Abstract # 146

Government of Alberta
Agriculture and Rural Development

Effect of Extrusion on Nutrient Digestibility in Corn and Wheat DDGS for Broilers

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Background

- **Government-mandated ‘green’ content in fuels:**

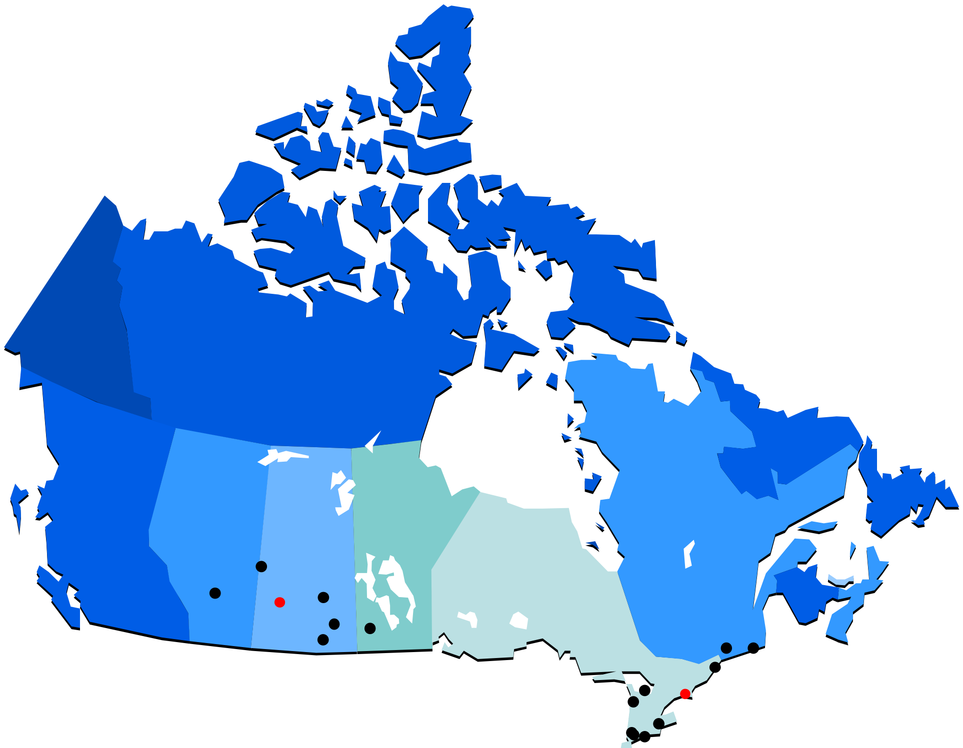
5% in gasoline by 2010
2% in diesel/heating oil by 2012

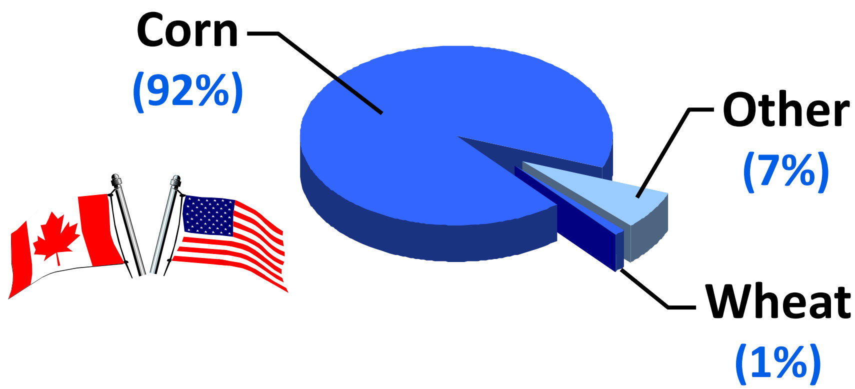
36 B Gallons by 2022
(~15% of gasoline consumption)

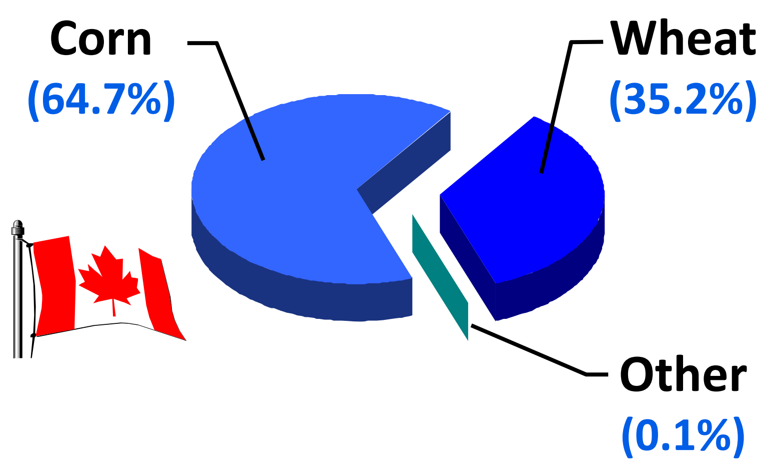
Background

- **Demand created by renewable fuel standards will likely stimulate ethanol production**
  - ↑ demand/competition for feed grains
  - ↑ supply of ethanol co-products (i.e., DDGS)

Ethanol Production in Canada







Disposition of Canadian Wheat
(in millions of metric tonnes)

	Wheat (except Durum)		
	2007-08	2008-09	2009-10
Total Supply[1]	22.00	26.83	22.42
Exports	12.68	14.50	12.50
Food & Industrial Use	3.02	3.25	3.20
Feed, Waste & Dockage	1.79	3.67	2.08
Total Domestic Use	5.60	7.73	6.12

[1] Annual domestic production + imports + carry-over stocks

Implication: Further expansion of Canadian starch-based ethanol will likely mean greater reliance on wheat as a feed stock

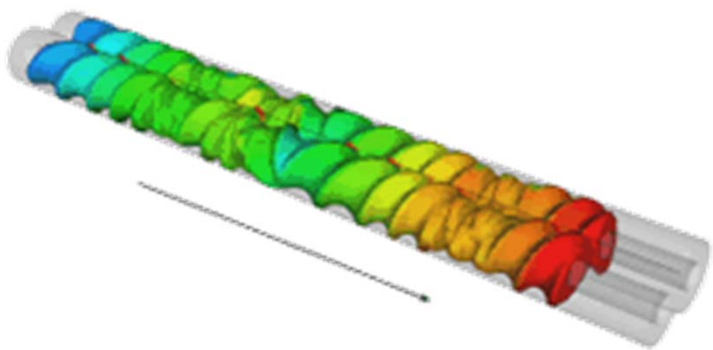
Source: Statistics Canada

Background

- **Distiller's dried grains and solubles (DDGS) have value as a protein ingredient for livestock**
  - Several challenges to expanded use but fibre level is perhaps most important for non-ruminants

Extrusion

- **Extrusion subjects ingredients to heat and shearing forces of a rotating screw auger**
  - Shear forces disrupt fibrous components
  - Heating can improve (or reduce) nutrient digestibility depending on conditions



Objectives

1. **Evaluate twin-screw extrusion as a possible low-cost processing strategy to improve feed value of DDGS**
2. **Increase knowledge of feeding value of wheat DDGS compared to corn DDGS for broilers**

Methods and Materials

Test system

- **Male Ross x Ross 308 broilers housed in cage batteries in a single room**
  - Approximately 7-8 birds per cage
  - Continuous access to nipple drinkers and trough feeder fitted with solid partitions
  - Wire mesh floors with conveyor belt system for each tier of battery

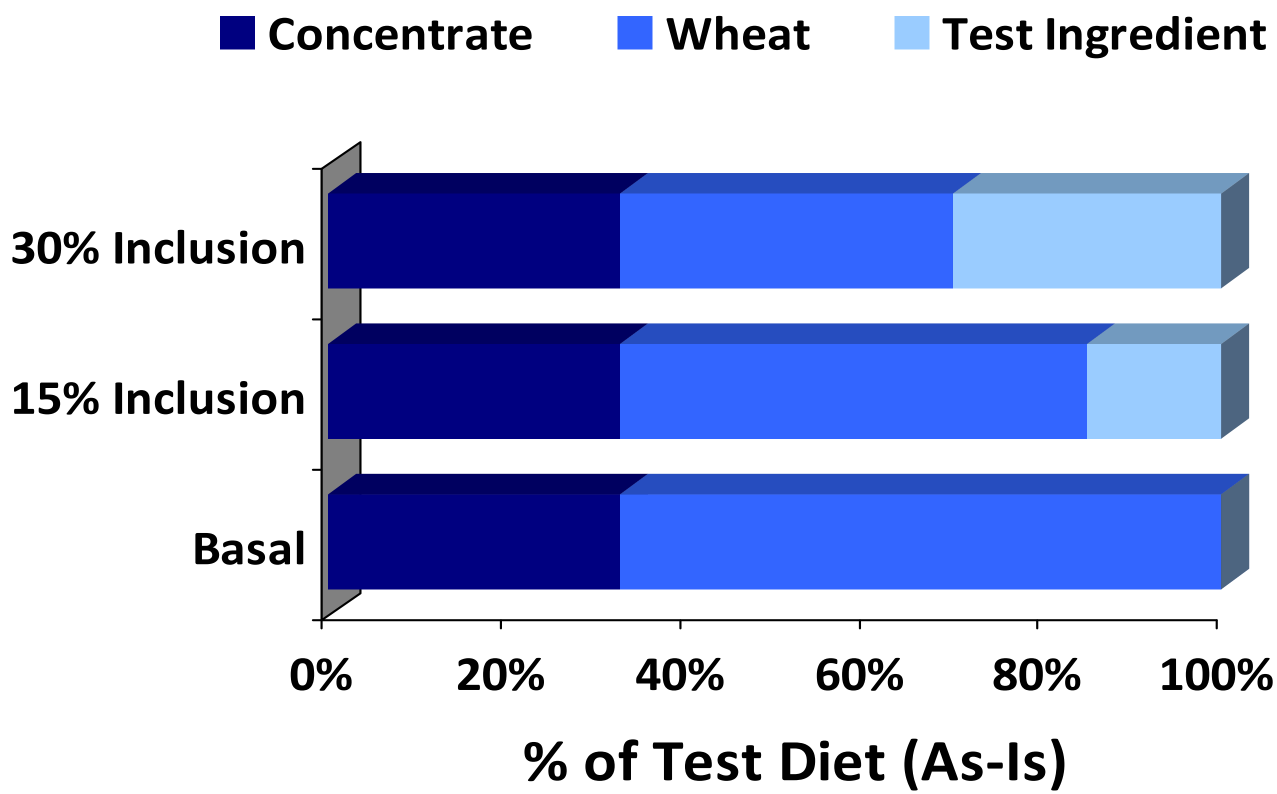
Experimental management

- **Test birds fed basal starter ration from d0-14 and basal grower ration from d14-21**
  - Birds received one of 9 test diets from d21-28
  - Sampled for ileal digesta on d 28 (1 pooled specimen/pen)

Test ingredients

- **Test ingredients:**
  - Wheat DDGS (Terra Grain Fuels; Belle Plaine, SK)
  - Corn DDGS (Imported Commercial Stock)
  - Twin screw extruded wheat DDGS
  - Twin screw extruded corn DDGS
- **All diets were supplemented with Superzyme^{TM} DDGS (0.05%)**

Test diets


Concentrate
Wheat
Test Ingredient
30% Inclusion
15% Inclusion
Basal
0%
20%
40%
60%
80%
100%
% of Test Diet (As-Is)

Test diets

- **9 test diets:**
  - Basal
  - 15% or 30%, twin-screw extruded or not extruded, wheat or corn DDGS (2 x 2 x 2 = 8)

Table 1. Estimated nutrient content of test diets

Nutrient	Basal (no DDGS)	Corn DDGS 15%	Corn DDGS 30%	Wheat DDGS 15%	Wheat DDGS 30%
Dry Matter, %	89.44	89.95	90.47	89.95	90.45
ME, kcal/kg	3152	3017	2883	3017	2883
Cr. Protein, %	20.11	22.07	24.04	22.95	25.79
Cr. Fat, %	7.15	8.52	9.89	7.96	8.77
Cr. Fiber, %	2.58	2.98	3.38	3.11	3.64
Av. Phosphorus, %	0.45	0.46	0.48	0.47	0.48
Calcium, %	0.90	0.90	0.89	0.91	0.92
Total Lys, %	1.10	1.18	1.27	1.18	1.27
Total Met + Cys, %	0.79	0.86	0.92	0.87	0.96

Experimental design

- **Randomized complete block:**
  - Test cages divided into 5 blocks based on location within battery and room
  - Each treatment fed to 1 pen/block
  - Pen = experimental unit

Statistical analysis

- **AID in test diets analyzed using mixed models (PROC MIXED) in SAS® v 9.1**
  - Model: **y = DDGS type | Level | Extrusion**
  - Random term: **block**
  - Covariate: **intake of ADF, crude fibre, nutrient**

Results and Interpretations

Significant terms in models

	Main Effects			Interactions			
	Level	Extrusion	Type	L x E	L x T	T x E	3-way
Dry Matter	<.0001	<.0001	<.0001	-	-	0.0027	0.0421
Gross Energy	<.0001	<.0001	<.0001	-	-	0.0915	0.0591
Crude Protein	<.0001	<.0001	-	-	0.0091	-	-
Lysine	<.0001	<.0001	0.0828	0.0443	0.0703	-	-
Methionine	<.0001	<.0001	-	-	0.0445	0.0346	-
Threonine	<.0001	<.0001	-	-	0.0014	0.0625	-
Arginine	<.0001	<.0001	-	-	0.0015	-	-
Total AA's	<.0001	<.0001	-	-	0.0026	-	-

Results: AID test diets

- **Level of inclusion:**
  - Clear pattern - 15% > 30%
- **Extrusion:**
  - Consistently improved AID in test diets
- **DDGS type:**
  - More complex

Table 2. Apparent ileal nutrient digestibility in diets containing 15% non-extruded and extruded corn or wheat DDGS

	Corn DDGS		Wheat DDGS		Pooled
Nutrient	Not	Extruded	Not	Extruded	SEM
Dry Matter	65.69[c]	71.78[a]	65.57[c]	68.26[b]	0.48
Gross Energy	71.61[c]	76.39[a]	71.01[c]	73.53[b]	0.46
Crude Protein	82.35[b]	85.81[a]	82.26[b]	84.60[a]	0.47
Lysine	83.36[b]	85.76[a]	82.08[b]	84.16[ab]	0.72
Methionine	85.51[b]	88.22[a]	85.11[b]	86.68[ab]	0.76
Threonine	75.85[bc]	79.87[a]	75.41[c]	77.93[ab]	0.78
Arginine	85.54[bc]	88.16[a]	84.54[c]	86.86[ab]	0.52
Total Amino Acids	83.72[c]	86.66[a]	83.03[c]	85.22[b]	0.53

Different superscripts within rows denote significant differences ($P < 0.05$)

Table 3. Apparent ileal nutrient digestibility in diets containing 30% non-extruded and extruded corn or wheat DDGS

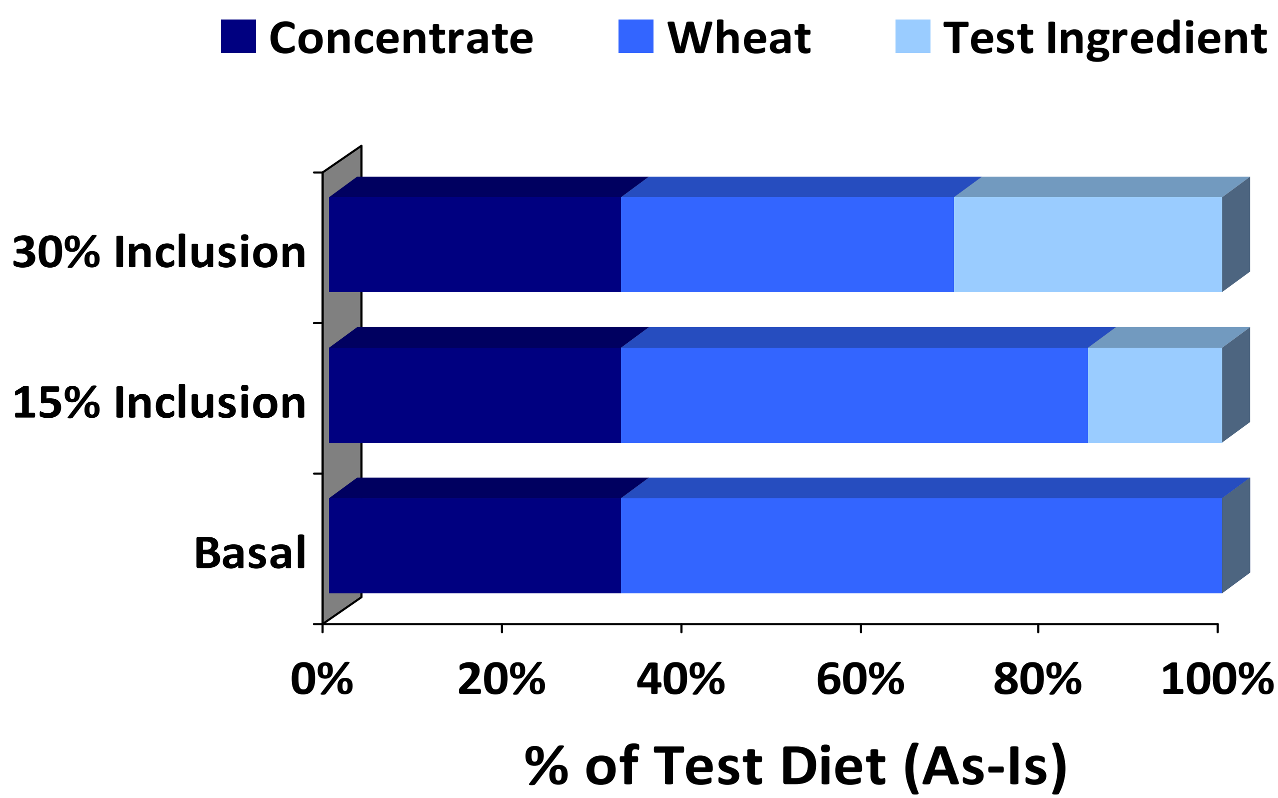
	Corn DDGS		Wheat DDGS		Pooled
Nutrient	Not	Extruded	Not	Extruded	SEM
Dry Matter	61.17^{c}	64.99^{a}	60.13^{c}	63.22^{b}	0.47
Gross Energy	67.92^{b}	70.55^{a}	66.76^{b}	69.52^{a}	0.45
Crude Protein	78.33^{c}	81.62^{a}	79.65^{b}	82.20^{a}	0.46
Lysine	78.05^{b}	82.37^{a}	78.51^{b}	81.97^{a}	0.70
Methionine	81.42^{b}	85.79^{a}	83.34^{b}	85.34^{a}	0.74
Threonine	70.20^{c}	74.29^{ab}	73.35^{b}	75.36^{a}	0.76
Arginine	81.83^{c}	85.34^{a}	83.42^{b}	85.48^{a}	0.51
Total Amino Acids	79.46^{c}	82.61^{a}	81.11^{b}	82.97^{a}	0.52

Different superscripts within rows denote significant differences ($P < 0.05$)

Estimating AID in test ingredients

- **Interest in estimating nutrient digestibility coefficients for each DDGS type**
  - How much did extrusion improve AID in DDGS?
  - Needed dig nutrient contents in order to formulate diets for performance study

Test diets


Concentrate
Wheat
Test Ingredient
30% Inclusion
15% Inclusion
Basal
0%
20%
40%
60%
80%
100%
% of Test Diet (As-Is)

Procedure used to estimate nutrient digestibility in test ingredients

As a result, for the diets in our study:

$$D_{assay} = D_{wheat} \times RC_{wheat} + D_{conc} \times RC_{conc} + D_{test} \times RC_{test}$$

This can be rearranged to solve for $\mathbf{D_{test}}$:

$$D_{test} = \frac{D_{assay} - D_{conc} \times RC_{conc} - D_{wheat} \times RC_{wheat}}{RC_{test}}$$

Table 4. Literature AID coefficients for wheat used to estimate AID in test ingredients

	w/ NSPase
Gross Energy	0.68
Crude Protein	0.77
Lysine	0.92
Methionine	0.96
Threonine	0.82
Arginine	0.90

Derived from:

Afshermanesh et al. 1998 (Can. J. Anim Sci. 86: 255-261)
Huang et al. 2005 (Brit Poult. Sci. 46: 236-245)
Ravindran 1999 (Brit. Poult. Sci. 40: 266-274)
Rutherfurd et al. 2002 (Brit. Poult. Sci. 44: 598-606)
Rafuse et al. 2005 (Can. J. Anim. Sci. 85: 493-499)
Scott et al. 1998 (Poult. Sci. 77: 456-463)
Bedford et al. 1998 (Can. J. Anim. Sci. 78: 335-342)
Huang et al. 2006 (Poult. Sci 86: 625-634)

Significant terms in models

	Main Effects			Interactions			
	Level	Extrusion	Type	L x E	L x T	T x E	3-way
Gross Energy	<.0001	<.0001	<.0001	<.0001	0.0075	0.0137	0.0074
Crude Protein	<.0001	<.0001	-	0.0018	0.0087	0.0116	-
Lysine	0.0006	<.0001	0.0089	-	0.0506	-	-
Methionine	0.0039	<.0001	-	-	0.0917	-	-
Threonine	<.0001	<.0001	-	0.0550	0.0094	-	-
Arginine	0.0002	<.0001	-	-	0.0042	-	-

Interpretation: effect of level not solely the result of wheat inclusion (assumptions underlying difference method reasonable???)

Results: AID in test ingredients

- **Level:**
  - AID estimates generally lower when based on observed digestibilities in 30% test diets
- **Extrusion:**
  - Consistent improvements in AID

Results: AID in test ingredients

- **DDGS type:**
  - AID in extr. corn DDGS > extr. wheat DDGS, based on 15% inclusion
  - Based on 30% diets, AID in extrudates statistically similar

Table 5. Apparent ileal nutrient digestibility in non-extruded and extruded corn or wheat DDGS (based on 15% inclusion)

Nutrient	Corn DDGS		Wheat DDGS		Pooled SEM
	Not	Extruded	Not	Extruded	
Gross Energy	47.44[c]	75.31[a]	43.88[c]	58.31[b]	1.67
Crude Protein	62.09[c]	81.26[a]	64.39[c]	73.15[b]	1.76
Lysine	63.24[b]	83.27[a]	49.69[c]	70.89[b]	4.27
Methionine	83.70[bc]	94.13[a]	82.78[c]	89.73[ab]	2.59
Threonine	65.18[c]	85.78[a]	62.14[c]	76.31[b]	3.25
Arginine	75.06[c]	92.70[a]	69.49[c]	85.10[b]	2.51

Interpretation: Extrusion large, significant improvements in nutrient digestibility (in particular AA's) in DDGS

Different superscripts within rows denote significant differences ($P < 0.05$)

Table 6. Apparent ileal nutrient digestibility in non-extruded and extruded corn or wheat DDGS (based on 30% inclusion)

	Corn DDGS		Wheat DDGS		Pooled
Nutrient	Not	Extruded	Not	Extruded	SEM
Gross Energy	45.78^{bc}	53.89^{a}	41.68^{c}	50.17^{ab}	1.65
Crude Protein	60.03^{c}	68.28^{ab}	64.76^{b}	69.79^{a}	1.74
Lysine	52.17^{b}	71.48^{a}	50.06^{b}	69.13^{a}	4.22
Methionine	76.33^{b}	87.12^{a}	82.88^{a}	86.82^{a}	2.56
Threonine	56.28^{b}	67.49^{a}	63.41^{ab}	70.58^{a}	3.21
Arginine	67.86^{c}	81.31^{a}	73.96^{b}	82.07^{a}	2.48

Interpretation: Extrusion resulted in similar pattern and order of improvement as in 15% diets, through AID estimates were lower

Different superscripts within rows denote significant differences ($P < 0.05$)

Summary

- **Increased demand for ethanol will increase availability of DDGS for livestock & poultry feeding**
  - US: corn DDGS
  - Canada: wheat (west) and corn (east) DDGS
- **Extrusion consistently improves AID of nutrients in both corn and wheat DDGS**

Summary

- **AID coefficients are similar between corn and wheat DDGS at high inclusion levels**
- **Level of inclusion in test diets appeared to influence AID estimates for DDGS**
  - Possibly due in part to fibre load in test diets
  - Other factors…assumptions of difference method valid (??)

What all this means…

	Increase in dig. nutrient content (units/T)	Value of dig. nutrient content ($/unit)	Estimated increase in value ($/T)
Energy	350 Mcal/T	$0.07/Mcal	$24.50
Lysine	2 kg/T	$2.40/kg	$4.80
Methionine	1 kg/T	$7.50/kg	$7.50
Threonine	2 kg/T	$3.00/kg	$6.00
		Total	$42.80

Side benefits of extrusion

- **Improved handling characteristics**
  - Flowability improved dramatically
- **Eliminates or reduces toxin/pathogen levels**
  - Some reports suggest extrusion effective against certain mycotoxins (??)

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