Further Processing for Better Utilization of Co-products in Monogastrics

Matt Oryschak and **Eduardo Beltranena**

Alberta Agriculture and Rural Development

Edmonton, AB

34th Western Nutrition Conference

Alberta Agriculture and Rural Development

Overview

- **Co-products: challenges/opportunities**
- **Processing technologies**
  - Enzymes
  - Extrusion
  - Fractionation

Why the interest in co-products?

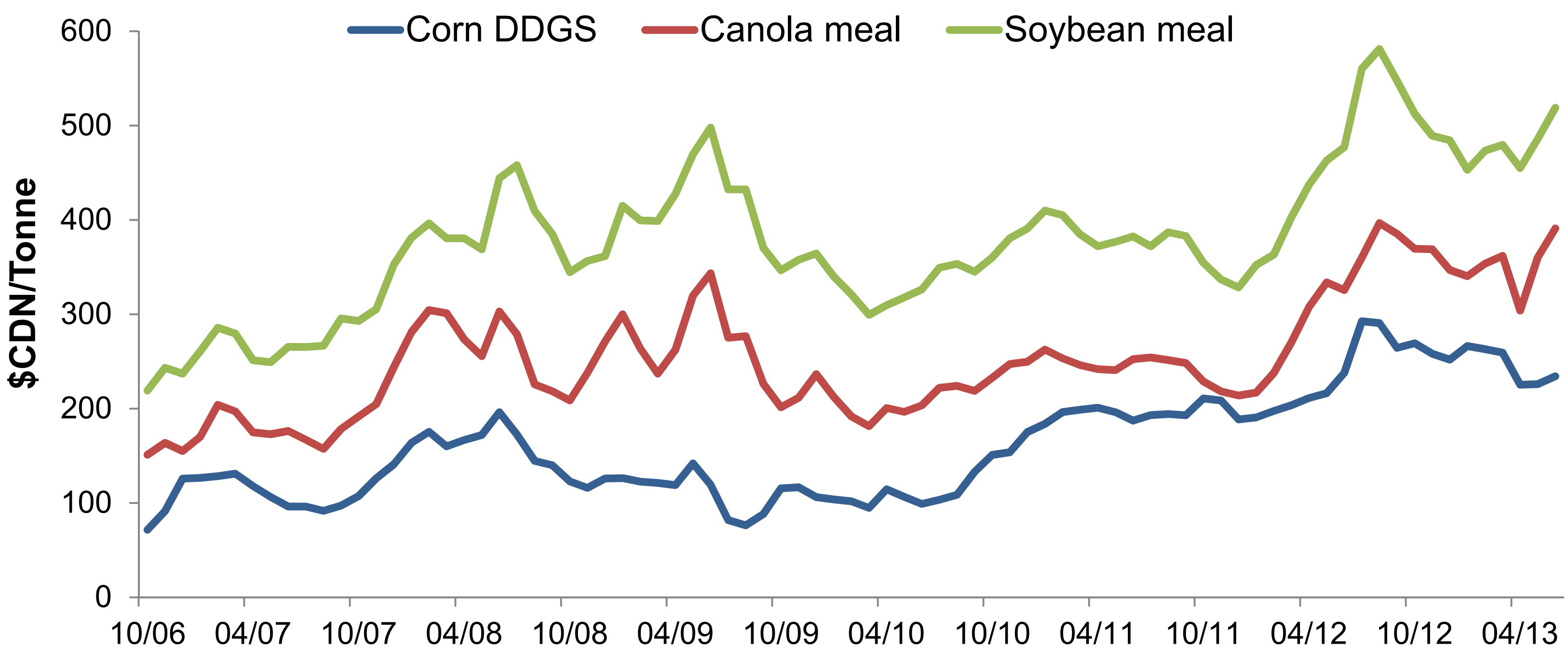


Figure 1. Recent trends in prices of corn DDGS, canola meal and soybean meal

Sources: USDA - AMS, CME, Canola Council of Canada

Why the interest in co-products?

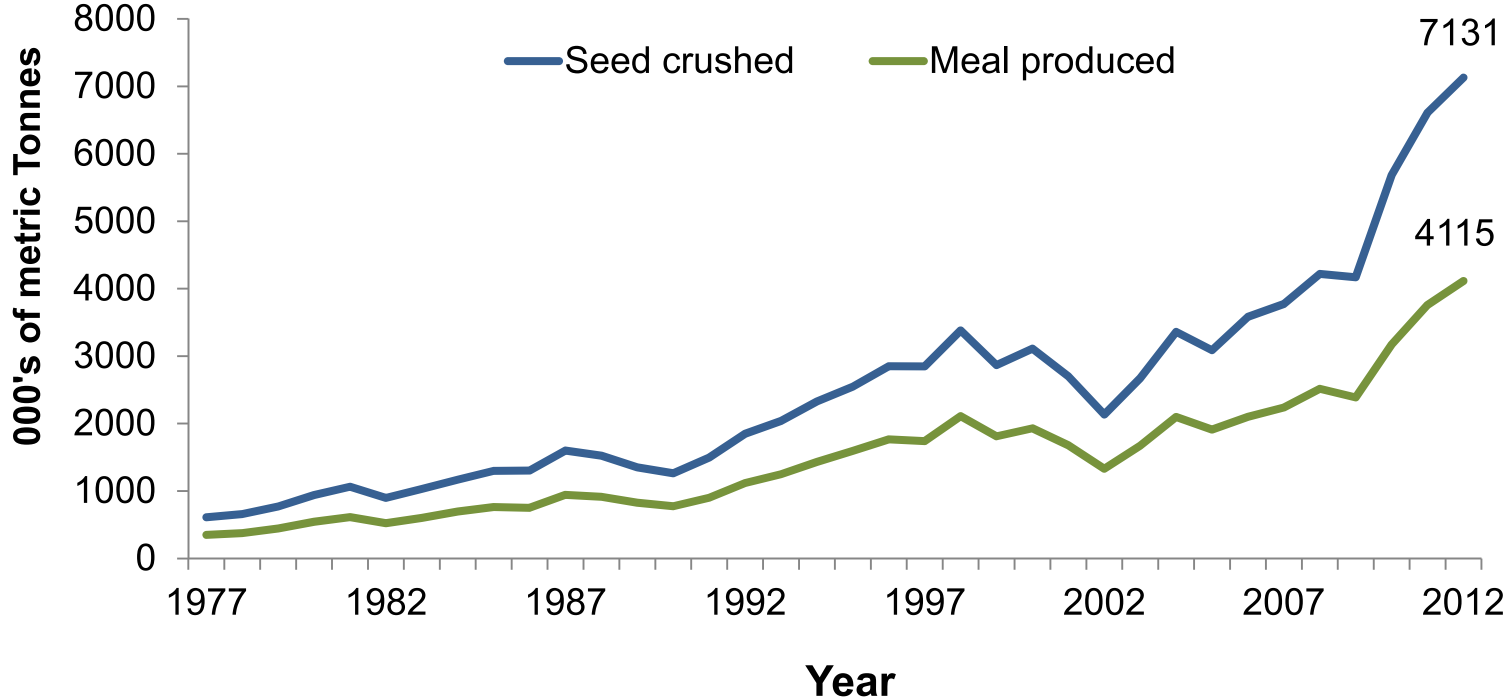


Figure 2. Historical canola seed crush and meal production in Canada

Source: Canola Council of Canada

Alberta Agriculture and Rural Development

34th Western Nutrition Conference

Why the interest in co-products?

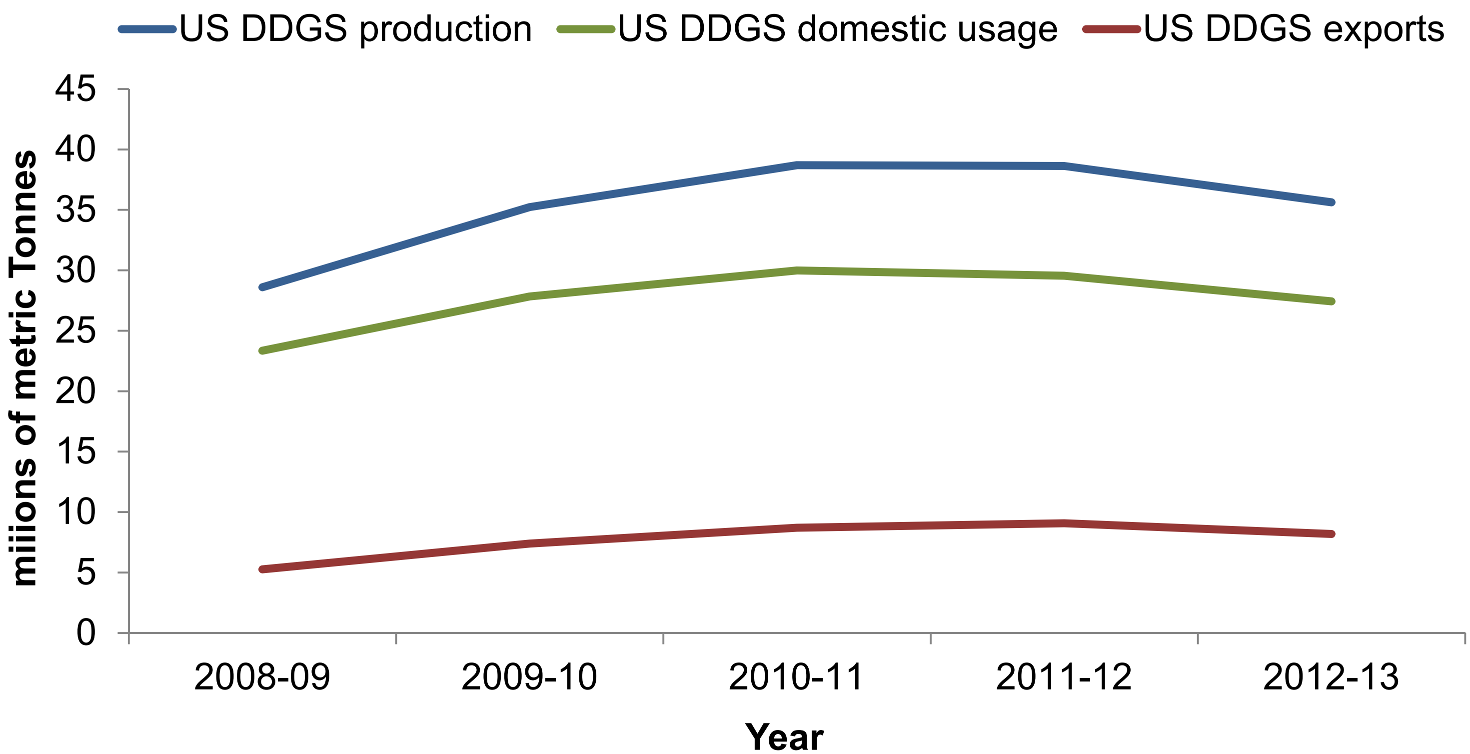


Figure 3. US DDGS production and disposition, 2008-13

Alberta Agriculture and Rural Development

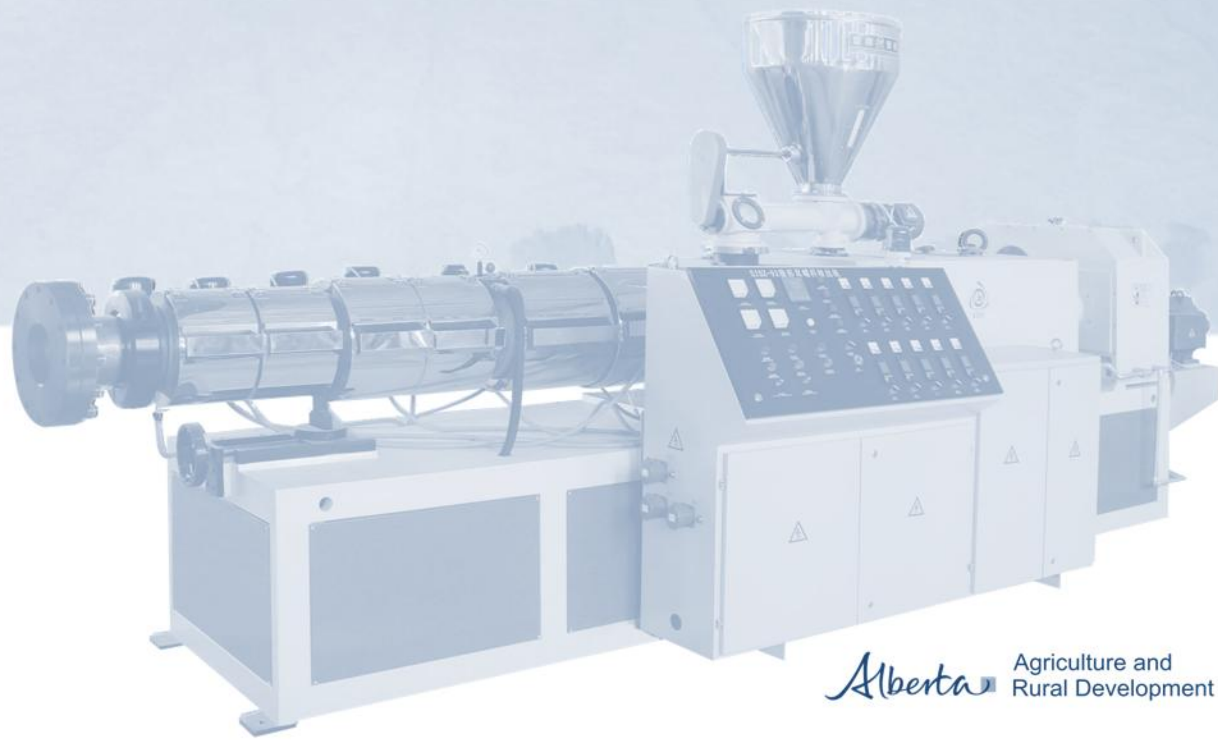
Source: USDA - AMS

34th Western Nutrition Conference

Canola meal and DDGS

- **In both cases, processing results in concentration of:**
  - Protein
  - Minerals
  - Fibre
- **Inclusion in practical diets is generally limited by digestible nutrient content**

Extrusion



Extrusion

- **Seldom used for feeds other than petfood or aquaculture**
  - High capital and operating expense
- **Relative cost of co-products may present opportunity to increase value**
  - Cost vs. benefit?

How extrusion positively impacts feedstuffs *(potentially)*

Carbohydrates

- Destruction of oligosaccharides
- ⇩MWt of hemicellulose
- ⇧solubility of fibre

Proteins

- ⇧denaturation of protein
- ⇧protein digestibility

Anti-nutritional factors

- Inactivation/destruction of tannins, TI, lectins and phytate

from Singh et al., 2007

Extrusion

- **Next to no data on value of extrusion of canola meal for monogastrics**
  - Keady and O'Dougherty (2000) – no benefit for pigs
  - We have studied extruded-expelled meals
- **Our group studied single and twin screw extrusion of different DDGS types fed to broilers**
  - Oryschak et al., 2010a, 2010b

Table 1. Effect of DDGS type and twin-screw extrusion on digestibility coefficients of energy and amino acids in DDGS fed to growing broilers.

	DDGS Type		Extrusion			Effect	
	Corn	Wheat	(-)	(+)	SEM	Type	Extrusion
Gross energy	52.2[a]	48.4[b]	46.2[b]	54.5[a]	1.1	*	***
Arginine	77.2	80.5	73.6[b]	84.1[a]	1.1	*	***
Lysine	65.5	63.6	55.1[b]	74.0[a]	2.0	NS	***
Methionine	82.6	84.3	79.4[b]	87.5[a]	1.1	NS	***
Threonine	63.3[b]	68.3[a]	61.2[b]	70.4[a]	1.3	*	**
Tryptophan	69.9[b]	79.2[a]	72.5[b]	76.6[a]	1.3	***	*

from Oryschak et al., 2010a

Table 2. Effect of single-screw extrusion on digestibility coefficients of energy and amino acids in triticale DDGS fed to growing broilers.

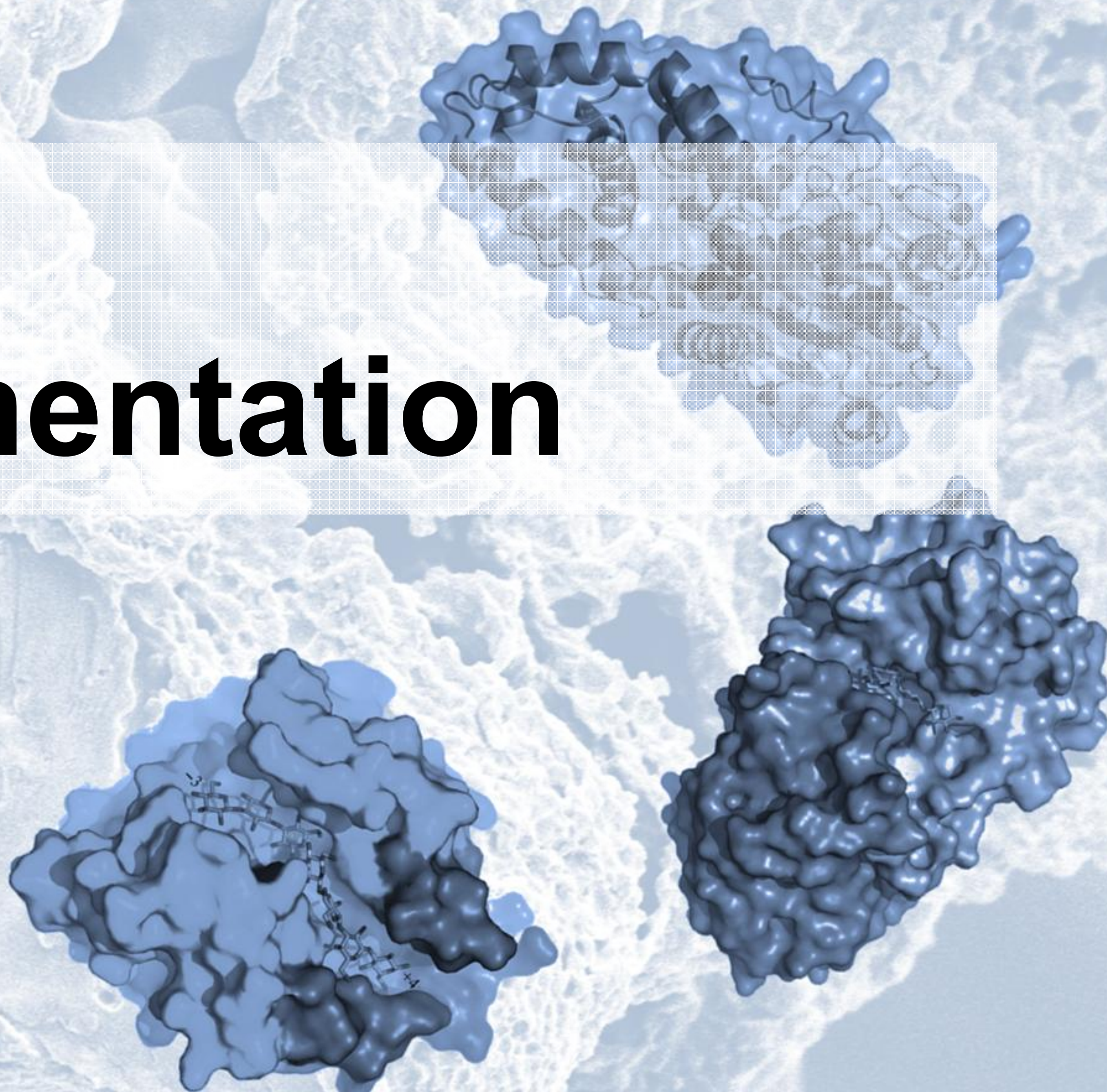
	Extrusion			Effect
	(-)	(+)	SEM	Extrusion
Gross energy	41.1	44.9	2.10	NS
Arginine	78.2	77.6	3.56	NS
Lysine	62.0	58.2	3.26	NS
Methionine	73.0[b]	81.2[a]	1.47	***
Threonine	60.3	59.5	3.09	NS
Tryptophan	70.0[b]	75.6[a]	1.81	**

from Oryschak et al., 2010b

So why the inconsistent response to extrusion?

- **Single screw vs. twin screw extrusion**
- **<u>Hypothesis:</u> extrusion has differential impact on solubles vs. distillers grain**
  - AA in solubles recognized to be less digestible than distillers grains
  - Response ≈ solubles content of DDGS

Enzyme Supplementation



34th Western Nutrition Conference

Alberta Agriculture and Rural Development

Enzyme supplementation

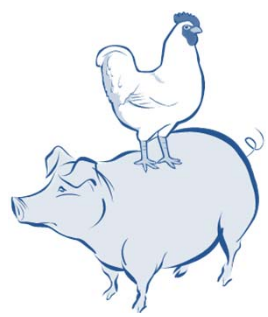
- **Use of enzymes in monogastric feeds is widespread**
  - Global sales of $780 million in 2012
  - 60% NSPases
  - 40% of total volume used in poultry
- **Considerable interest in supplementing diets containing co-products**

The theory: enzymes + co-products

Digestibility nutrient density in co-products limits inclusion

Co-products are relatively cheap

Monogastrics lack intrinsic enzyme activities to take full advantage



Reduced feed costs

Higher inclusion levels of co-products is possible

Exogenous enzymes help degrade problematic substrates in co-products

Nutrient digestibility in co-products is increased

Alberta Agriculture and Rural Development

34th Western Nutrition Conference

What the literature says…

	No positive effects	Limited positive effects	Positive effect
DDGS	Jones et al. (2010) Świątkiewicz and Koreleski (2006) Jacela et al. (2010)	Feoli et al. (2008) Emiola et al. (2009) Oryschak et al. (2010)	
CANOLA MEAL	Mushtaq et al. (2007) Thacker (2001) Jia et al. (2008) *	Kong and Adeola (2011) Zijlstra et al. (2004) Kocher et al. (2001)	Józefiak et al. (2010) * Buchanan et al. (1997) Meng et al. (2005)

Table 3. Effect of enzyme supplementation within triticale DDGS inclusion level on apparent total tract and ileal nutrient digestibility of diets fed to growing broilers.

DDGS level	0%		15%		30%			Effect
Enzyme	(-)	(+)	(-)	(+)	(-)	(+)	SEM	L x E
Apparent total tract digestibility, %								
GE	76.7[a]	77.2[a]	70.4[c]	74.4[b]	66.0[d]	70.5[c]	0.7	**
DM	70.6[a]	70.7[a]	63.0[c]	67.5[b]	58.2[d]	62.8[c]	0.7	**
[NDF-ADF]	63.8	67.5	73.0	72.8	58.6	48.5	3.6	NS
Growth performance								
ADFI g/d	219.2	205.0	209.9	173.8	196.4	197.7	17.0	NS
ADG, g/d	96.0	95.7	90.0	78.5	79.8	82.6	7.9	NS
Gain:Feed	0.440	0.465	0.428	0.492	0.406	0.415	0.027	NS

Why ‘theory’ doesn’t translate to observable differences?

- Enzyme-substrate contact
- Animal factors
- Ingredient quality
- Enzyme-substrate specificity

- Activity vs. [substrate]
- Physical feed factors
- Interactions with intrinsic enzymes

Enzymes for co-products

- **Supplementation should be based on substrate content of diets, not ingredients**
  - Can’t recommend enzyme supplementation based solely on improvements in co-products
- **More targeted approach needed?**
  - Incorporate enzymes directly into co-product production streams???
  - Are certain types of co-products likely to benefit more (e.g., expeller-pressed canola meal)?

Fractionation

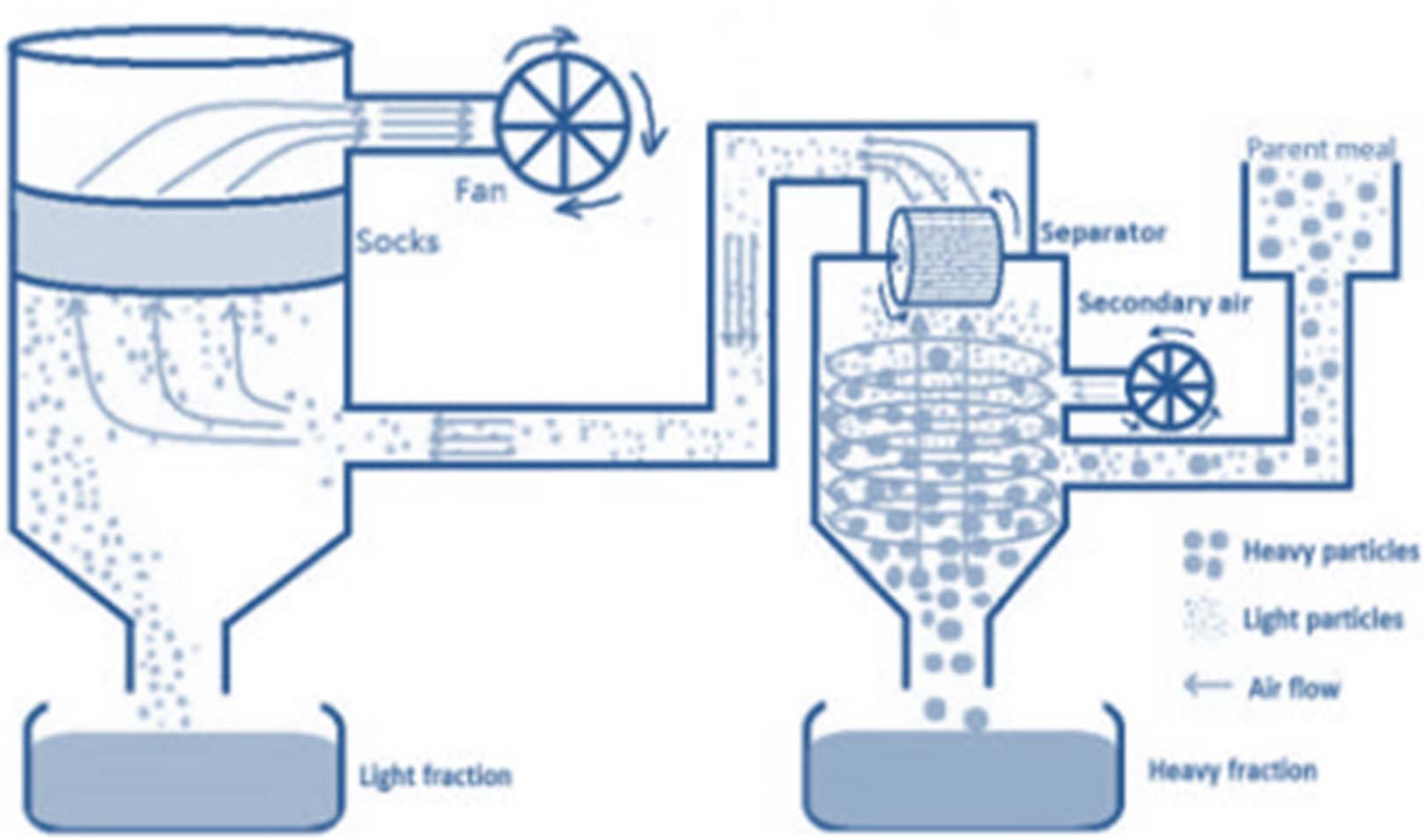
Fractionation

- **Our group has focused heavily on fractionation technologies for domestic co-products**
  - Wheat DDGS & canola meal
- **Our group's criteria for fractionation technologies**
  - Low capital expense
  - Continuous throughput (rather than batch)
  - Fully scalable for various size operations

Fractionation

- **Dry fractionation technologies are based primarily on separation by:**
  - Particle size
  - Particle weight
- **Ideally, particles differing in either property differ as well in nutrient or fibre content**
  - Can therefore generate 2 differentiated products from a single parent material

Air classification



Alberta Agriculture and Rural Development

34th Western Nutrition Conference

Table 4. Analyzed composition (%) and glucosinolate content of solvent-extracted *B. napus* and *B. juncea* meals and their air-classified fractions.

	B. napus			*B. juncea*		
	Parent meal	Light fraction	Heavy fraction	Parent meal	Light fraction	Heavy fraction
Crude protein	39.2	41.9	37.3	38.4	41.0	37.2
Acid detergent fibre	20.1	13.1	25.6	12.9	8.6	16.5
Neutral detergent fibre	27.2	20.6	31.5	20.4	13.6	23.5
Lysine	2.0	2.4	2.1	1.9	2.1	1.8
Methionine	0.7	0.8	0.7	0.7	0.8	0.7
Total glucosinolate, μmol/g	6.4	4.7	3.9	11.7	9.8	9.0

from Zhou et al., 2013

Table 5. Effect of fraction type on apparent total tract and ileal digestibility (%) of dietary energy and nutrients in growing pigs.

	Canola fraction type				Effect
	Parent stock	AC 'Light' fraction	AC 'Heavy' fraction	SEM	Type
Apparent total tract digestibility, %					
Dry matter	74.2^{a}	76.7^{a}	70.2^{b}	0.8	***
Gross energy	74.1^{b}	78.0^{a}	71.3^{c}	0.9	***
Apparent ileal digestibility, %					
Gross energy	41.7^{b}	57.2^{a}	37.8^{b}	2.5	***
Crude protein	67.0^{a}	70.5^{a}	61.1^{b}	2.0	***
Lysine	72.9^{a}	75.5^{a}	68.0^{b}	2.1	**
Methionine	79.7^{ab}	81.8^{a}	76.7^{b}	1.9	*
Threonine	65.1^{ab}	70.5^{a}	60.1^{b}	2.2	**

preliminary data from Zhou, unpublished

Table 6. Main effect of canola fraction type on overall (d 0 – 37) growth performance of weaned pigs fed diets containing 20% dietary inclusions of *Brassica napus* or *Brassica juncea* meals or their air classified light or heavy fractions.

	Canola fraction type				Effect
	Parent stock	AC 'Light' fraction	AC 'Heavy' fraction	SEM	Type
ADFI, g/d	736.3	740.8	740.7	6.8	NS
ADG, g/d	501.3	519.2	505.4	5.7	0.070
Gain:Feed, g/g	0.721^{b}	0.739^{a}	0.720^{b}	0.006	***

from Zhou et al., 2013

Table 7. Apparent ileal digestibility (%) of amino acids in *Brassica napus* canola meal compared to light and heavy air classified fractions fed to broilers

	B. napus product				Effect
	Parent stock	AC 'Light' fraction	AC 'Heavy' fraction	SEM	Product
Lysine	77.5[b]	85.9[a]	87.4[a]	1.4	***
Methionine	88.7[b]	92.5[a]	95.5[a]	1.6	**
Met + Cys	76.8[b]	85.3[a]	87.5[a]	2.1	*
Threonine	72.7	74.4	79.1	2.6	NS
Arginine	88.6[b]	94.5[a]	96.4[a]	0.7	***
Total AA	78.2[b]	86.2[a]	89.7[a]	1.5	***

from Oryschak et al., 2011b

Table 8a. Effect of fraction type on overall (d 8 – 35) growth performance and selected carcass traits of broilers fed diets containing 20% dietary inclusions of *B. napus* or *Brassica juncea* meals or their air classified light or heavy fractions.

	Canola fraction type				Effect
	Parent stock	AC 'Light' fraction	AC 'Heavy' fraction	SEM	Type
Growth performance (d 8 – 35)					
ADFI, g/d	73.4^{b}	77.3^{a}	75.9^{a}	0.9	**
ADG, g/d	97.1	96.4	98.2	1.5	NS
Gain:Feed, g/g	0.757^{b}	0.807^{a}	0.774^{ab}	0.013	*
Carcass traits (d 36)					
Ante-mortem weight, kg	2047.2^{b}	2148.1^{a}	2114.7^{a}	22.2	**
Carcass weight, kg	1446.5	1441.2	1455.1	4.6	0.10
Dressing percentage, %	68.72	68.51	69.16	0.20	NS

from Oryschak and Beltranena, 2013

Table 8b. Effect of fraction type on calculated ingredient AME and energetic efficiency of broilers fed diets containing 20% dietary inclusions of *B. napus* or *Brassica juncea* meals or their air classified light or heavy fractions.

	Canola fraction type				Effect
	Parent stock	AC 'Light' fraction	AC 'Heavy' fraction	SEM	Type
Starter phase (d 8 – 14)					
Ingredient AME, kcal/kg	2588[b]	2805[a]	2498[c]	24	***
AME intake:gain, kcal/g	4.15	4.33	4.07	0.08	0.06
Grower phase (d 15 – 35)					
Ingredient AME, kcal/kg	2202[b]	2495[a]	2100[b]	39	***
AME intake:gain, kcal/g	5.22	5.05	5.01	0.10	NS

from Oryschak and Beltranena, 2013

Two-step dry fractionation

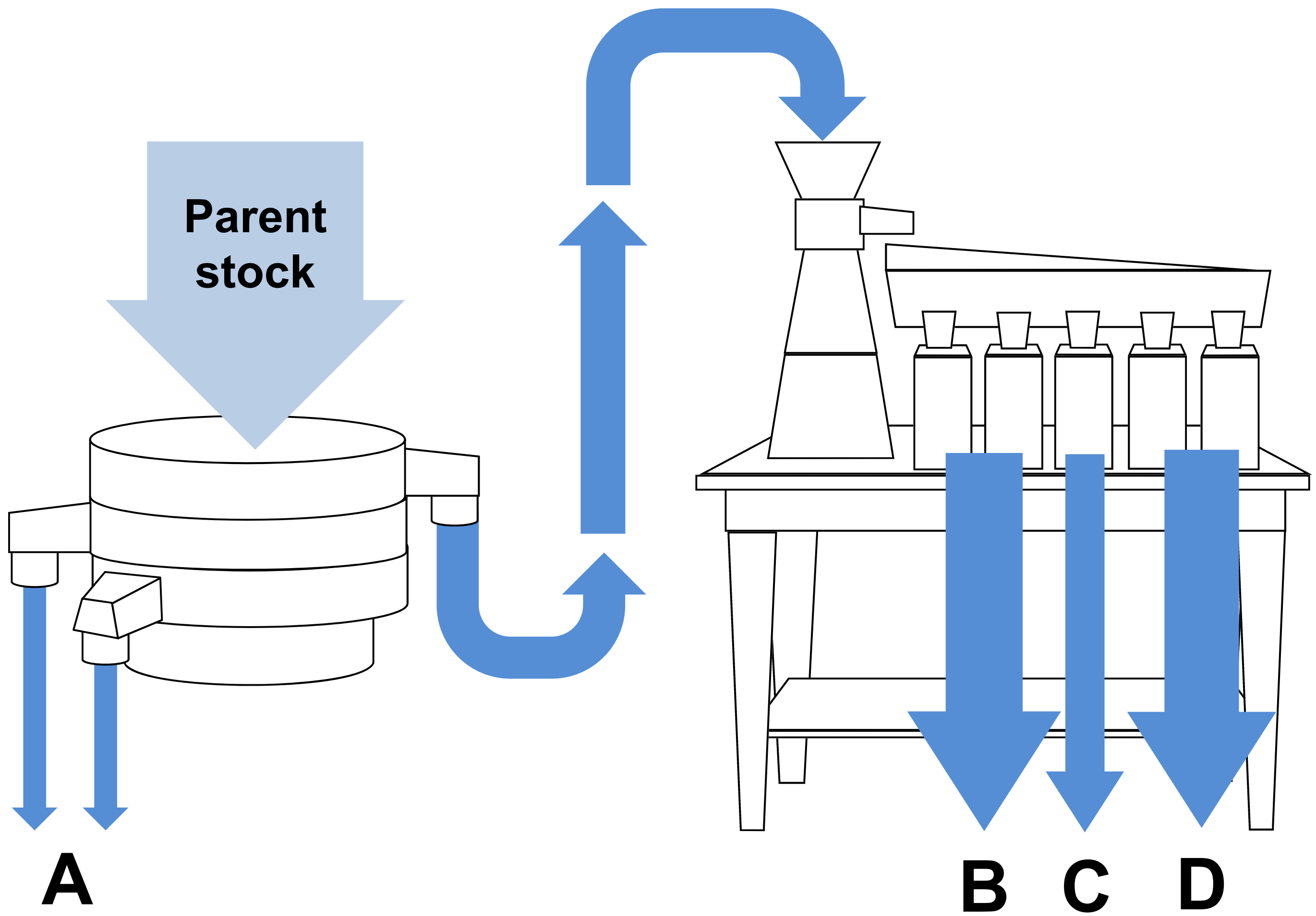


Table 10. Analysed nutrient composition of wheat DDGS compared to 3 DDGS fractions produced using a 2-step dry fractionation procedure.

	Parent stock	Fraction 'A'	Fraction 'C'	Fraction 'D'
Crude protein	38.4	44.8	39.3	33.8
Acid detergent fibre	10.7	9.4	11.6	12.9
Neutral detergent fibre	36.1	29.1	35.1	37.5
Lysine	0.84	0.90	0.85	0.74
Methionine	0.53	0.61	0.53	0.45
Threonine	1.09	1.22	1.09	0.94
Tryptophan	0.39	0.43	0.37	0.31

Table 11. Apparent total tract digestibility of gross energy and apparent ileal digestibility of selected amino acids in wheat DDGS and 3 wheat DDGS fractions fed to growing broilers.

	Parent stock	DDGS Fraction				Effect
		A	C	D	SEM	Fraction
GE	62.7	75.1	56.8	69.0	5.2	NS
Lysine	73.5	67.3	69.8	77.3	5.4	NS
Met + Cys	83.7	79.9	78.4	86.4	5.1	NS
Threonine	76.3	74.2	71.8	82.6	5.3	NS
Arginine	85.7	82.5	81.9	88.7	3.0	NS
Total AA	85.2	81.2	80.7	86.6	4.2	NS

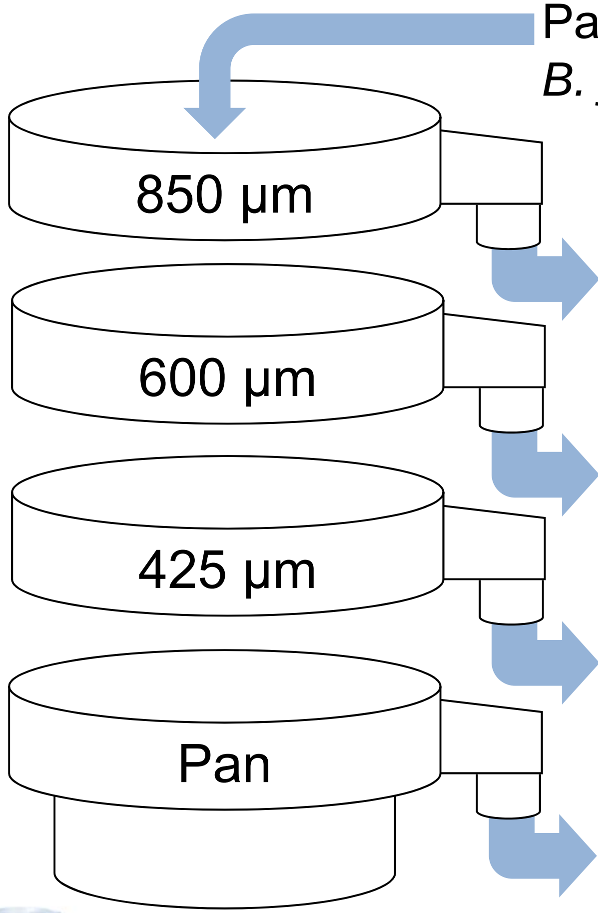
from Oryschak et al., 2011a

Table 12. Standardized ileal digestibility of crude protein and selected amino acids in wheat DDGS, soybean meal and 3 wheat DDGS fractions fed to growing pigs

	Wheat DDGS	Soybean meal	DDGS fraction				Effect
			A	C	D	SEM	Ingred
Crude protein	77.3	75.5	79.6	75.7	86.4	2.8	0.060
Arginine	87.9^{b}	86.4^{b}	87.6^{b}	84.4^{b}	96.6^{a}	2.6	*
Lysine	71.2^{bc}	79.2^{b}	68.8^{bc}	67.6^{c}	90.1^{a}	3.7	***
Methionine	79.8	82.2	81.0	79.0	83.8	1.5	NS
Threonine	78.4^{ab}	72.9^{b}	77.2^{b}	74.7^{b}	86.6^{a}	3.2	*
Tryptophan	84.0^{b}	81.8^{b}	83.9^{b}	80.8^{b}	94.9^{a}	2.4	**

from Yàňez, submitted

The 'yield vs. density' conundrum



	Yield, %	CP, %	ADF, %	NDF, %
Parent stock *B. juncea*	-	39.1	13.4	19.8
> 850 µm	33.4	41.5	15.0	22.8
< 850 µm	20.1	40.6	14.9	23.6
< 600 µm	19.0	42.9	12.0	18.6
< 425 µm	23.9	47.0	7.6	11.8

Putting it all together

- **Enzymes**
  - No clear improvements in diets with co-products
  - Alternative approaches to supplementation??
- **Extrusion**
  - Seems to increase AA digestibility in DDGS
  - Gap: potential benefits of extrusion for canola products
  - Incorporate extrusion into production streams for co-products??

Putting it all together

- **Fractionation**
  - Capable of generating higher density fractions more suited to monogastrics
  - Improves nutrient digestibility: canola meal - yes; DDGS – no
  - Technology meets key criteria
  - BIG QUESTION – Where is the ‘best’ balance between yield and density??

Acknowledgements

Canadian Triticale Biorefinery Initiative

AARI Alberta Agricultural Research Institute

cbs Canadian Bio-Systems

O&T Farms

Canada

Alberta Livestock Industry Development Fund

Agriculture & Food Council *The Catalyst*

FOBI Feed Opportunities from Biofuels Initiative

Alberta Canola Producers Commission

SaskCanola Saskatchewan Canola Development Commission

TERRA Grain Fuels

Alberta Agriculture and Rural Development

Manitoba Canola Growers

canolacouncil of Canada