated	Poly unsaturated	
	Temp. for growth		Capric Acid C10:0	Lauric Acid C12:0	Myristic Acid C14:0	Palmitic Acid C16:0	Stearic Acid C18:0	Oleic Acid C18:1	Linoleic Acid (ω6) C18:2	Alpha Linolenic Acid (ω3) C18:3
Elm TE GMO canola	20°C/15°C	1.7	-	-	7	28	2	40	16	7
Elm TE GMO canola	25°C/20°C	1.3	-	-	9	32	2	34	19	4
Cuphea TE GMO canola	20°C/15°C	2.0	-	-	1	30	2	42	18	7
Cuphea TE GMO canola	25°C/20°C	1.1	-	-	3	43	2	31	18	3

* Adapted from Tang, Scarth and McVetty 2004

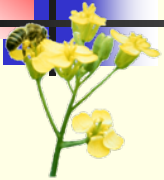
Transgenic High Palmitic Canola fatty acid composition changes over temperature

At higher temperature, saturates increase, mono unsaturates decrease and poly unsaturates decrease slightly

At higher temperature, unsaturates to saturates ratio decreases



Climate change effects on fatty acid composition of plants oils




Average temperature increases during the growing season will affect fatty acid composition of plant oils

As average temperature increases, saturates and mono unsaturates will increase, while poly unsaturates will decrease

As average temperature increases, the unsaturates to saturates ratio will decrease





Climate change effects on fatty acid composition of plants oils


As average temperature increases, warm season crops will replace cool season crops

This crop replacement will increase saturates and mono unsaturates and decrease poly unsaturates

This crop replacement will lower the unsaturates to saturates ratio

This is a simplified version of the effects of climate change on fatty acid composition of plant oils





Petro Diesel composition compared to the fatty acid composition of plants oils

Petro diesel is a mixture of ~75% saturated and ~ 25% aromatic hydrocarbons ranging in size from $C_{10}H_{20}$ to $C_{15}H_{28}$

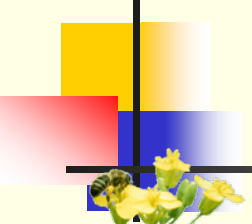
Commonly observed plant oils range in size from $C_{10}H_{20}O_2$ to $C_{22}H_{42}O_2$

The presence of O_2 in the fatty acids has mostly beneficial effects in biodiesel

Tropical plant oils most closely resemble petro diesel

High quality biodiesel can be made from a range of plant oils, including those high in C18 fatty acids






Climate change effects on fatty acid composition of plants oils - Canadian R&D

Canadian crops and Canadian agriculture must adapt to climate change

Total plant oil supply in Canada must increase significantly to provide the plant oil feed stocks required to meet Canada's increasing plant oil demands

Canada must conduct agronomy, breeding, genetic, genomic, pathology, physiology and processing R&D in current and new oilseed crops to ensure an adequate supply of plant oils for edible, industrial and biofuel end uses





Climate change effects on fatty acid composition of plants oils - Canadian R&D

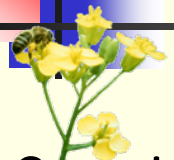
Canada may need to develop plant oils with unique fatty acid composition for use in next generation diesel engines

Biodiesel from plant oils will be a significant contributor to “A Sustainable Biofuel Economy in Canada” for the foreseeable future





References



Canvin, D.T. 1965. The effect of temperature on the oil content and fatty acid composition of the oils from several oil seed crops. *Can. J. Bot.* 43: 63-69.

Deng, X. and Scarth, R. 1998. Temperature effects on fatty acid composition during development of low-linolenic oilseed rape. *J. Am. Oil Chem. Soc.* 75:759-766.

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