A Review of the Impact of Extraction Conditions and Seed Quality on Canola Oil Characteristics

Greg Hatfield, Bunge North America

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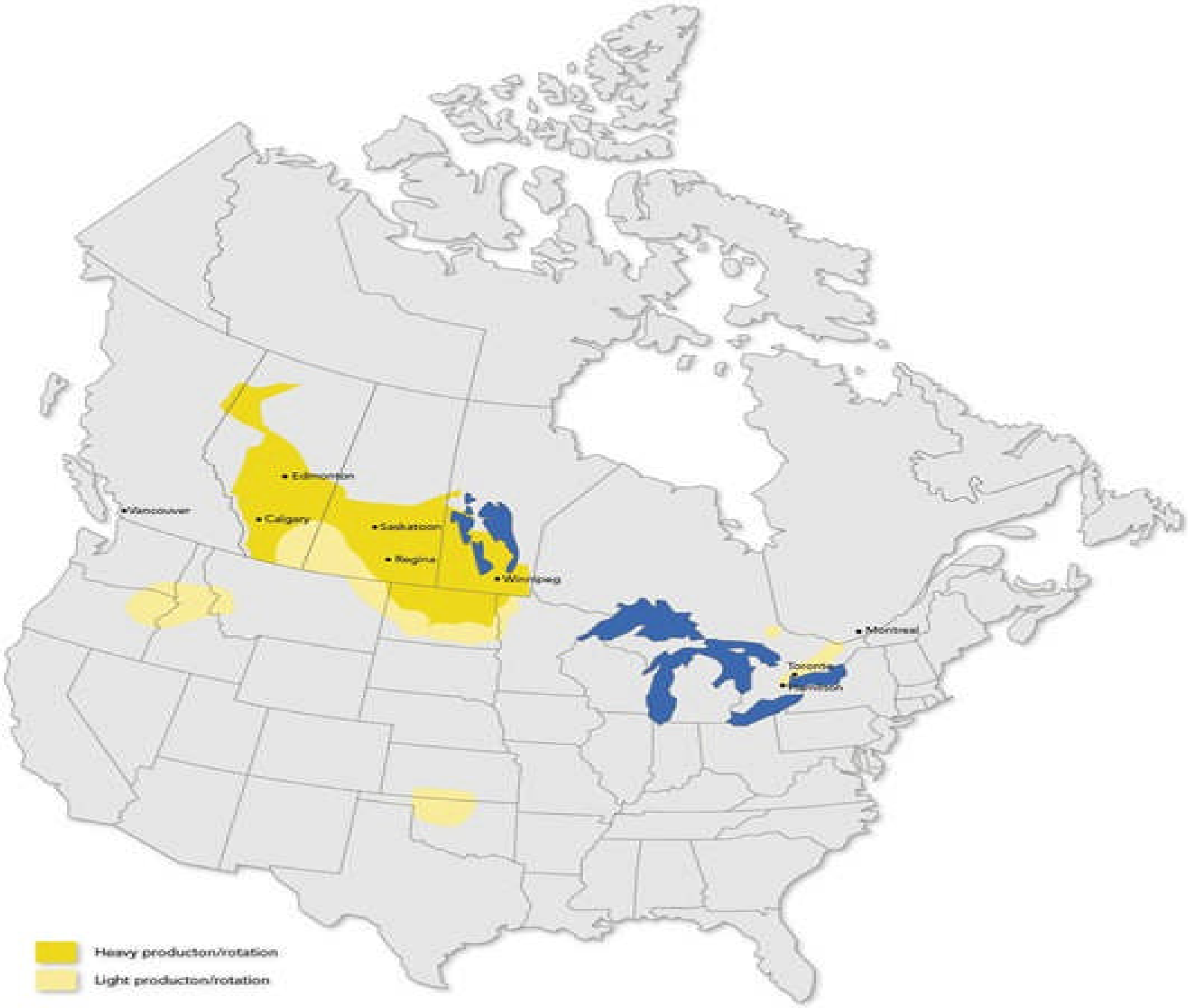
Presentation Outline

- Comparison of Canadian and Australian canola seed
- Impact of conditioning and seed quality on oil characteristics
- Effect of chlorophyll and sulfur on processing

Canola Growing Regions of Canada and The U.S.



From Canola Council of Canada

2007 Canola Production

	Australia	Canada
Production (kilotonne)	1069	8802
Seeded Area (kilohectare)	758	5876
Average Yield (tonne/hectare)	1.41	1.50

From *Quality of Western Canadian Canola – 2007*, Canadian Grain Commission
Quality of Australia Canola 2007/08, AOF & NSW Dept. of Primary Ind.

Seed Quality

	Australia 2007	Australia Average '96 – '06	Canada 2007	Canada Average '96 – '06
% oil in seed (8.5% moisture basis)	42.8	40.4	43.4	43.1
% protein content (oil free meal, 8.5% moisture basis)	40.6	39.0	41.2	40.8
Glucosinolates µg/g (8.5% moisture basis)	8	7	10	11
Chlorophyll mg/kg	-	-	15	14

Adapted from *Quality of Australia Canola 2007/08,* AOF & NSW Dept. of Primary Ind.
From *Quality of Western Canadian Canola – 2007,* Canadian Grain Commission

Oil Quality

	Australia 2007	Australia Average '96 – '06	Canada 2007	Canada Average '96 – '06
C18:1 (%)	59.7	60.4	61.5	61.2
C18:3 (%)	11.0	10.3	9.8	9.9
C22:1 (%)	0.0	-	0.04	0.15
Sat F.A. (%)	7.4	7.1	7.0	7.1
Iodine value	116.6	-	113	113

From Quality of Western Canadian Canola – 2007, Canadian Grain Commission
Quality of Australia Canola 2007/08, AOF & NSW Dept. of Primary Ind.

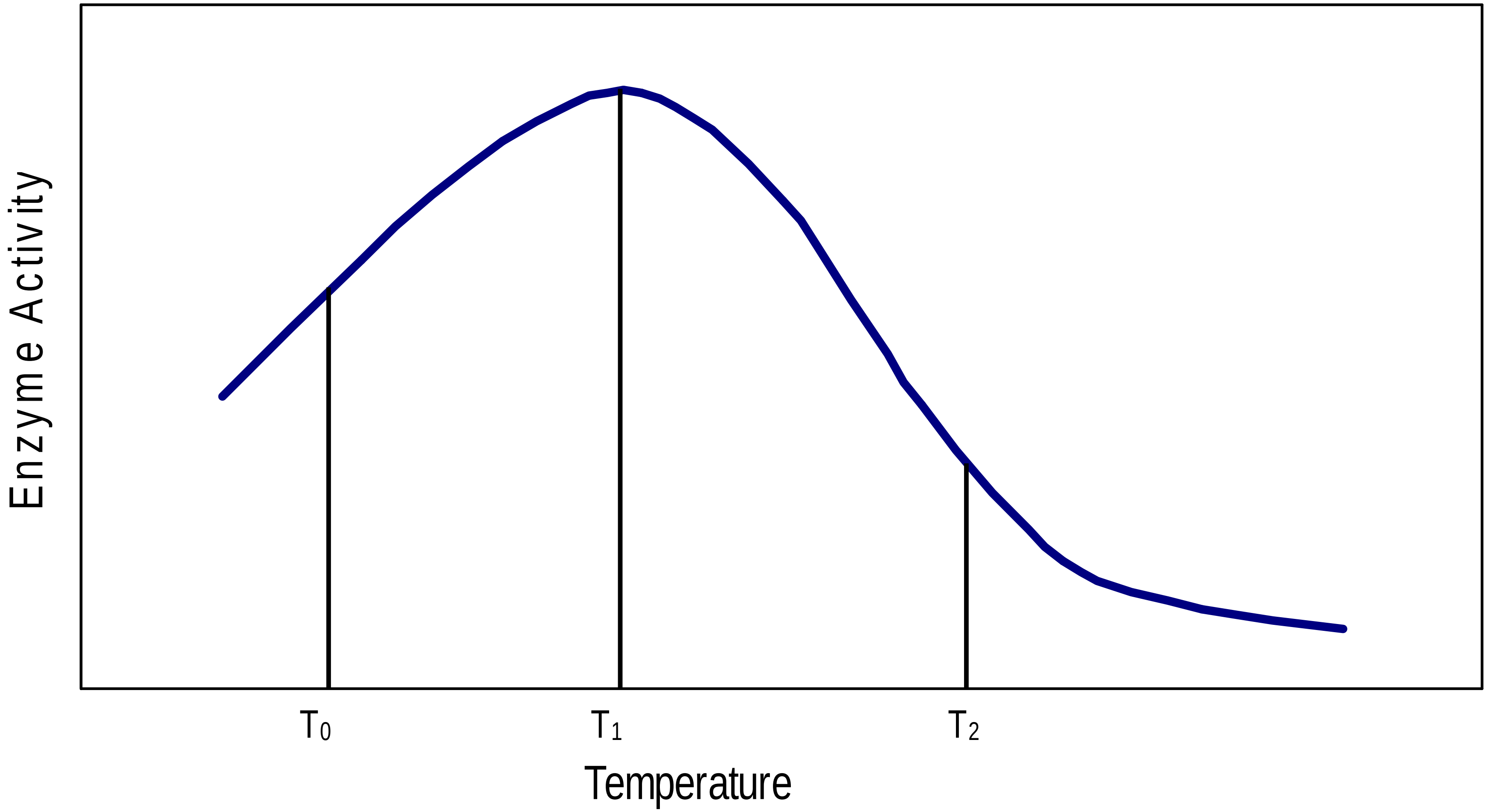
Impact of Conditioning and Seed Quality on Oil Characteristics

Enzyme Activity

- Enzymes accelerate the production of undesirable compounds in the crude oil

- Two parameters affect enzyme activity
  - temperature
  - seed structure

Temperature Effect on Enzyme Activity



Seed Structure

- Enzymes are usually isolated in the seed
- Damaged seed increases oil exposure to enzymes
- If the seed structure has been damaged for some time, then the impact on oil quality will be significant
- Examples are split seeds, insect and mould damage
- Degradation can be controlled if time is minimized

Sulfur

- Canola seed contains glucosinolates

- Myrosinase breaks down glucosinolates during seed preparation to form isothiocyanates and thiocyanates

- These compounds remain in the oil when extracted from the seed.

Sulfur

Myrosinase Deactivation – Indirect Heating

(Appelqvist, *J Sci Fd Agric*, 1967)

4% moisture in seeds

90 ^{o}C for 15 min. $\longrightarrow$ little deactivation

6-8% moisture in seeds

90 ^{o}C for 15 min. $\longrightarrow$ total deactivation

Kozlowska (*World Conf Proc,*1992)

6-9 min. of steam deactivated myrosinase

Phosphorus

- Especially concerned with formation of nonhydratable phosphatides (NHP) in the oil
- NHP are more difficult to remove than hydratable phosphatides
- NHP are phosphatidic acids from degraded phospholipids
- Phospholipase converts phospholipids to NHP

Phosphorus

- Factors affecting NHP content in seeds

    - Early frost

    - Wet harvest/storage conditions

    - Spontaneous heating in storage

Phosphorus

Phospholipase Deactivation

Steam Heating of Flaked Soybeans (List, *JAOCS*, 1990)

Exposure Time (s)	% Enzyme Deactivated
30	0
60	7.3
120	23.5
180	95.8
240	99.8

Phosphorus

List (*JAOCS*, 1990)

- Flakes had 1.5-1.8 times the enzyme activity of whole soybeans
- Thinner flakes resulted in more enzyme activity

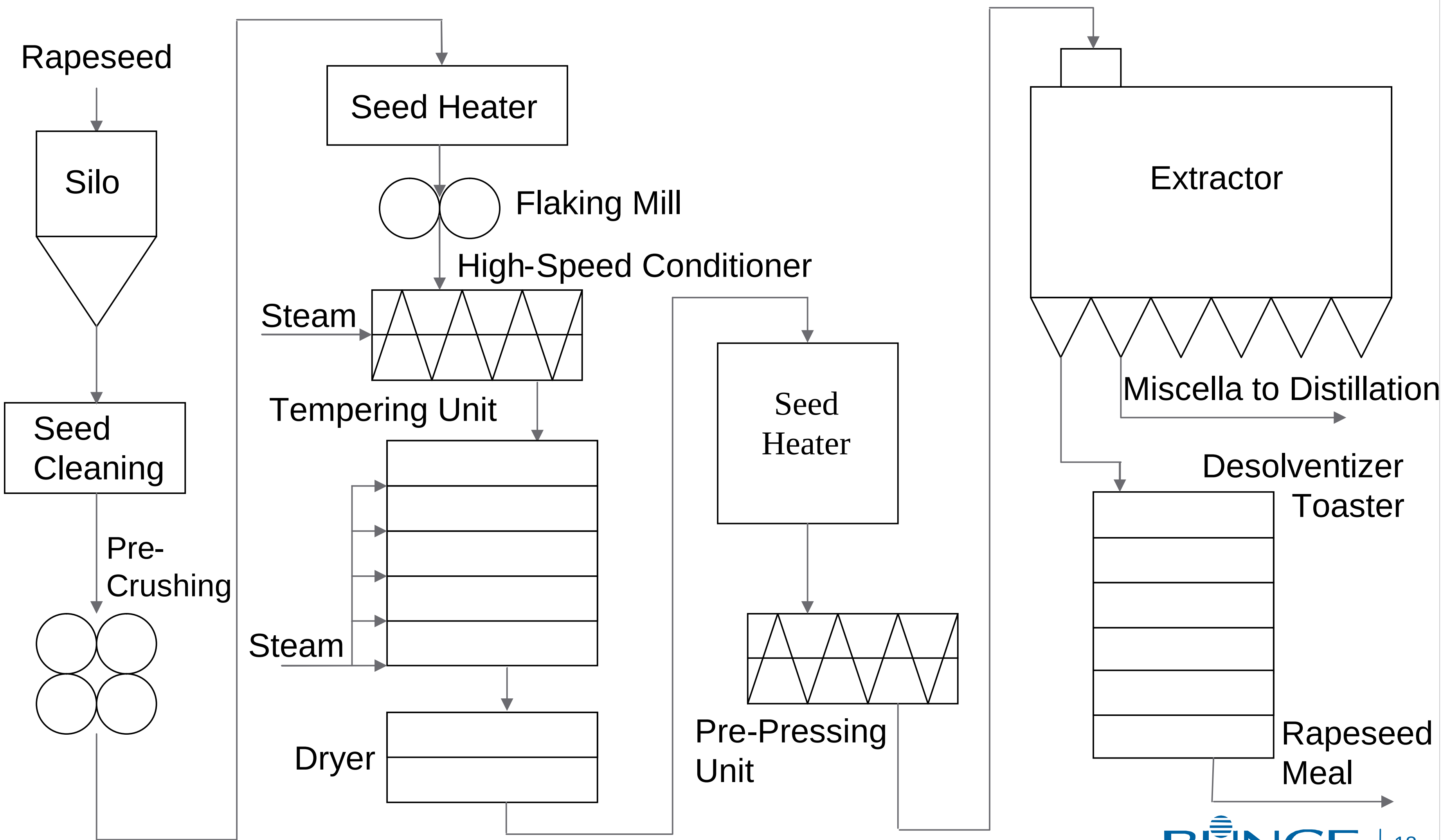
Novel Conditioning Processes

- "ALCON® Conditioning Effect"

- Well known process for soybean conditioning

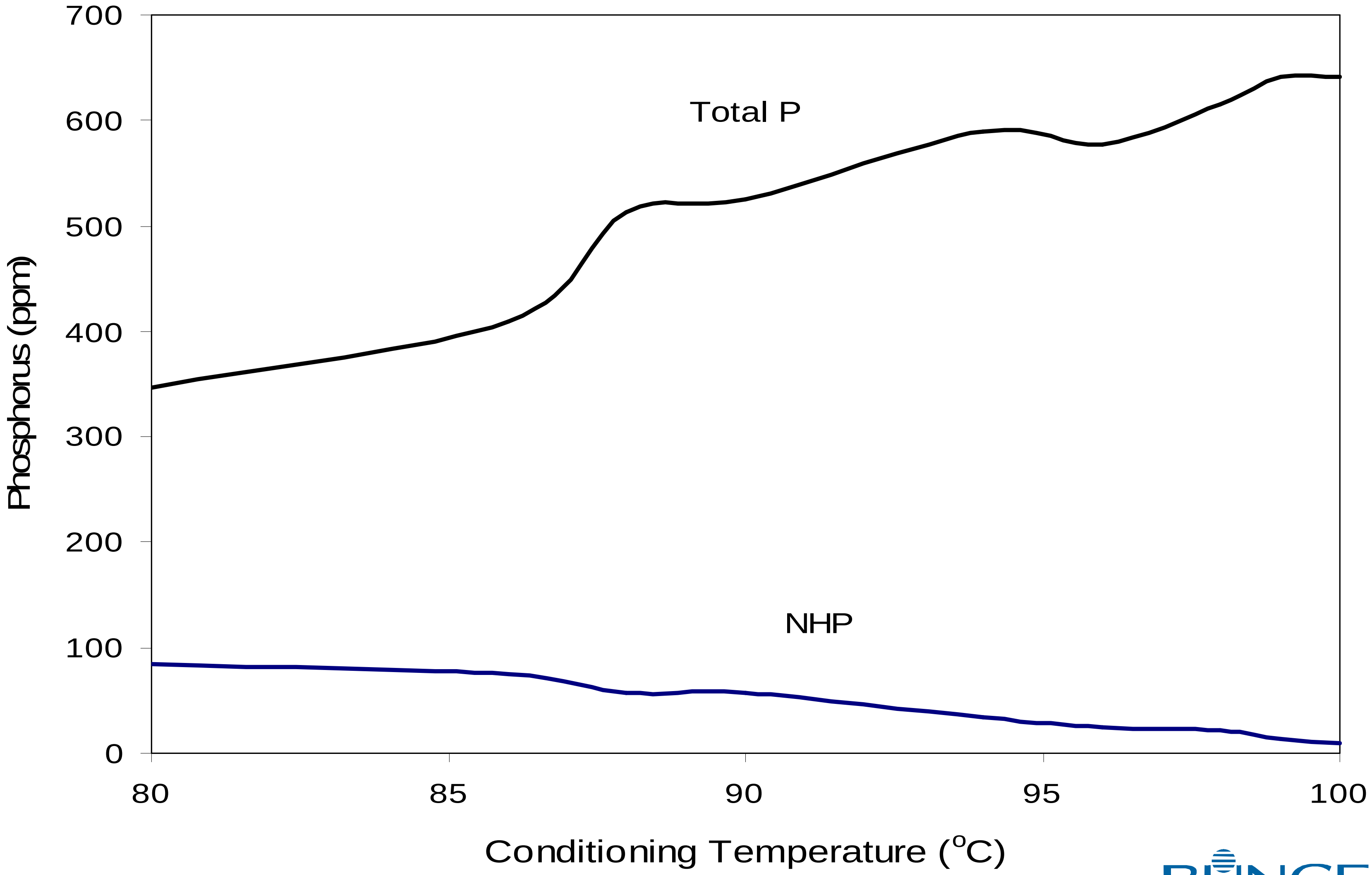
- Can be applied to rapeseed (Beyer, *Fett/Lipid*, 1997)

ALCON® Conditioning



Beyer, *Fett/Lipid*, 1997

ALCON® Conditioning



Beyer, *Fett/Lipid*, 1997

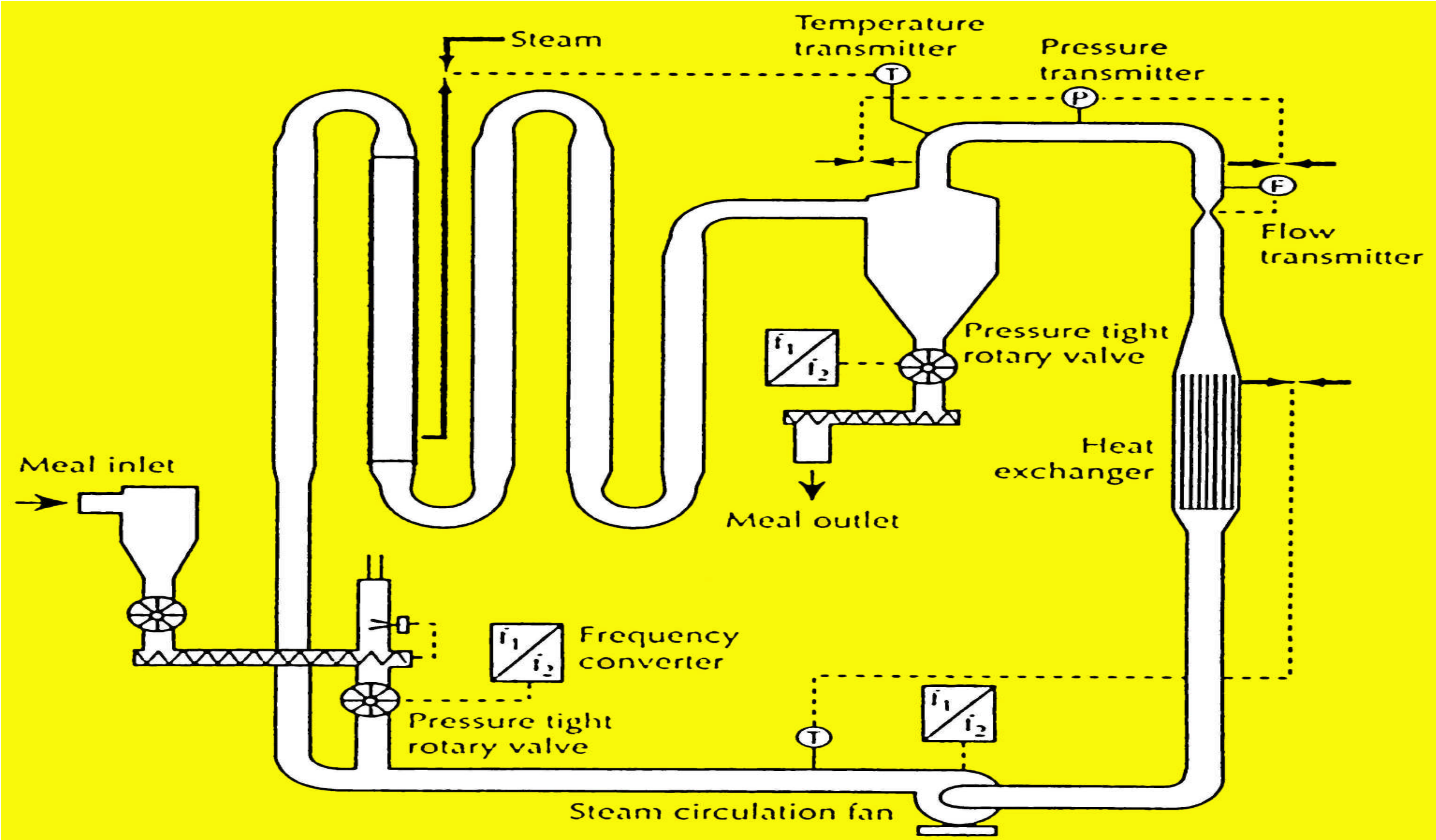
ALCON® Conditioning

- Colour better in oils conditioned in high-speed unit

- FFA concentration similar for both stack cooked and high-speed conditioned oils

- No data given for sulfur and chlorophyll

Novel Conditioning Processes – Super ExPro



Dahlen, *OCL*, 1998

Super ExPro Process

- Water degummed comparison

	Super ExPro	Stack Cooker
P (ppm)	6.1	100
FFA (%)	0.53	0.67

Dahlen, *OCL,* 1998

- Peroxide value data similar for Super ExPro and Stack Cooker oils

- No data given for sulfur and chlorophyll

Effect of Chlorophyll and Sulfur on Processing

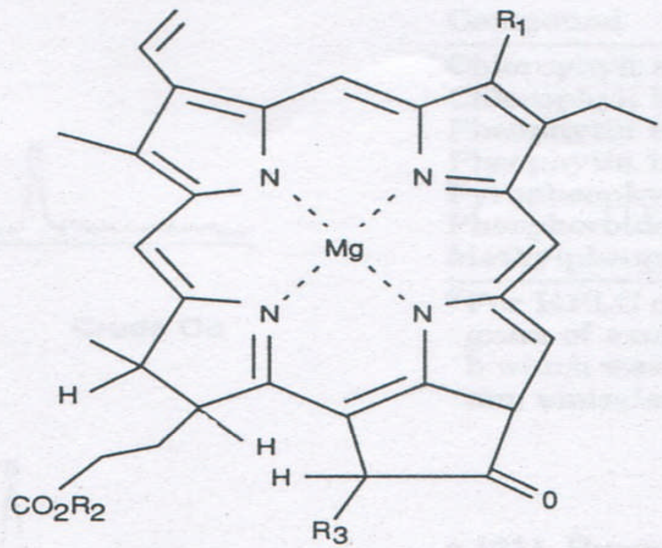
Chlorophyll

- Chlorophyll breaks down into several derivatives
- Mouldy, heated, and frost damaged canola seed have higher concentrations of pheophytin than good quality seed
- Chlorophyll/pheophytins promote oil oxidation
- They are also nickel catalyst poisons
- More bleaching clay is required to remove these compounds

Chlorophyll

Structures and Spectral Properties of Chlorophylls a and b, and Their Derivatives

Endo et al, *JAOCS*, 1992



Name	Abbrev.	X	R_1	R_2	R_3
Chlorophyll a	Chl a	Mg	CH_3	$C_{20}H_{39}$[a]	CO_2CH_3
Pheophorbide a	Pho a	H_2	CH_3	H	CO_2CH_3
Methylpheophorbide a	MePho a	H_2	CH_3	CH_3	
Pheophytin a	Phy a	H_2	CH_3	$C_{20}H_{39}$	CO_2CH_3
Pyropheophytin a	Pyr a	H_2	CH_3	$C_{20}H_{39}$	H
Chlorophyll b	Chl b	Mg	CHO	$C_{20}H_{39}$	CO_2CH_3
Pheophorbide b	Pho b	H_2	CHO	H	CO_2CH_3
Pheophytin b	Phy b	H_2	CHO	$C_{20}H_{39}$	CO_2CH_3
Pyropheophytin b	Pyr b	H_2	CHO	$C_{20}H_{39}$	H

Chlorophyll

Chlorophyll breakdown products (Endo et al, *JAOCS*, 1992)

Seed
Major: Chls a and b
Minor: Phy a, Pho a, MePho a

Meal
Major: Phy a, Pyr a
Minor: Pho a, MePho a, Phy b

Crude Oil
Major: Phy a > Pyr a
Minor: Pho a, MePho a, Phy a

Degummed Oil
Major: Pyr a > Phy a
Minor: Phy b, (Pyr b), MePho a

Chlorophyll

- According to Suzuki and Nishioka (*JAOCS*, 1993), the adsorption of each derivative on bleaching clay decreases in the following order:

Pheo a > Pyro a >> Pheo b > Pyro b

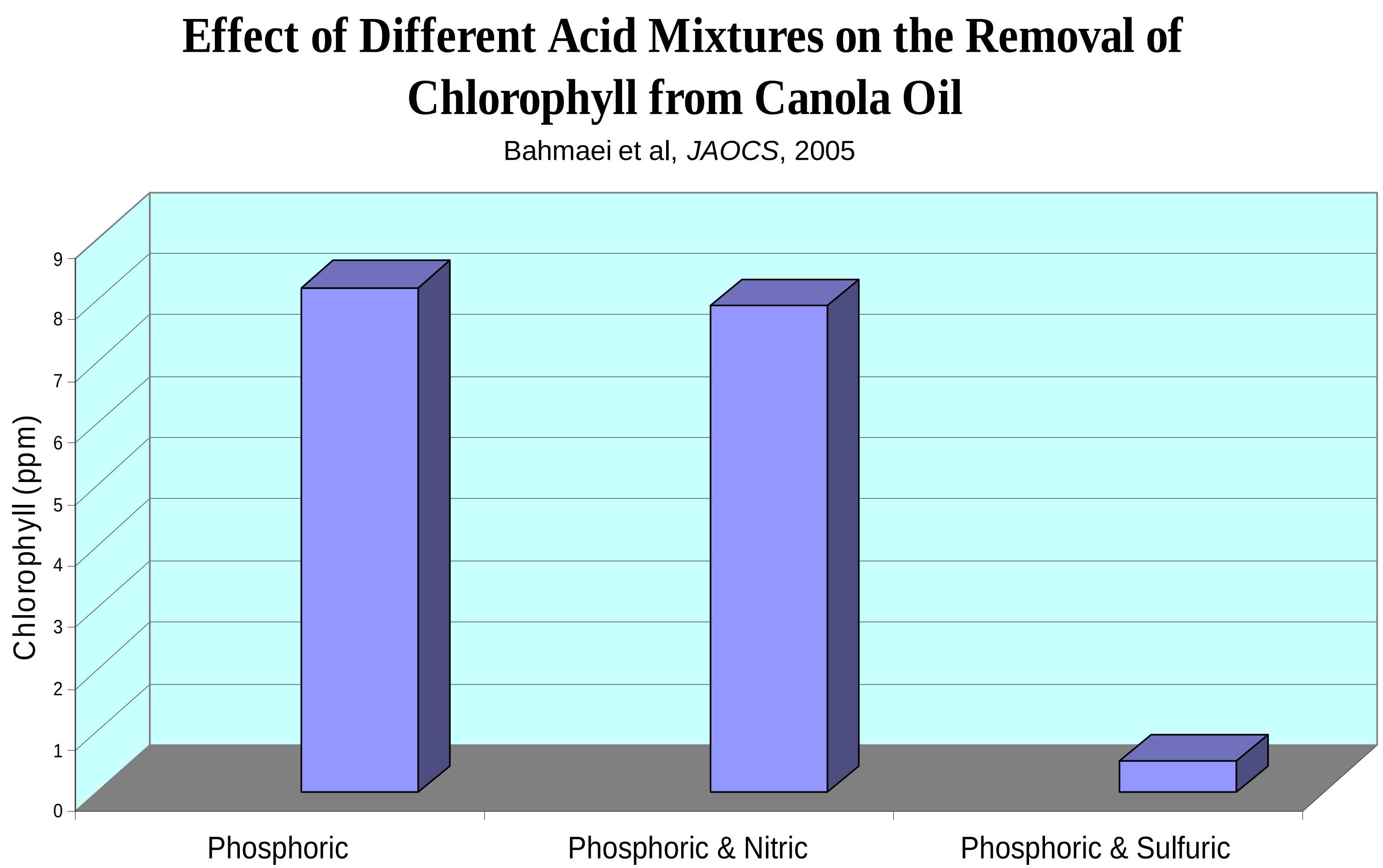
Novel Chloro. Removal Methods

- 1994 US Patent 5,315,021 (P&G)
- 98% removal from crude or degummed oil
- Oil is contacted with 0.05-1.0% H_3PO_4 at 80-105^{o}C for 10-30 minutes
- Moisture < 0.04%
- Precipitated chlorophyll removed by centrifugation or filtration after neutralization

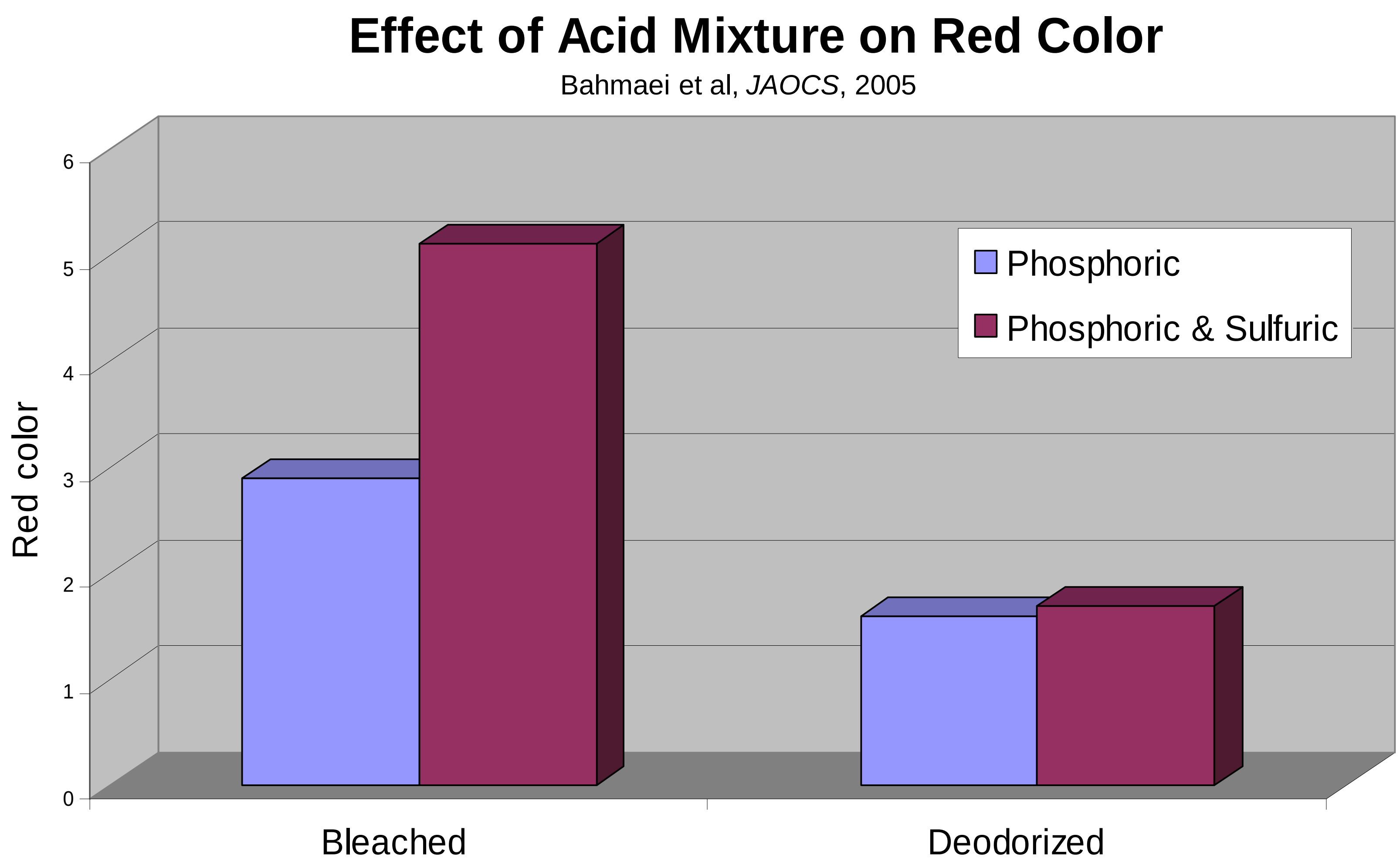
Novel Chloro. Removal Methods

- 2002 US Patent 6,376,689 (Cargill)
- Chlorophyll removal down to 5 ppm
- Process is single step acid degumming process
- Oil is contacted with a 0.6-0.8% mixture of H_3PO_4 and H_2SO_4 at 20-50^oC for 2-6 hours
- Moisture < 0.5% before acid addition, < 1.0% after
- Precipitated chlorophyll removed by centrifugation or filtration

Novel Chloro. Removal Methods



Novel Chloro. Removal Methods



Sulfur Content (ppm)

	Rutkowski, *JAOCS* (1982)	Daun & Hougen, *JAOCS* (1976)
Crude	36	31
Degummed	20	16
Refined	12	7
Bleached	10	5
Deodorized	1	1

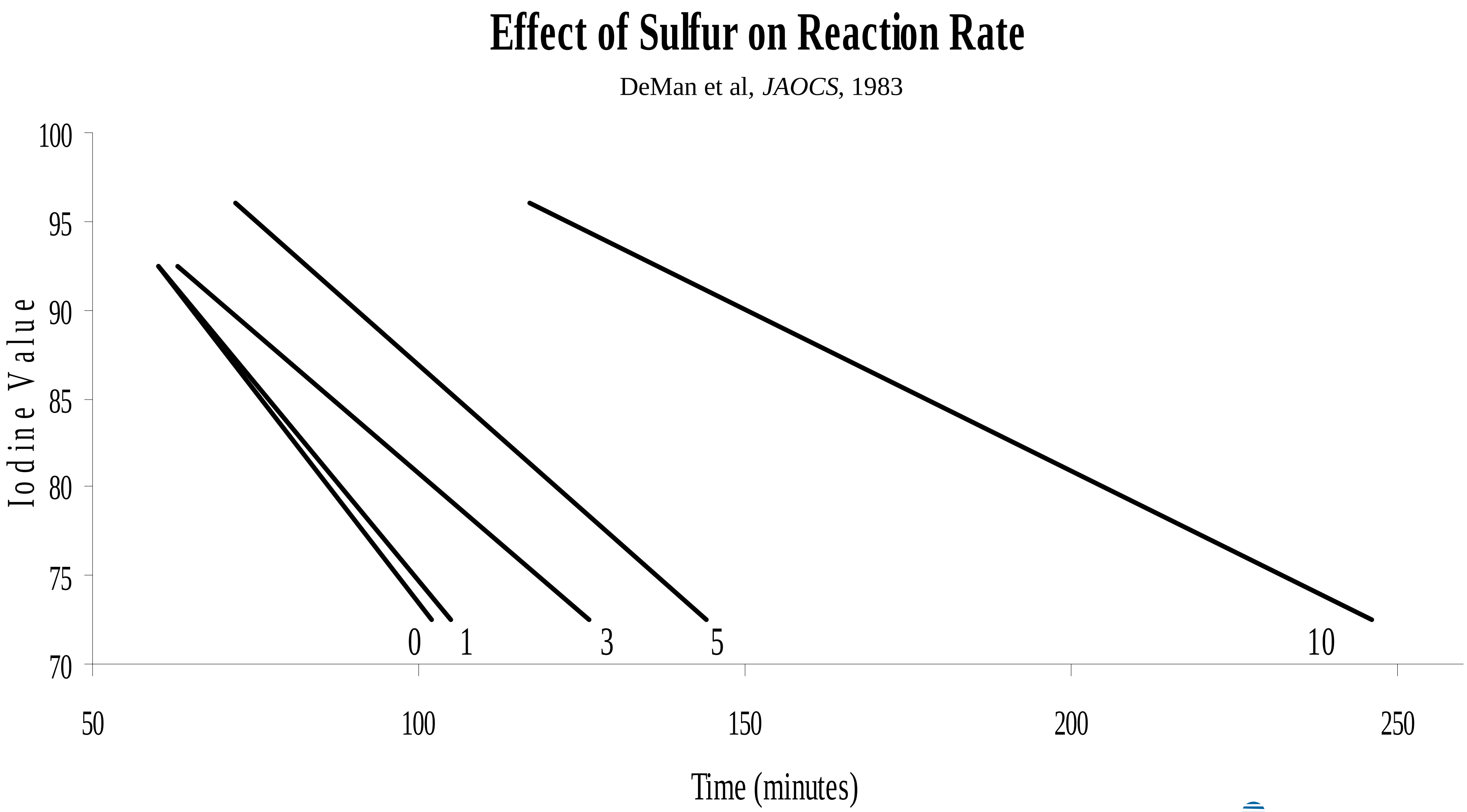
Sulfur Content (ppm)

	DeClerq et al, *GCRIC Conference* (1991)	Toeneboehn & Welsh, *AOCS Conference* (1992)
Degummed	7.8	5.8

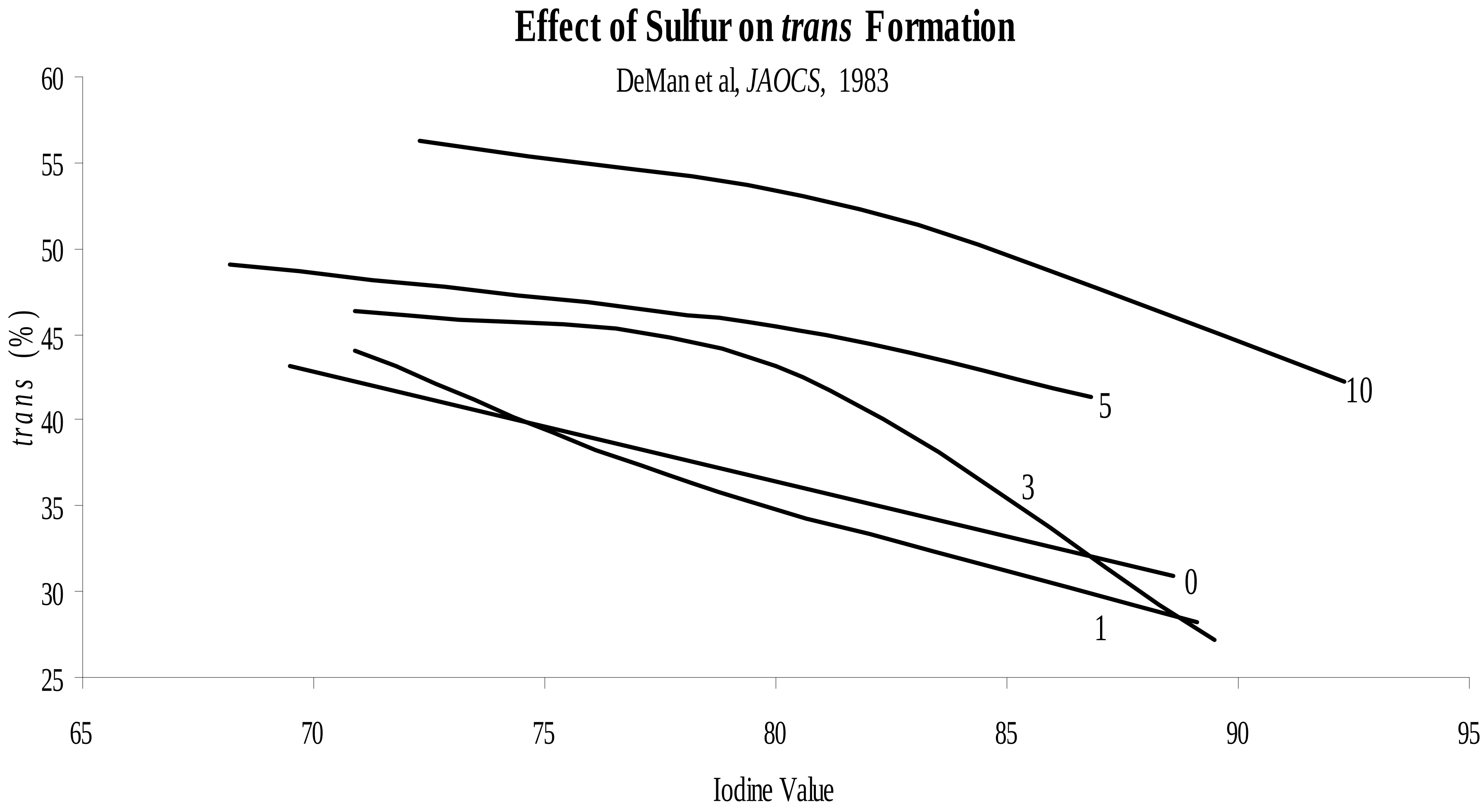
Sulfur

- 1 ppm sulfur poisons 0.004% nickel catalyst (Ottensen, *Scand. Symposium*, 1970)
- Very significant!
- Typical canola oil hydrogenation will use 0.0125-0.025% nickel catalyst

Sulfur


Effect of Sulfur on Reaction Rate
DeMan et al, *JAOCS*, 1983
Iodine Value
100
95
90
85
80
75
70
0
1
3
5
10
50
100
150
200
250
Time (minutes)

Sulfur



Effect of Sulfur on *trans* Formation
DeMan et al, *JAOCS*, 1983
60
55
50
45
40
35
30
25
trans (%)
10
5
3
0
1
65
70
75
80
85
90
95
Iodine Value

Sulfur

- Effect on hydrogenation
  - Decreases reaction rate
  - Increases *trans* formation
  - Increases melting point
  - Increases steepness of SFC curve

Sulfur

- Catalyst usage is approx. 50% higher in canola hydrogenation compared to soybean
- Sulfur is very difficult to remove
- Significant adsorption occurs on spent nickel catalyst
- Deodorization will also remove sulfur since the compounds are volatile

Questions?

From www.dpvta.uniud.it/ Inn_Did/img/canola.jpg