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CANOLA
Proteins & Respective Demands & Innovations

Curtis Rempel MBA PhD PAg
Vice President, Crop Production & Innovation
Canola Council of Canada
Winnipeg, Manitoba

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Outline

1. Canola seed/meal composition & function (vs soy)
2. The case for plant (canola) proteins
   a) Supply vs Demand
   b) Health & Cultural drivers
   c) Value added & specialty products
   d) Sustainability
3. Canola Protein – a) Economic value, b) History, c) Regulatory, d) Limitations
4. Canola Protein FUTURE – Economic Opportunity and Economic Value Added
   a) Competitive marketplace – CANADIAN Approach
   b) Canola Protein Processing Innovation
   c) Fixed and variable costs
   d) Life Cycle Analysis
5. Conclusion

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Canola seed/meal composition & function (vs soy)

Driver of protein use & value

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Protein & fiber composition of Canola meal and soybean meal

Golbitz 2008; Wanasundara 2011

Nutrient	Canola meal	Soy meal
Protein (%)	36	48
Crude Fiber (%)	12	3.9
Methionine		
(% of meal)	0.74	0.67
(% of protein)	2.05	1.40
(% digest. – swine)	82	86
Lysine		
(% of meal)	2.08	3.02
(% of protein)	5.78	6.29
(% digest. – swine)	74	85
Phytate (%)	3.1	1.7

Meal Amino Acid Composition

- Lysine content ranging 1.67 to 3.15%
- Methionine content ranging 0.48 to 1.06%
- Cysteine content ranging 0.62 to 1.08%

Comparison of FAO/WHO/UNO Suggested Pattern of Amino Acid Requirements with the Composition of Various Protein Sources

AA	FAO	Beef	Milk	Wheat	Soy	Rape	Cruciferin*	Napin**
Lysin	5,5	7,6	7,6	2,3	6,3	5,7	3,45	9,03
Thr	4,0	4,7	4,3	2,8	4,0	4,8	4,05	3,14
Cys+Met	3,5	4,2	3,2	3,2	3,6	4,8	1,91	9,18
Val	5,0	5,3	6,1	4,1	4,8	6,1	6,01	5,51
Ile	4,0	5,0	5,6	3,7	4,2	4,6	5,23	3,95
Leu	7,0	8,2	10,1	6,6	7,9	8,5	8,79	8,25
Tyr	6,0	3,8	4,9	2,5	4,6	3,0	3,2	1,38
Phe	6,0	4,3	5,1	4,7	6,1	4,7	5,93	3,50

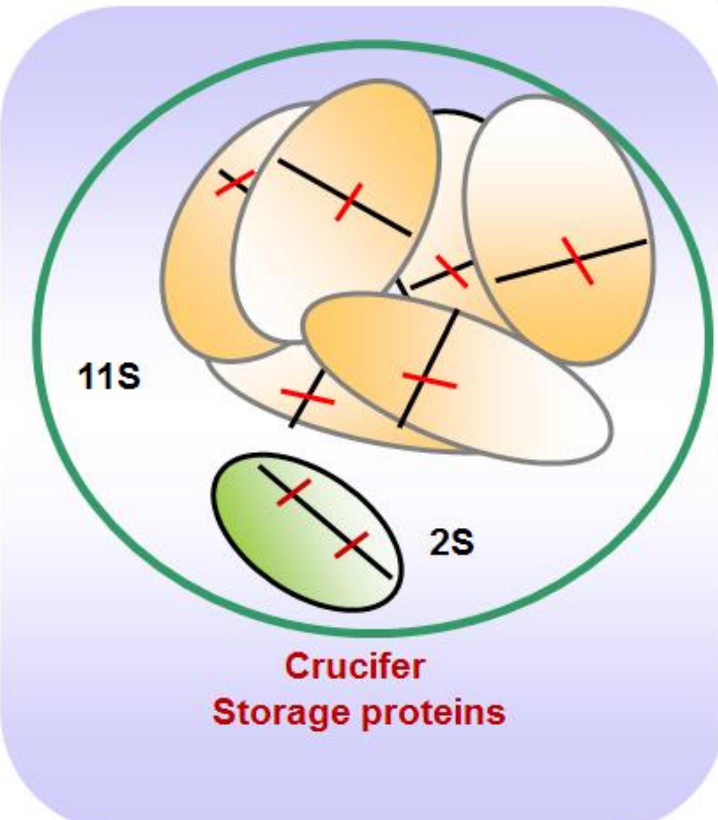
J.P Krause et al. UFOP 2007 in Pudel 2011

Proteins of Canola Seed

Product differentiation

Canola meal content already contains about 60 per cent cruciferin and 20 per cent napin.

Seed & Meal Protein



Wanasundara, AAFC

Cruciferin: 60% Napin: 25%

11 S globulin cruciferin	2 S albumin napin
• Larger globular protein mm ~ 340 kDa	• Smaller mm ~ 15 kDa
• Similar to 12S proteins (glycinin) found in soy	• Highly soluble
• Rich in lysine and methionine	• High glutamine, prolinme, cysteine
	• Potentially allergenic
	• Less competitive: ❖ Sensory ❖ Nutritive properties
	• Regulatory

Case for plant (canola) proteins

a) Supply vs Demand
b) Health & Cultural drivers
c) Value added & specialty products
d) Sustainability

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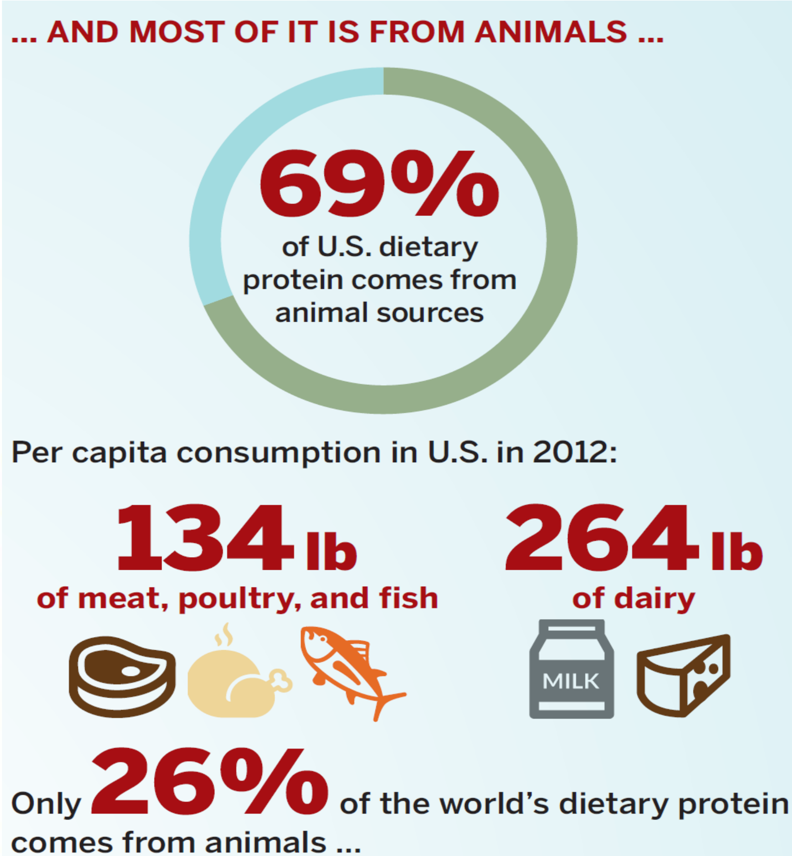
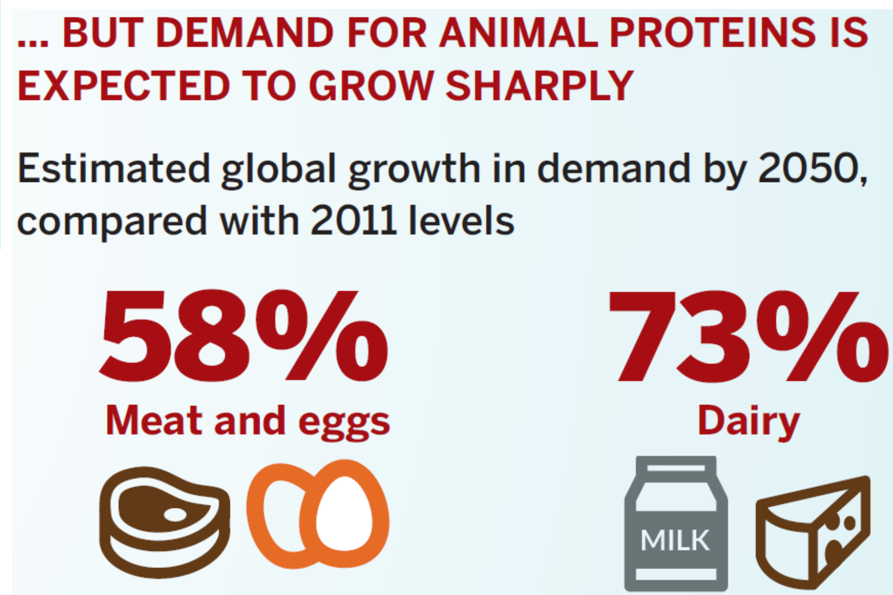
We need protein…



Major use for plant proteins will continue to be feed for animal (livestock) production

- Especially aquaculture/fish farming

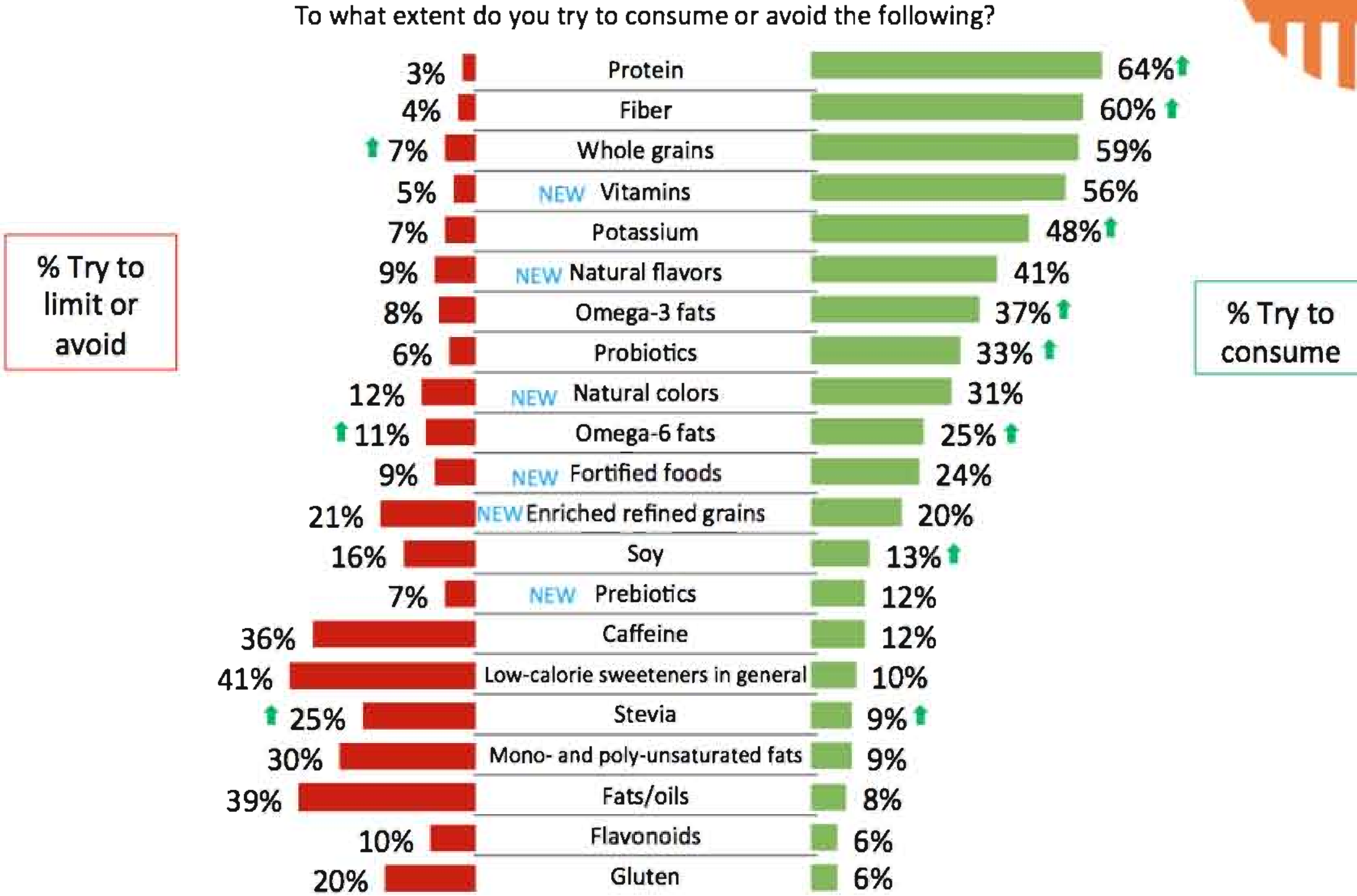


Institute of Medicine, USDA, National Academies – from CEN.ACS.ORG

2016 Food and Health Survey. Food Insight, May 11, 2016. International Food Information Council

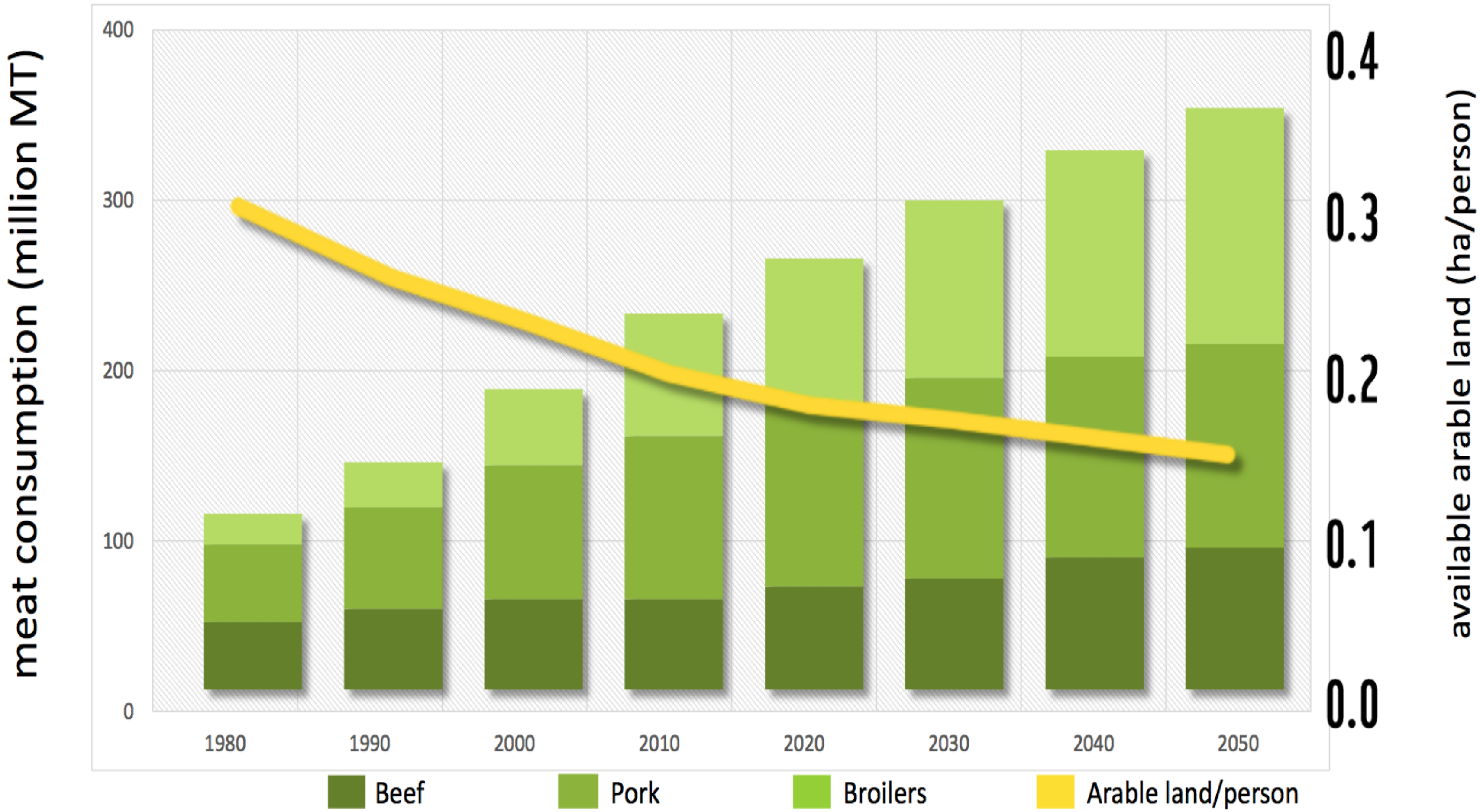
More Americans are trying to consume several nutrients and components, with protein and fiber topping the list.

DIETARY COMPONENTS



2016 n=1,003; Arrows indicate significant (.95 level) differences vs. 2015.

World animal protein consumption is growing



Source: WWF Sandra Vijn

Canadian canola meal = 12 mmt

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Home » Tillage » Global feed production is almost at 1 billion tonnes

Global feed production is almost at 1 billion tonnes

11:11 am - January 25, 2016

Amy Forde
Email

10 Shares

Global feed tonnage is estimated to be at **995.5m tonnes**, a 1.5% increase on last year, according to the latest Alltech Global Feed Survey.

This is also a 14% increase on 2011, when Alltech published its first Global Feed Survey.

The analysis of five-year trends showed growth predominantly from the pig, poultry and aqua feed sectors and **intensification of production** in the African, Middle Eastern, Latin American and European regions, according

Increasing Demand for Plant Protein

- Consumers concerned about the ecological footprint (water consumption, greenhouse gas) off animal production; animal welfare.
- UN FAO – global food security and right of global citizen – protein quantity + bioavailability (quality).
- Cardiovascular health – consumers want high quality protein without saturated fats, extra calories.
- Hedonic attributes – TASTE, TEXTURE important – consumers taste preferences, food product preferences changing – favor plant proteins.

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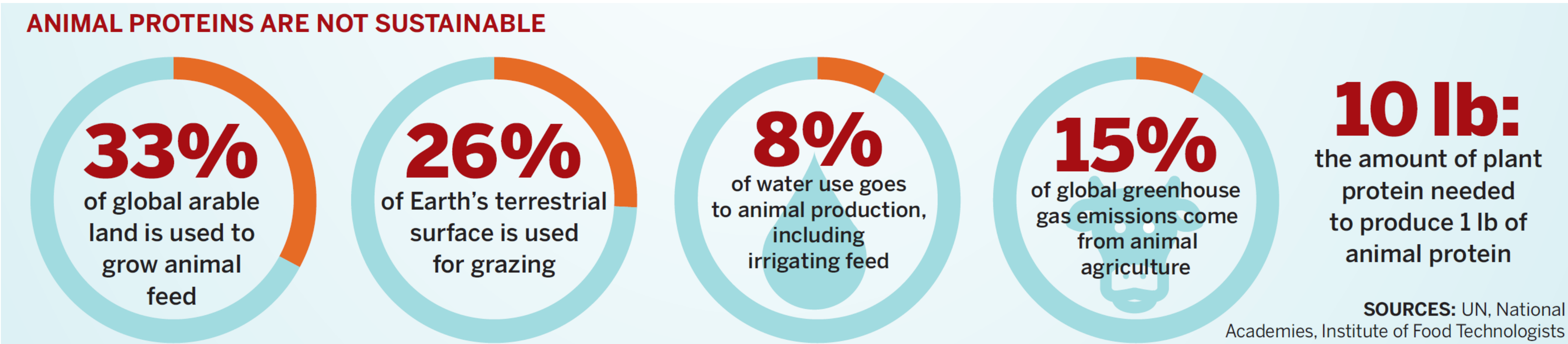
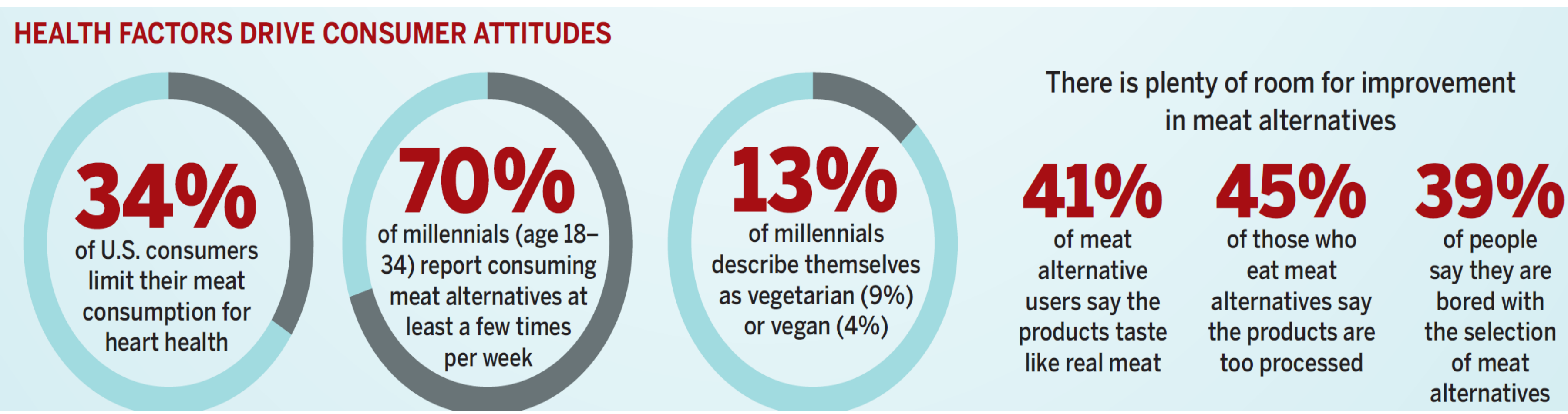


Aquaculture – Enhanced sustainability?



1 kg animal protein requires 10 kg feed beef; 5 kg pork; 3 kg poultry; 4 kg eggs; 5 kg for milk

Source: Mintel

Protein Requirements

AQUACULTURE

- Fast growing industry
- Popular in underdeveloped regions
- Exceptional FCR
- Very high protein (25-45%)
- Dense diets (high fat)
- Carnivore vs omnivore (fiber content)

COMPANION ANIMAL

- Protein required for our pets
- Often pay a premium for perceived premium products
- Rapidly growing area
- High protein required

Canola meal – Ruminant animals

Research shows that using canola meal instead of soy meal =

DAIRY

High quality protein and forage for milk production

Key driver is milk quantity and quality

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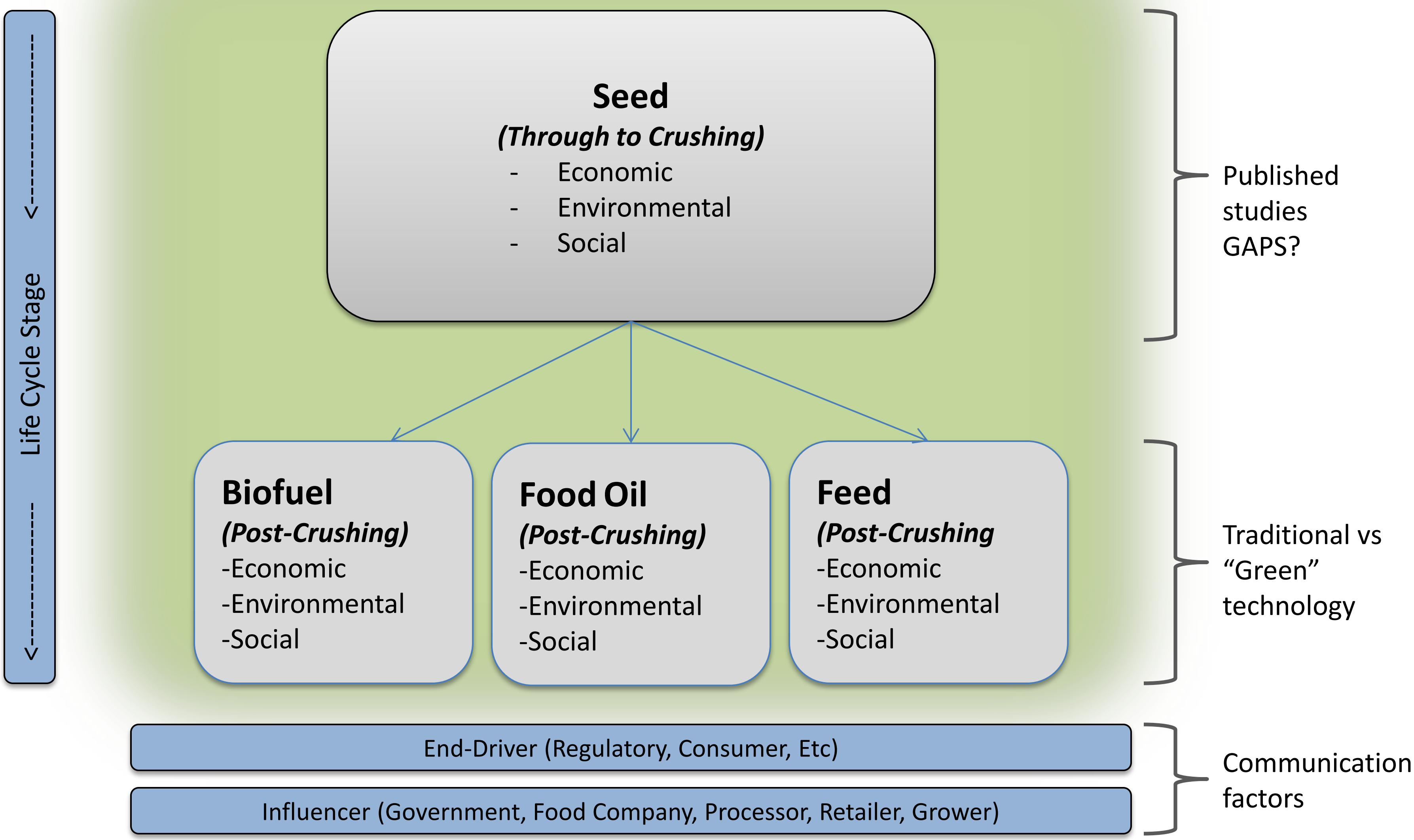
Sustainability Story



Canola Protein

a) Economic value
b) History
c) Regulatory
d) Limitations

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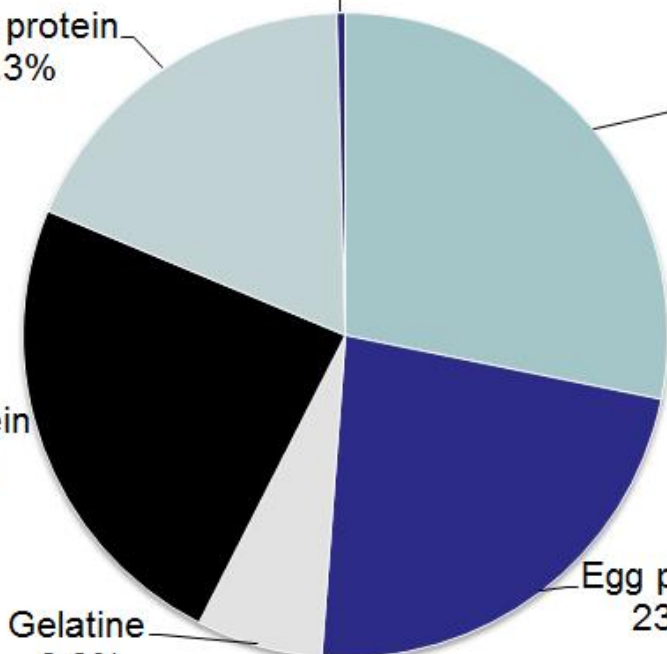
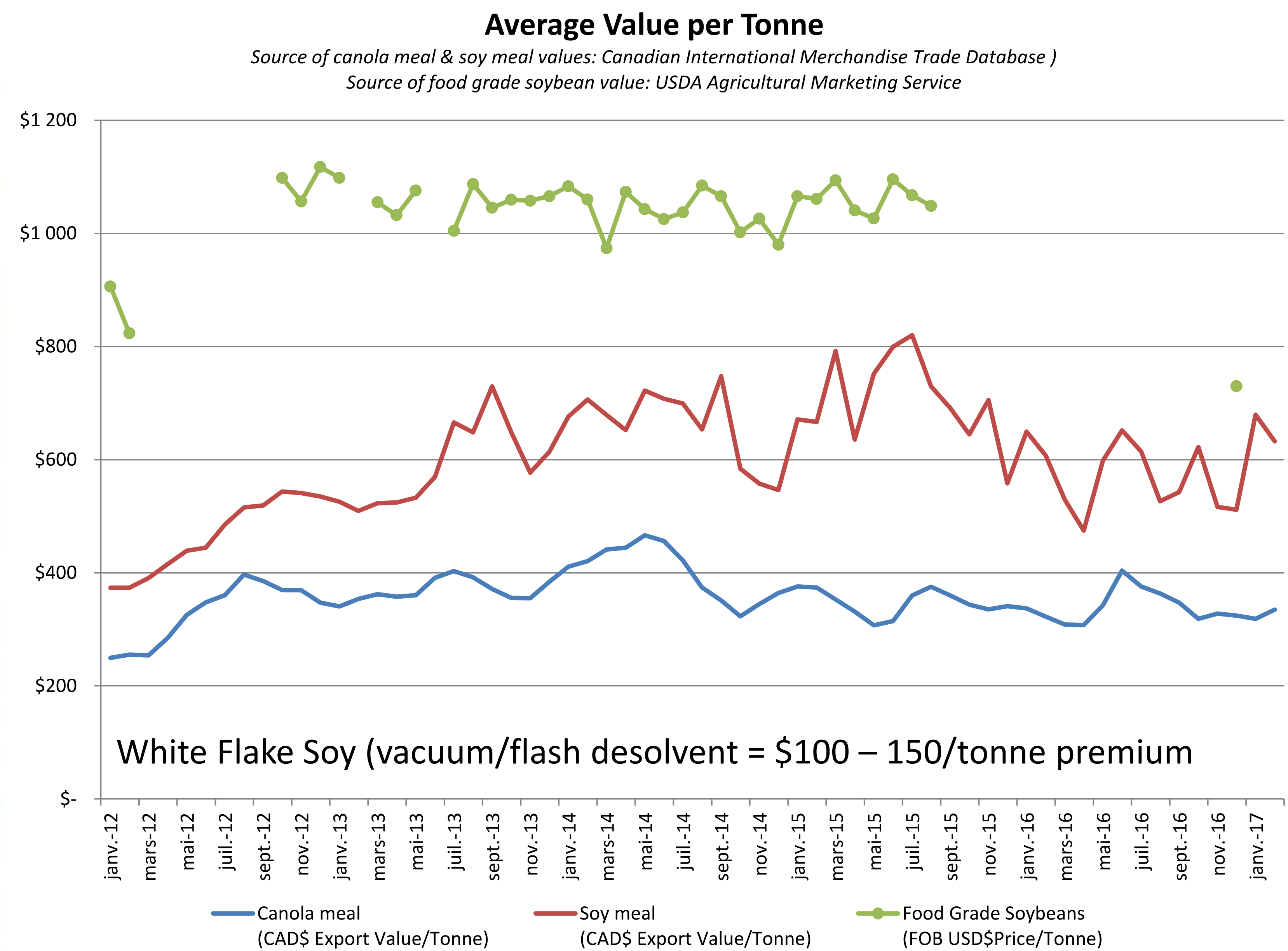
Global protein ingredients market 2012



Animal Protein = 57.5% (2.3 million metric tonnes)
Plant Protein = 42.5% (1.7 million metric tonnes)
Market value: $15 billion in 2008
$32 billion by 2018 at 7.7% CAGR

Reference: Frost & Sullivan

Economic Value: Canola Meal, Soy Meal



Protein Concentrate / Isolate - CANADA

- Burcon Inc. – Supertein, Puratein, Nutratein
- BioExx Specialty Proteins Inc. (TEUTEXX)

 - Isolexx and Vitalexx

- MCN Bioproducts Inc. -
  - IP, trademarked products – licensing agreements, extensive product testing re functionality & hedonic, favorable regulatory status.

- **Ready-to-drink beverages**
- **Powdered beverages**
- **Frozen desserts**
- **Aerated desserts**
- **Nutritional bars**
- **Functional Food**

- **Dressings & Sauces**
- **Meat applications**
- **Protein bars**
- **Baked goods**

Napin (albumin) = Excellent foaming, solubility, heat stability
High content of sulfur containing amino acids, Cysteine nearly 2x whey
Cruciferin (globulin) = Opaque heat induced gels, emulsifier, ingredient binder

Uses for Canola Protein

Industrial

- Fillers / binders chipboard
- Binders for specialty papers
- Biodegradable plastics – plasticizer and network matrix
- Glues, adhesives
- Aerogels, encapsulating agents
- Detergents
- Personal care; Cosmetics

Food Products

- WHO/FOA/UN – suggested pattern of amino acid requirements for adults, school children, pre-school – canola/oilseed rape proteins favorable amino acid composition

Global Market for Meat Replacer

Plant proteins that replicate taste, feel, experience of eating meat attracting significant investment in past 5 years

- Burcon / ADM – pea protein, Clarisoy
- Beyond Meat (California)
- Impossible Foods (California)
- Ripple Foods (California)
- Hampton Creek (California)
- Gardein
- Embria Health Science
- Kellogg
- GTC Nutrition
- Estimated 200 start-up companies

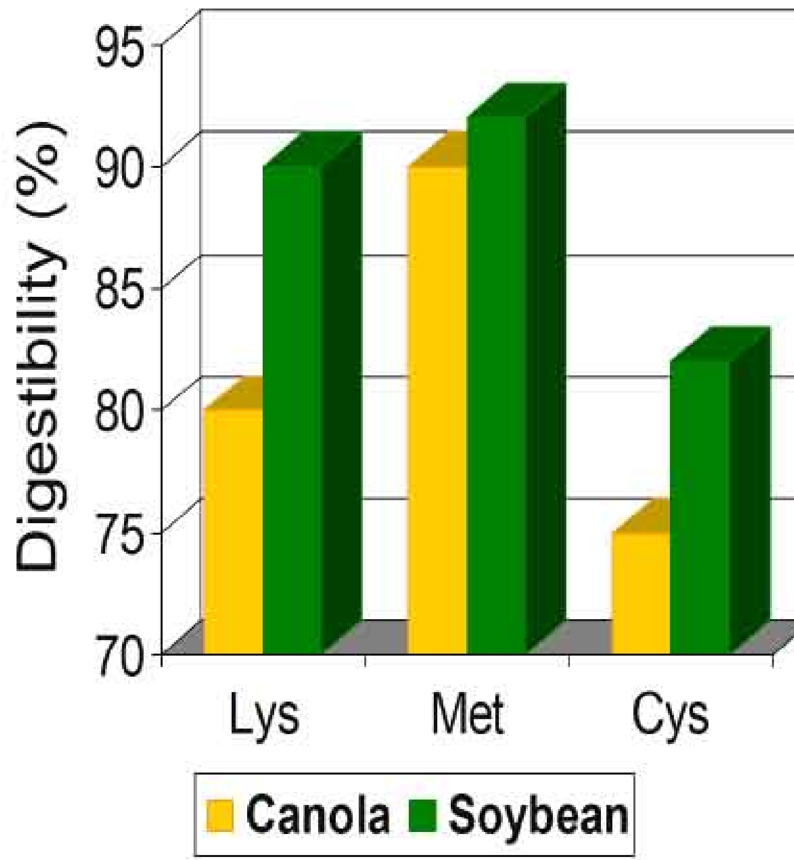
Limitations

- Solvent extraction; Desolventizing / toasting
  - Protein denaturation/degradation
  - Binding of protein/fiber complex
- Impact functionality, nutrition

Meal quality - poultry

NRC, 1994

- Lower amino acid digestibility than soybean meal
- More variable amino acid digestibility
- Contains 75% of the protein of soy, often sells at 60% of the price
- Effect of processing on meal quality poorly understood



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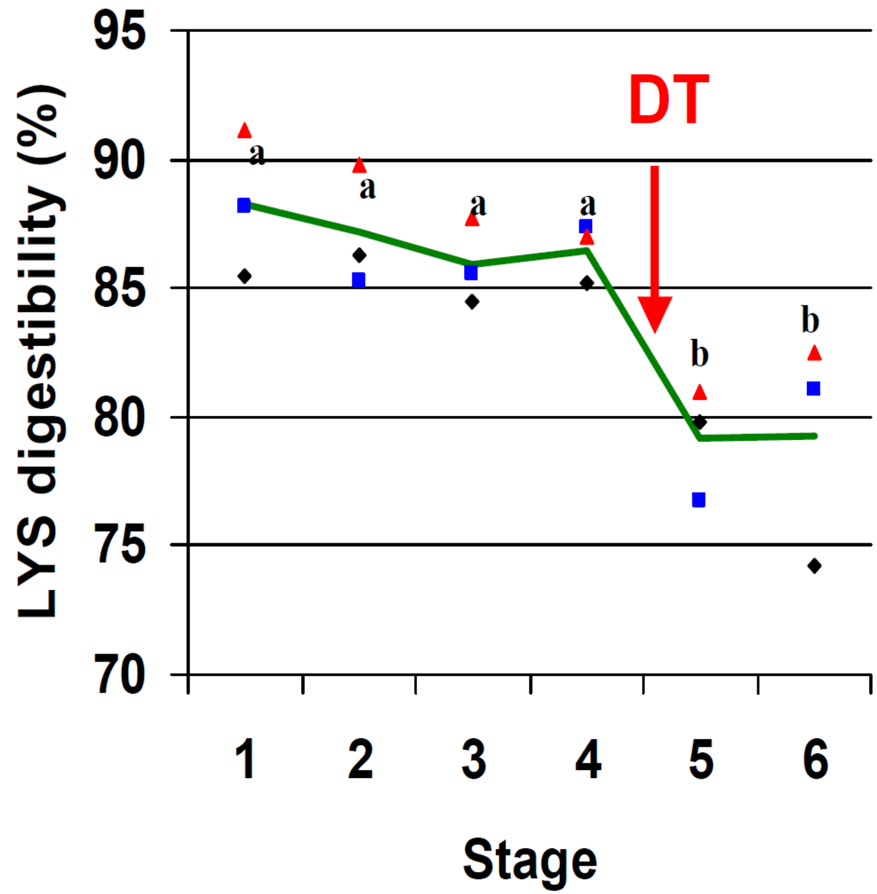
Amino acid digestibility

- Desolventisation/toasting decreased LYS digestibility
- Desolventisation/toasting decreased digestibility ($P<0.05$) of most amino acids (CYS, GLU, GLY, ASP, THR, ALA, VAL, ILE, LEU, PHE, HIS, ARG, PRO, & ASN)



Source: Classen, University of Saskatchewan

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Canola Protein FUTURE
Economic Opportunity and Economic Value Added

a) Competitive marketplace – CANADIAN Approach
b) Canola Protein Processing Innovation
c) Fixed and variable costs
d) Life Cycle Analysis

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Typical Challenges with Canola

- **Colour and flavour**
  - Need to avoid phenolic oxidation
  - Could phenolics be reduced/eliminated?
- **Yields**
  - Depending on process may not be economical
- **Selection of starting material**
  - Conventional DT meal is challenging
  - Desolventising process requires changes

3 Pronged Approach

- DT Meal – separation fiber/protein complex – fine milling/air classification
- Emerging “Green” technologies
  - Crushers need to be willing to make changes to desolventizing process
  - Economically feasible alternatives to hexane extraction resulting in low residual oil levels? Preserve protein functionality?
- Breeding/Genomics
  - Reducing color?
  - Manipulating cruciferin/napin ratios
  - Increase amino acid bioavailability
  - Increasing overall protein content

Canola Protein Extraction

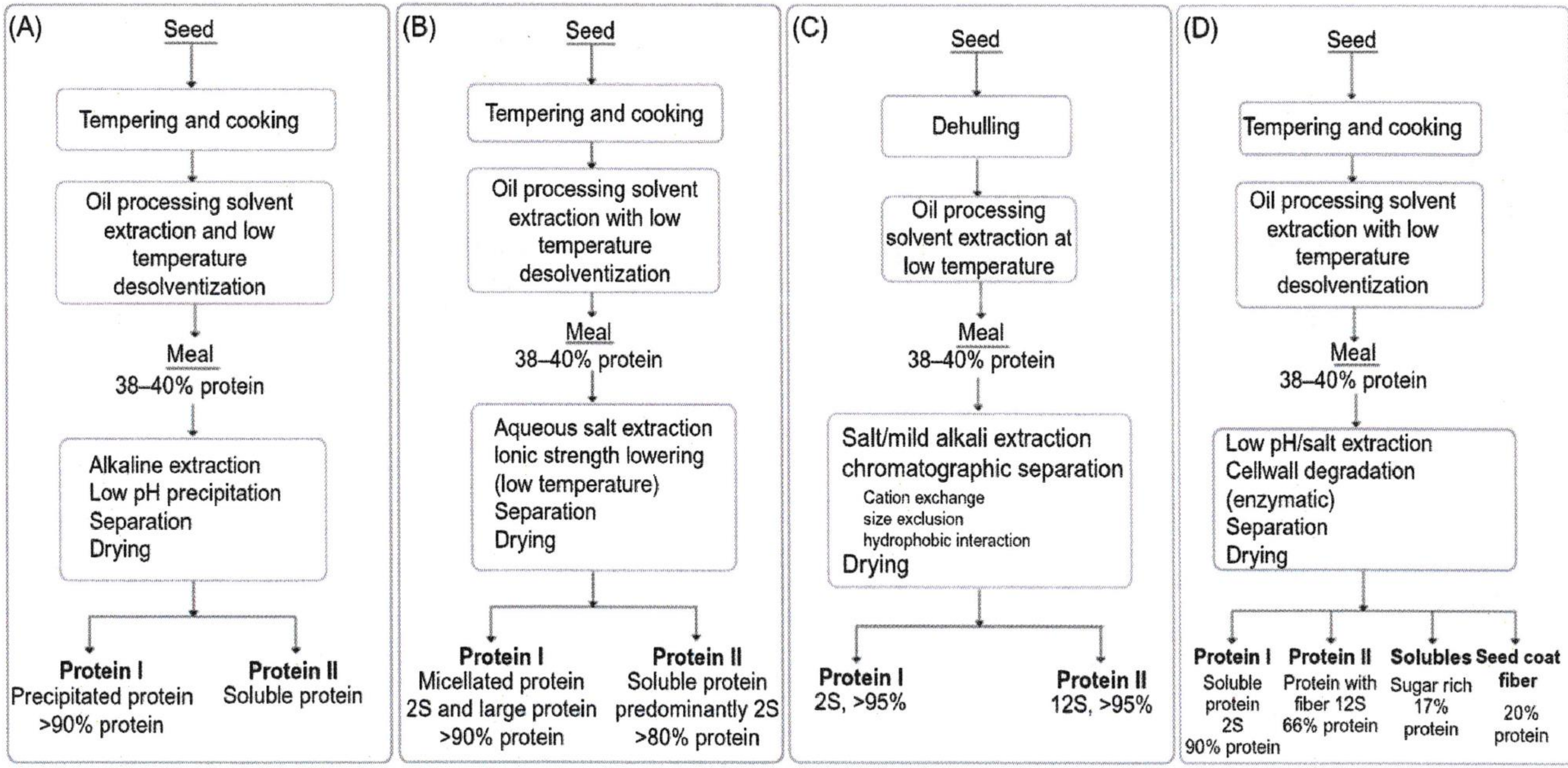


FIGURE 18.1 Flow charts summarizing important processing steps and products for four different methods described and employed to obtain protein products from canola/rapeseed. Processes depicted here are either reported as scaled up to pilot level or patented. (A) Alkali extraction of protein and recovery at low pH (Diosady et al., 2005; Newkirk et al., 2009); (B) protein micelle formation method (Murray, 1999; Schwizer & Greene, 2005); (C) chromatographic separation (Berot et al., 2005); and (D) meal component fractionation method developed by Wanasundara and McIntosh (2013).

Wanasundara et al 2015

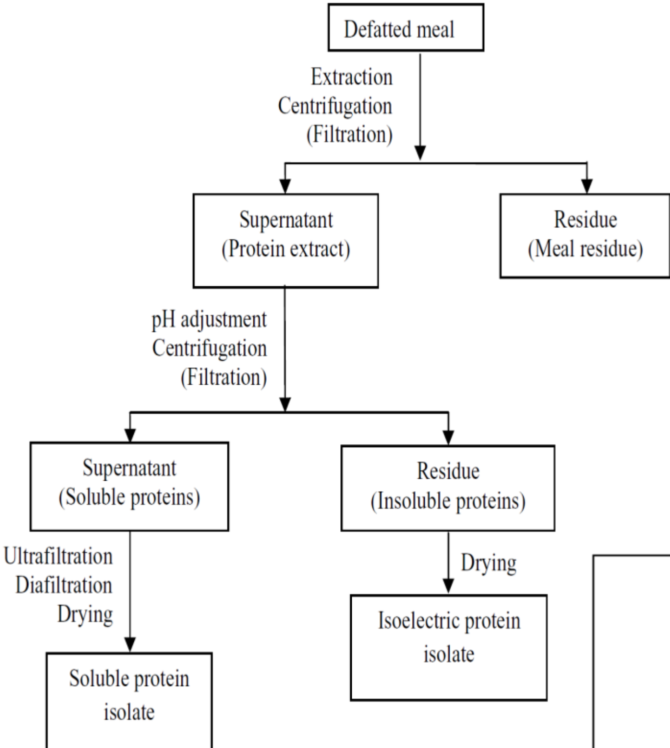


Figure 1–Schematic representation for alkaline extraction of canola meal protein isolates.

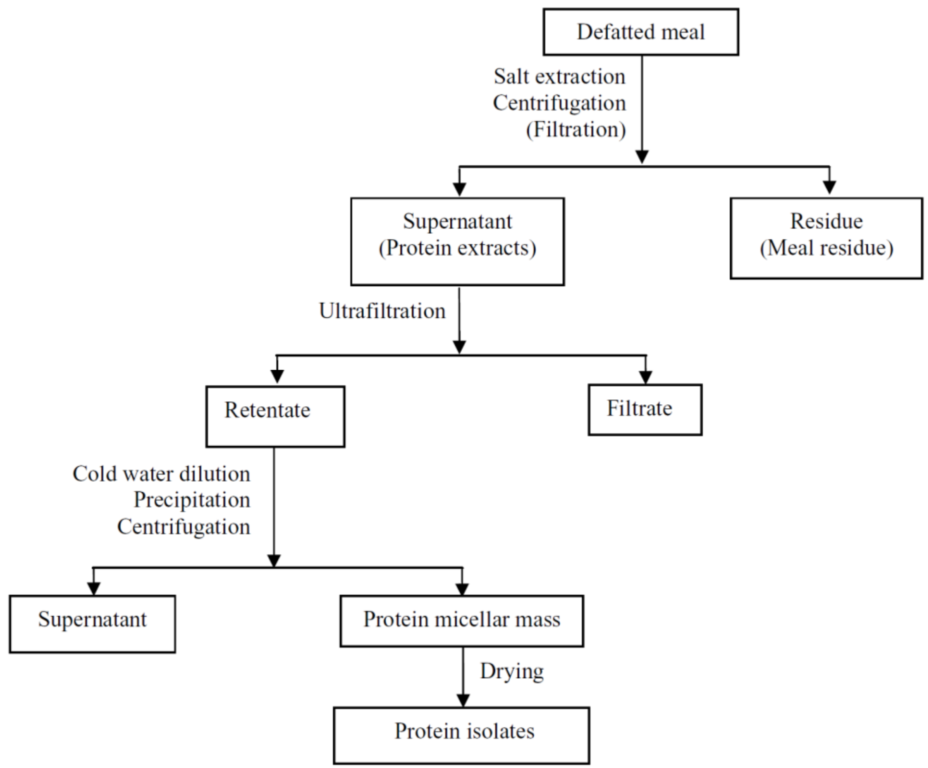


Figure 2–A schematic of the protein micellar mass method used for extracting canola meal protein isolates. Source: Ser and others (2008).

Tan et al 2011

“Green” canola protein processing

- Oil extraction:
  - Pressing only = 7% residual oil – emulsion formation during protein extraction
  - Need process which leaves 1-2% residual oil?
  - Need to deactivate myrosinase
  - Dehulling to reduce fiber, lower anti-nutritional compounds?
  - Solvent choice and desolventization key (fluidized bed?)
- Protein Extraction/Fractionation Process:
  - “Dry” fractionation vs “Wet”
  - Ion exchange chromatography? Membrane filtration?

Source: Pudel 2011

Breeding - Amino Acid Composition

Amino Acid	*B. napus* germplasm	Canola Meal (Canada)	Soy Meal (USA)
Alanine	2.18 🟡 🟢	1.57	2.05
Arginine	2.99 🟡	2.08	3.48
Asparagine	3.92 🟡	2.61	5.52
Cysteine	0.93 🟡 🟢	0.86	0.79
Glutamine	8.54 🟡	6.53	8.62
Glycine	2.19 🟡 🟢	1.77	1.97
Histidine	1.30 🟡 🟢	1.12	1.21

🟡 - exceeds national averages for canola meal

🟢 - exceeds national averages for soy meal

Dehulling - Economic Considerations

- Expansion of gross crushing margin is possible with front end dehulling of high protein canola meal versus conventional canola processing
- Assumes canola meal would be 95% value of soybean meal with an equal protein content

	Conventional Seed	High Protein Seed	High Protein Meal	High Protein Hulls
Oil (wt%, as is)	40%	40%	1%	24%
Protein (wt%, as is)	25%	29%	54%	18%

	Conventional Canola Process			Dehulled High Protein Process		
Revenue	CDN$/ MT	MT/ MT seed	CDN$/ MT seed	CDN$/ MT	MT/ MT seed	CDN$/ MT seed
Oil	946.32[9]	0.46	435.31	946.32[9]	0.42	398.97
Meal	340.35[9]	0.54	183.79	552.57*	0.42	231.20
Hulls				150.00[8,10]	0.16	24.00
Total Revenue			**619.10**			**654.17**
Seed Expense	534.45		**534.45**	534.45		**534.45**
Gross Crushing Margin			**84.65**			**119.72**

*Calculated based extrapolating value of conventional canola meal and 95% value of soybean meal

Source: DOW AgroSciences

Material Inputs and Output (wet basis)
2 tonne $hour^{-1}$ processing line

MATERIALS	AMOUNT (kg $hour^{-1}$)	AMOUNT (Tonne $Annum^{-1}$)
Input		
Canola meal (bulk density 565 kg m^{-3})	2,000	16,800
Recycled water	115,661	971,560
New taped water	676	5,675
NaOH	54	456
H_2SO_4	71	596
NaCl	123	1,029
Celluclast	240 (200L)	2,016 (1.68ML)
Viscozyme	240 (200L)	2,016 (1.68 ML)
Output		
Product 1	216	1,811
Product 1-a	213	1,792
Product 5	278	2,333
Product 5-a	374	3,140
Product 6	793	6,660
Water recycled	115,662	971,560
Waste slurry	1,168	9,814
Water lost	362	3,039

Mupondwa , Li, Wanasundara, . 2015

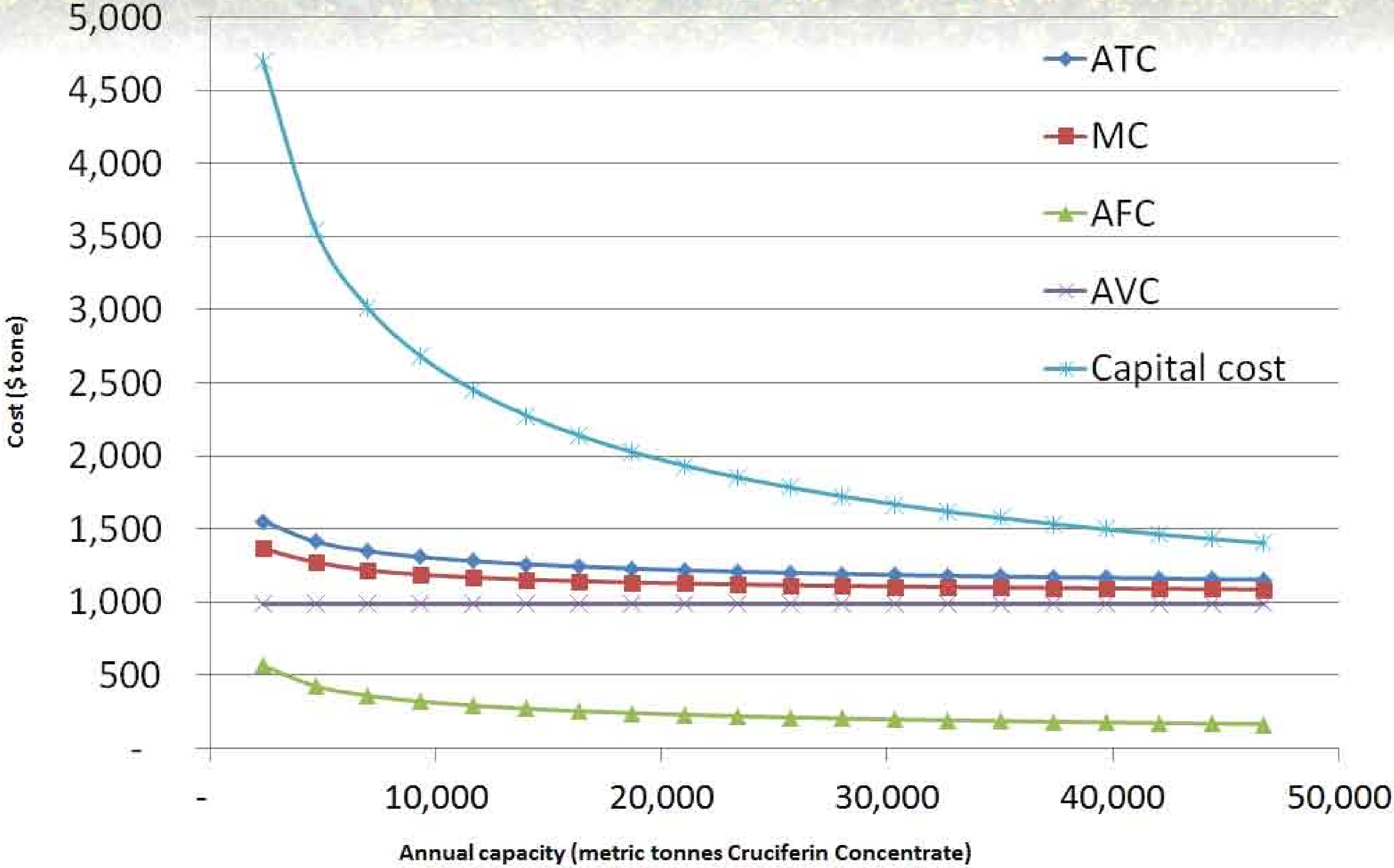
Distribution of key canola protein plant costs over a range of capacity – Selected Co-products

Napin Isolate
Cruciferin Concentrate

Abbreviations
ATC – Average Total Cost
AFC – Average Fixed Cost
AVC – Average Variable Cost
MC – Marginal Cost

Mupondwa, Li, Wanasundara, 2015

Cruciferin Concentrate - Distribution of plant costs over a range of capacity

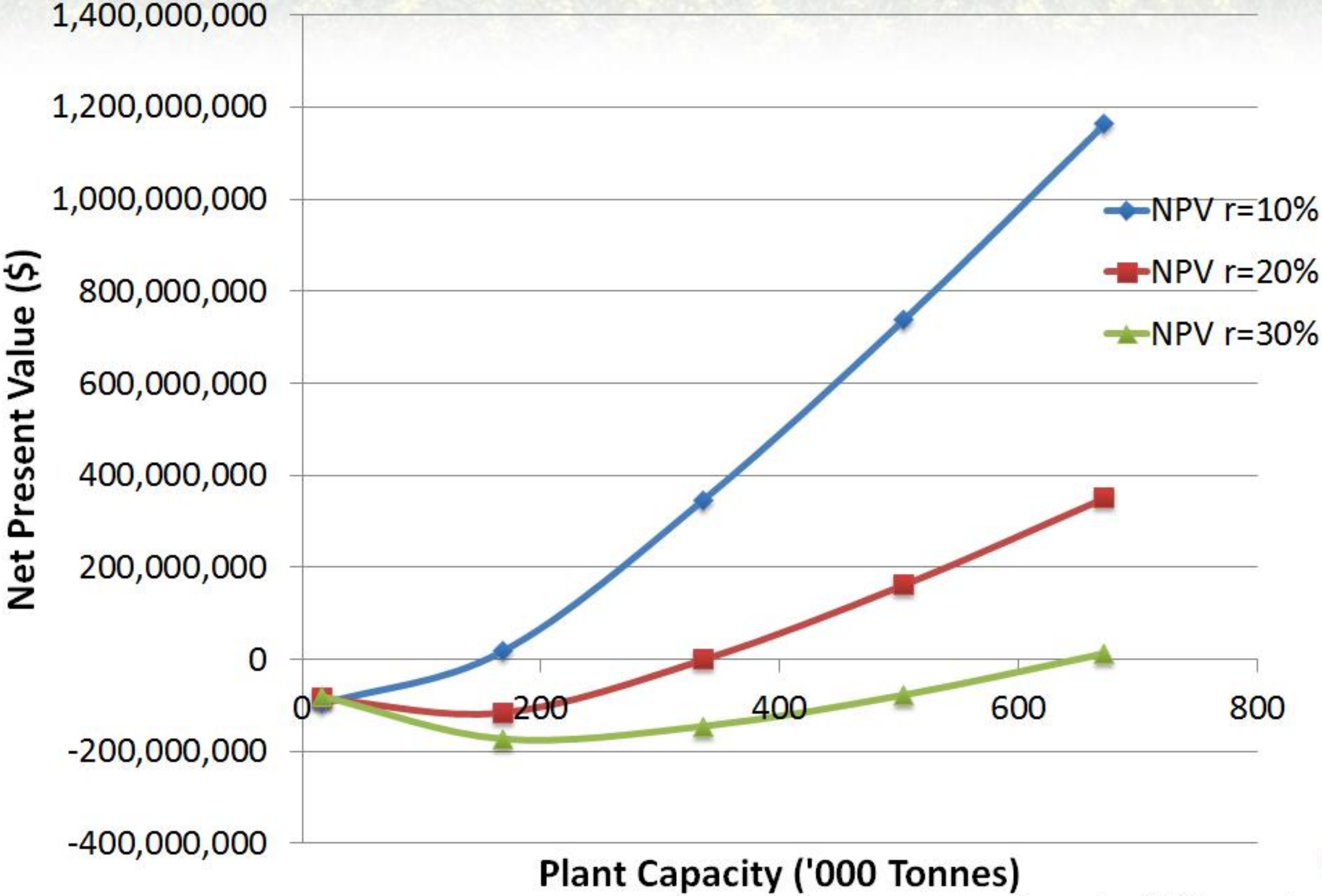


Canola Co-product Prices - Assumptions

CO-PRODUCT	DESCRIPTION	PRICE RANGE ($ kg^{-1})	PRICE A ($ $tonne^{-1}$)	PRICE B ($ $tonne^{-1}$)
Product 1	Napin isolate	$3.00-10.00	$6,000	$10,000
Product 2	Protein + soluble fibre	$0.25-0.50	$350	$500
Product 3	Cruciferin concentrate	$0.80-1.20	$1,000	$1,200
Product 4	Hull fibre	$0.10-0.20	$150	$200
Product 5	Sugar-rich solubles	0.05-0.15	$50	$150

Mupondwa, Li, Wanasundara, 2015

Net Present Value of Canola Protein Plant



Mupondwa, Li, Wanasundara, 2015

Conclusion

- Canola proteins have significant potential but need to solve some current hurdles
- Demand for canola protein for human consumption & aquaculture will be significant if industry can cost-effectively de-oil/fractionate – even in a crowded marketspace
- Genomics/breeding increases the value proposition
- “Green” or “Clean Label” are more than a passing fade – will drive change in many sectors including food processing
- Cost of these technologies will decrease significantly
- Can we use new technologies on existing infrastructure? If we can do this, opportunity for evolution significant.