



Swine Innovation Porc

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CHANGING LIVES
IMPROVING LIFE

Towards Integrated Nutritional Management of Growing-Finishing pigs

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Many factors should be considered when optimizing feeding programs:

Towards decision support systems (DSS)



Outline

- **Introduction:**
 - Univ. of Guelph swine nutrition research objectives
- **Highlights of three research projects:**
 - Long-term impact of post-weaning feeding program
 - Estimating and manipulating the nutritional value of alternative pig feed ingredients: (Ontario) DDGS
 - Integrating cumulative knowledge in user-friendly decision support systems
- **Conclusions and acknowledgements:**

Univ. of Guelph Swine Nutrition Research Program

Research Objectives

- Improve efficiency/profitability of pork production
- Improve pork quality and safety
- Minimize environmental impact
- Reduce reliance on in-feed medication



Production

Metabolism

Isolation

Meat lab

+ extensive analytical capability (nutrition; microbiology; genomics)

University of Guelph swine nutrition researchers



Dr. M. Fan



Dr. T. Smith



Dr. P. Luimes



Mr. P. McEwan

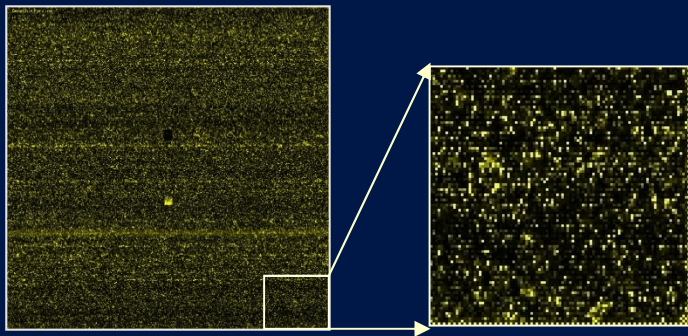
- + 5 Post-docs, >10 Grad Students, >5 Research associates,
- + Many collaborators (meat, veterinary, molecular sciences, economics) at U of Guelph, other institutes & industry

Impact of post-weaning feeding strategies on subsequent productivity of growing pigs

- Two opposing views:
 1. Higher post-weaning growth performance will result in sustained higher growth performance up to market weight (Mahan et al., 2004; Tokach et al., 2007):
 - Relationship is generally established based on observations on individual pigs within groups of pigs
 2. Reduced post-weaning growth performance will induce compensatory growth (Wellock et al., 2009):
 - Represents a means to reduce feed costs
 - Extent of compensatory growth may vary with cause of reduced post-weaning growth performance (e.g. amino acid or animal protein intake restriction, disease; Nelssen et al., 1999)

Impact of post-weaning feeding strategies on subsequent productivity of growing pigs

- **Missing piece:** Physiological link between the pigs' response to stress during weaning vs. expression of subsequent growth potential and carcass quality
 - Permanent alteration in the expression of genes involved in nutrient use and immune function?
 - Persistent increase in expression of genes involved in oxidative stress response in pigs fed soy protein (Junghans et al., 2007)



Identify differentially expressed genes using microarrays & quantitative assessment of expression of candidate genes over time

Impact of post-weaning feeding strategies on subsequent productivity of growing pigs

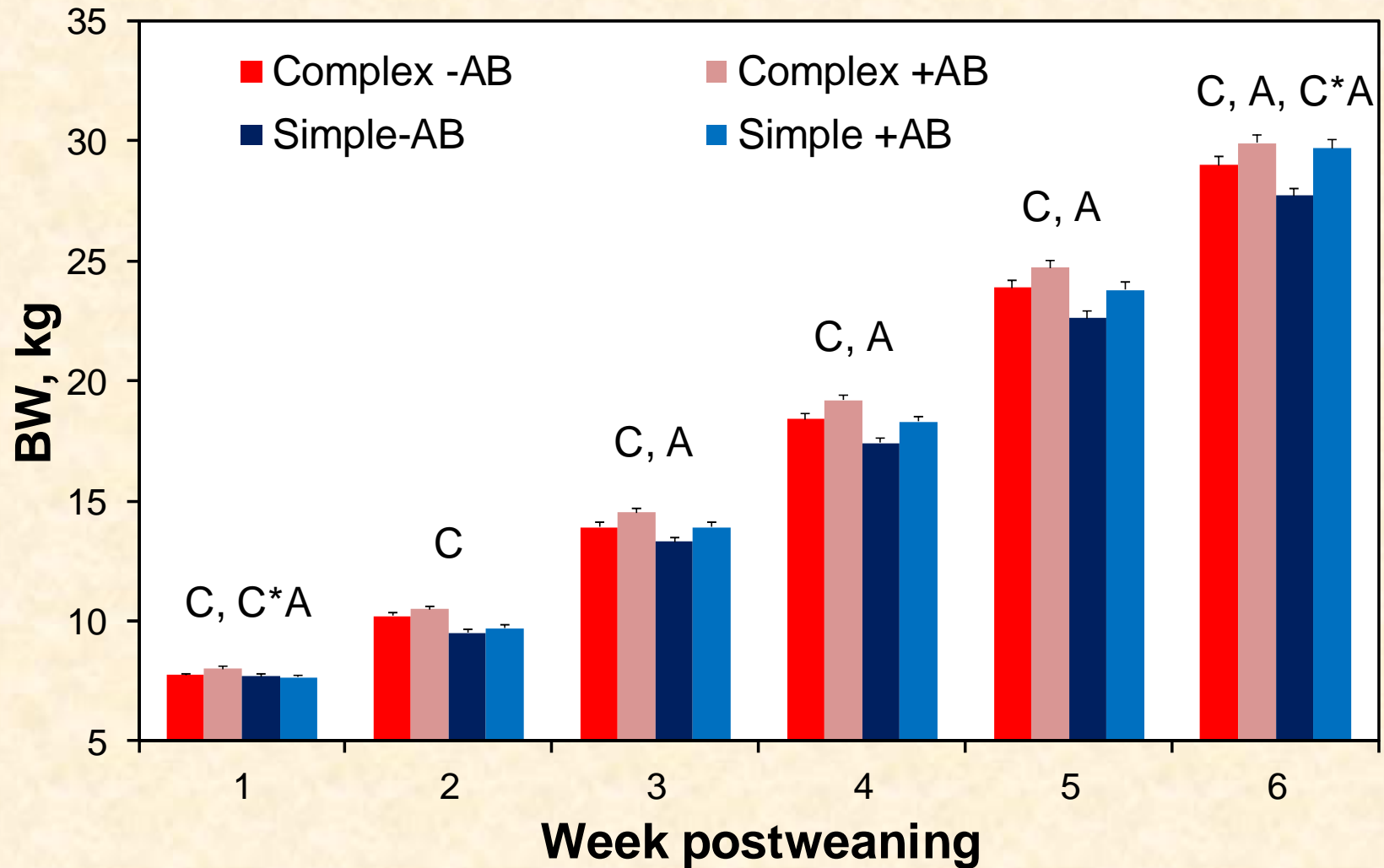
- **Objective I:**
 - Evaluate the effect of diet complexity and in-feed antibiotics in the nursery phase on (1) growth performance in the growing-finishing phase and (2) final carcass quality market weight
- **Objective II:**
 - Identify bio-markers for pig growth performance: monitor (1) plasma metabolites and (2) expression of genes involved in nutrient use and immune function in plasma, muscle, liver, fat and intestinal tissue from weaning to finishing

Diet compositions (% as fed)

	Complex			Simple		
Phase	I	II	III	I	II	III
Corn	18.85	38.7	50.23	47.14	49.57	47.25
Wheat				10	10	10
Barley	25	25	25			
SBM, 47.5%	10.8	15	21	24	34	37
Whey	20	8	-	8	-	-
Herring ml, %	5	3	-	5	-	-
Blood plasma, AP920	4.5	2	-	-	-	-
Blood ml, spray dried	-	2	2	-	-	-
Oat groats	10	-	-	-	-	-
Calcium propionate	0.4	0.4	0.2	-	-	-
Calcium formate	0.4	0.4	0.2	-	-	-
Fat, AA, vit, min	+	+	+	+	+	+
DE, MJ/kg	14.43	14.30	14.49	14.93	14.92	14.96
SID Lys, %	1.35	1.25	1.17	1.21	1.25	1.17

With or without Chlorotetracycline (Aureomycin 100; g/1000 kg: 400 in Phase I & II; 100 in Phase III)

Changes in body weight during the nursery phase (weaning weight 6.93 kg)



C, A = complexity, antibiotic, $P < 0.05$

C*A = interaction, $P < 0.10$

Preliminary data (n=8 pens/treatment; 8-10 pigs/pen)

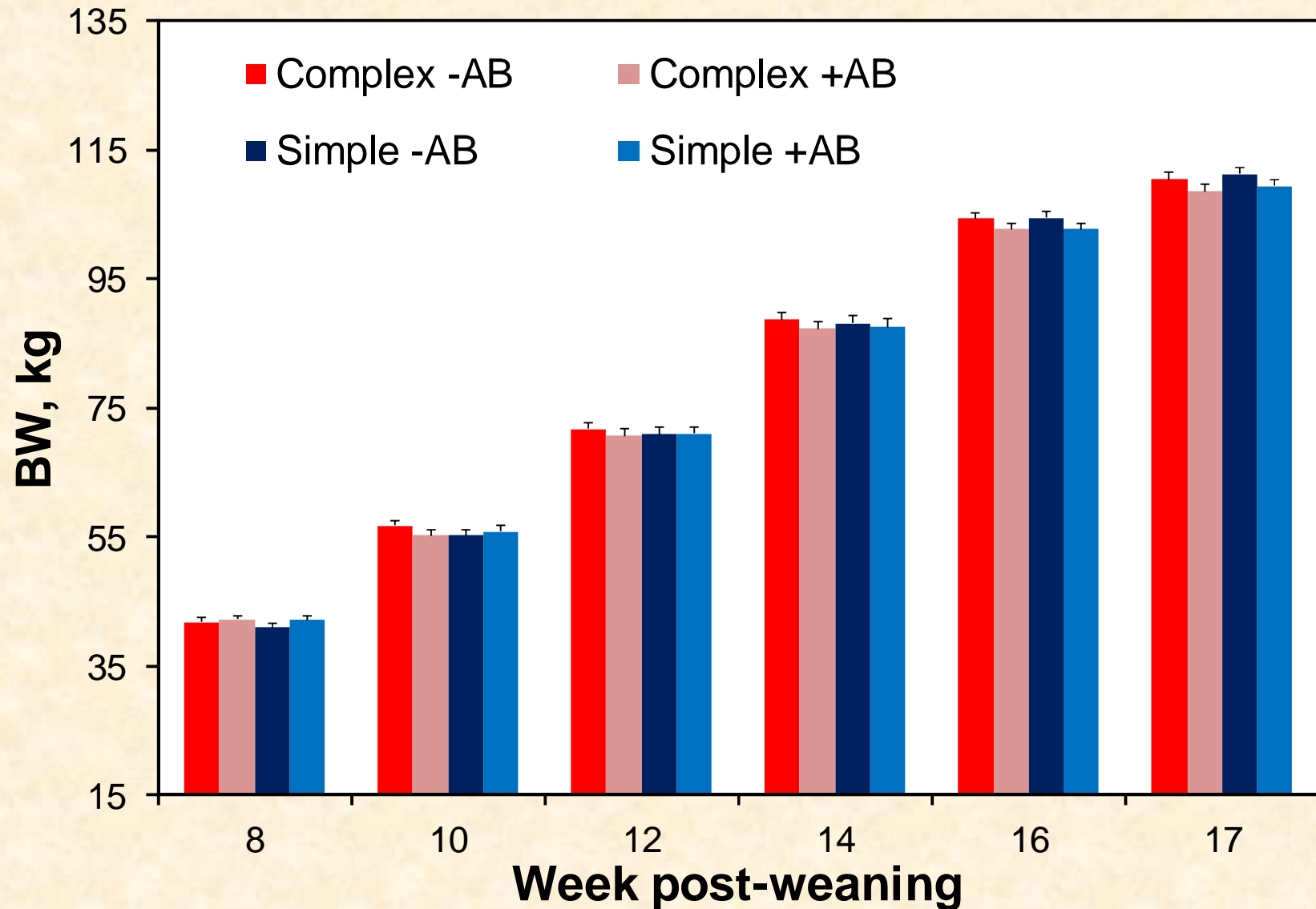
Growth performance during the nursery phase

Diet	week	Complex		Simple		SEM	P - value		
		-AB	+AB	-AB	+AB		Comp.	AB	Comp*AB
ADG, g/d	1	93	134	88	84	11	0.01	0.22	0.03
	2 to 3	443	459	397	437	14	0.002	0.17	0.23
	4 to 6	717	728	682	733	15	0.18	0.19	0.09
	0 to 6	526	543	490	535	7	0.01	0.04	0.18
ADF, g/d	1	170	206	179	173	9	0.17	0.15	0.01
	2 to 3	568	600	536	573	13	0.03	0.08	0.85
	4 to 6	1289	1332	1236	1265	38	0.04	0.29	0.78
	0 to 6	862	902	827	852	21	0.02	0.16	0.7
Gain:Feed	0 to 6	0.63	0.64	0.6	0.63	0.01	0.01	0.11	0.25

➤ Both diet complexity and feeding antibiotics impact nursery pig performance

Preliminary data (n=8 pen/treatment; 8-10 pigs/pen)

Changes in body weight during the GF phase (P>0.10)



Preliminary data (n=6 pens /treatment with 6-8 pigs/pen)

Impact on starter pig feeding on subsequent and overall growth performance & carcass quality

	Complex - AB	Complex +AB	Simple -AB	Simple +AB	P value (comp)	P value (AB)
ADG wk 1-6, g/d	392	408	364	398	0.01	0.04
Final BW, kg	110.4	108.5	111.2	109.4	0.42	0.10
ADG wk 8-17, g/d	1055	1019	1086	1038	0.17	0.02
ADG overall, g/d	868	852	875	860	0.43	0.10
Gain:Feed overall	0.415	0.426	0.427	0.419	0.77	0.86
Probe fat, mm	20.2	20.2	20.3	18.3	0.24	0.17
Lean yield, %	60.1	60.2	60.4	60.8	0.21	0.56

Diet complexity x AB: P > 0.10

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Diet complexity x AB: P > 0.10

➤ No impact on wean-to-finish performance and carcass characteristics

Impact of post-weaning feeding strategies on subsequent productivity of growing pigs

Conclusions & implications:

1. Reduced gain in the nursery due to reduced diet complexity or feeding antibiotics did not affect:
 - Days from weaning to market
 - Gain:Feed from weaning to market
 - Carcass composition
2. In-feed antibiotics in the nursery had a negative effect on gain in the growing-finishing phase
 - Nursery feed costs can be reduced without impacting performance to slaughter weight
 - Further explore physiological mechanisms & pig robustness

Variability of (Ontario) DDGS



- DDGS: a cost-effective alternative protein source
- Continued concerns about variability in nutritional value of DDGS, both within & between plants

Objective:

1. Assess variability in nutrient characteristics of DDGS samples
2. Identify predictors of nutritional value



Approach:

1. Sourced 12 samples from each of 7 sources (4 in Ontario; 2 in US; 1 in Quebec)
2. Detailed chemical analyses, in-vitro digestibility, objective colour, amino acids, reactive lysine, IDEEA, in-vivo digestibility

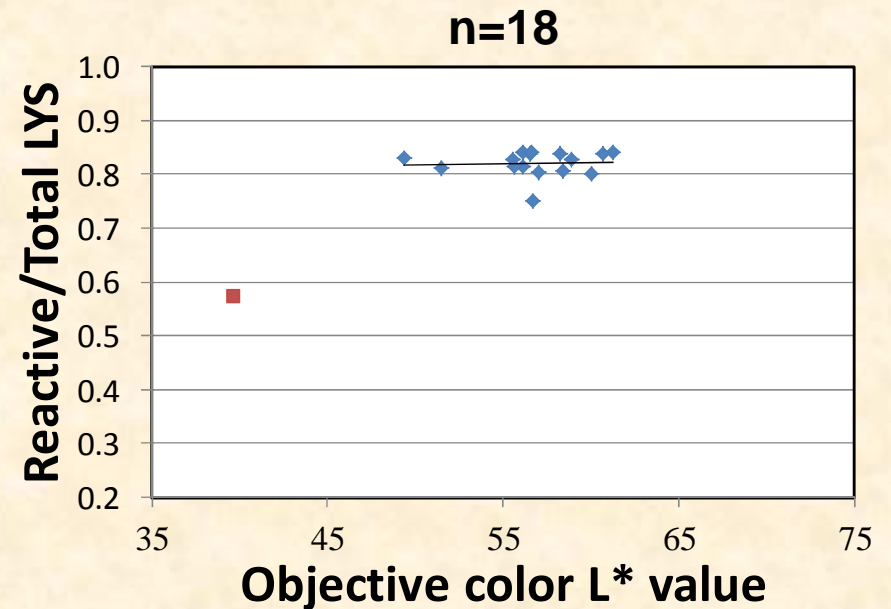
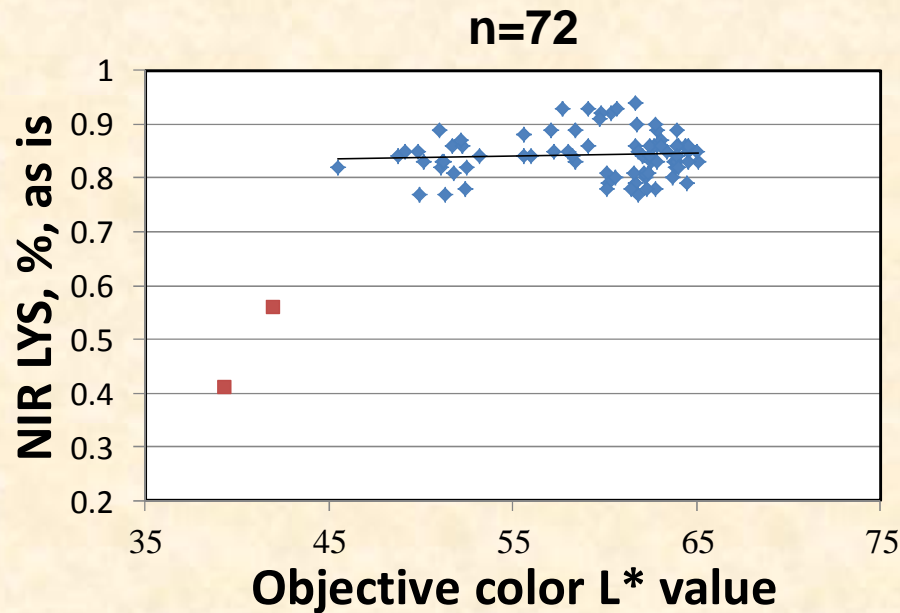
Colour & nutrient analyses of DDGS samples from 6 plants

	Mean	SEM (n=72)	Minimum	Maximum
Nutrient content (% as is)				
Dry Matter	87.68	0.20	85.72	89.85
Crude Protein	26.59	0.29	23.47	31.19
NDF	31.60	0.50	25.48	37.40
Fat	9.99	0.20	7.75	12.40
Starch	2.91	0.45	1.33	13.54
Phosphorus	0.78	0.01	0.59	0.88
Sulphur	0.57	0.02	0.39	1.03
<i>In vitro</i> nutrient digestibility (%)				
Dry Matter	62.42	0.47	57.33	72.20
Crude Protein	80.92	0.45	75.20	88.48
Colour evaluation (CIE, L* a* b* scale) for unground samples				
Colour L*	56.00	0.72	39.71	61.29
a*	9.76	0.21	8.09	12.62
b*	46.20	0.54	33.39	53.96

Plant differences in DDGS nutrient content & digestibility

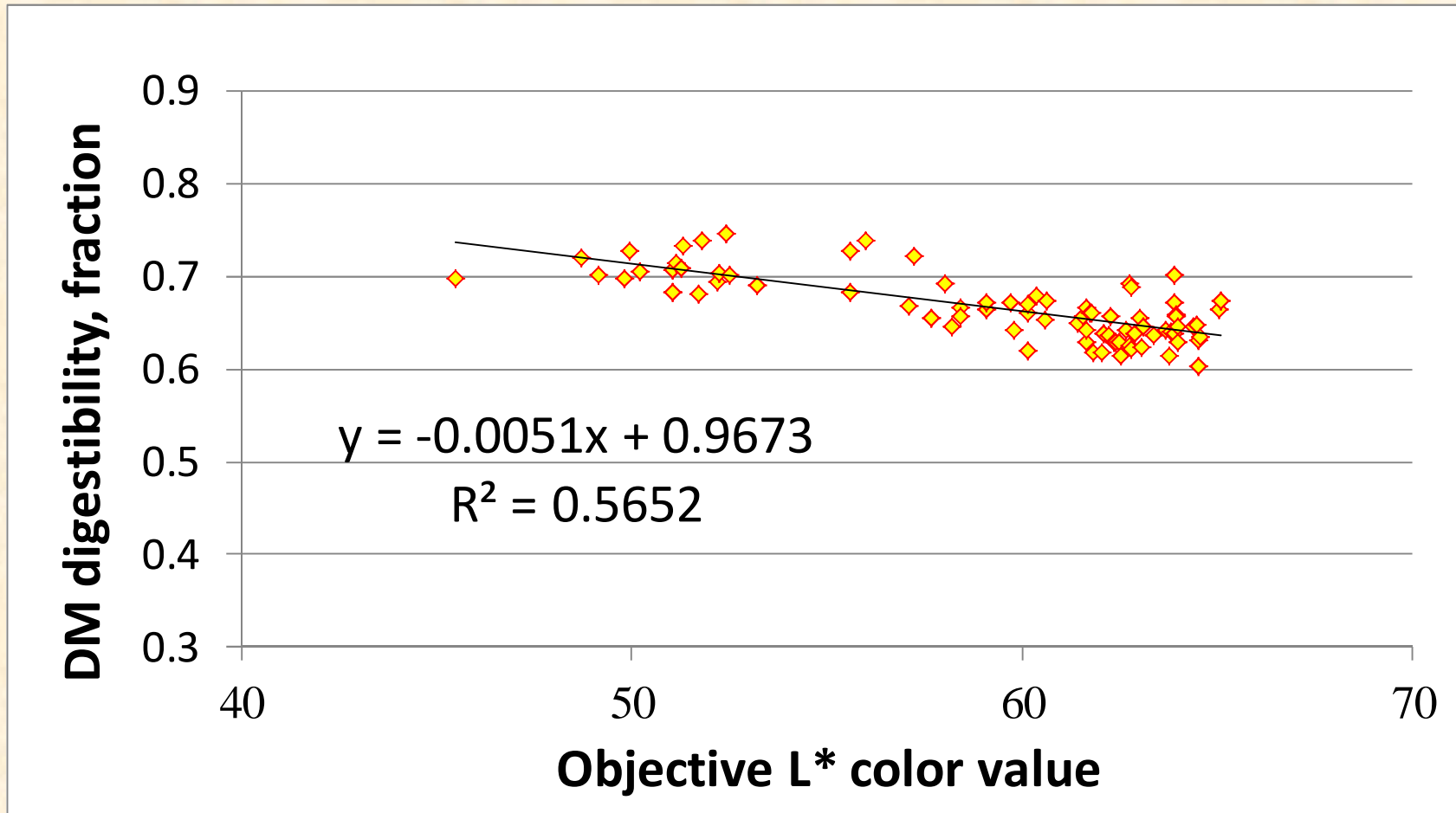
Plant	A	B	C	D	E	F
	<i>Nutrient content (% , as fed)</i>					
DM	89.2 ^{cd}	89.3 ^c	90.5 ^b	88.8 ^{de}	89.4 ^c	88.7 ^e
CP	26.7 ^b	28.6 ^a	25.8 ^c	25.8 ^c	26.9 ^b	26.2 ^{bc}
LYS	0.90^a	0.76^d	0.84^{bc}	0.80^{cd}	0.87^{ab}	0.84^{bc}
THR	1.03 ^b	1.08 ^a	0.98 ^c	0.98 ^c	1.02 ^b	1.00 ^{bc}
TRP	0.22 ^b	0.22 ^a	0.21 ^{bc}	0.21 ^{bc}	0.22 ^b	0.21 ^c
	<i>In vitro dry matter digestibility (%)</i>					
Total	67 ^c	73 ^a	63 ^e	65 ^d	65 ^d	65 ^{cd}
Soluble	32 ^b	37 ^a	31 ^b	31 ^b	32 ^b	32 ^b
Enzymatic	35 ^{ab}	36 ^a	31 ^d	33 ^{bc}	33 ^{cd}	34 ^{bc}

Lysine content in Ontario DDGS samples



- In conventional amino acid analyses ‘non-reactive LYS’ is included with total LYS:
 - Overestimating the amount available for metabolism
 - Of special concern in heat treated feed ingredients

In vitro dry matter (DM) digestibility is inversely related to sample lightness in Ontario DDGS samples



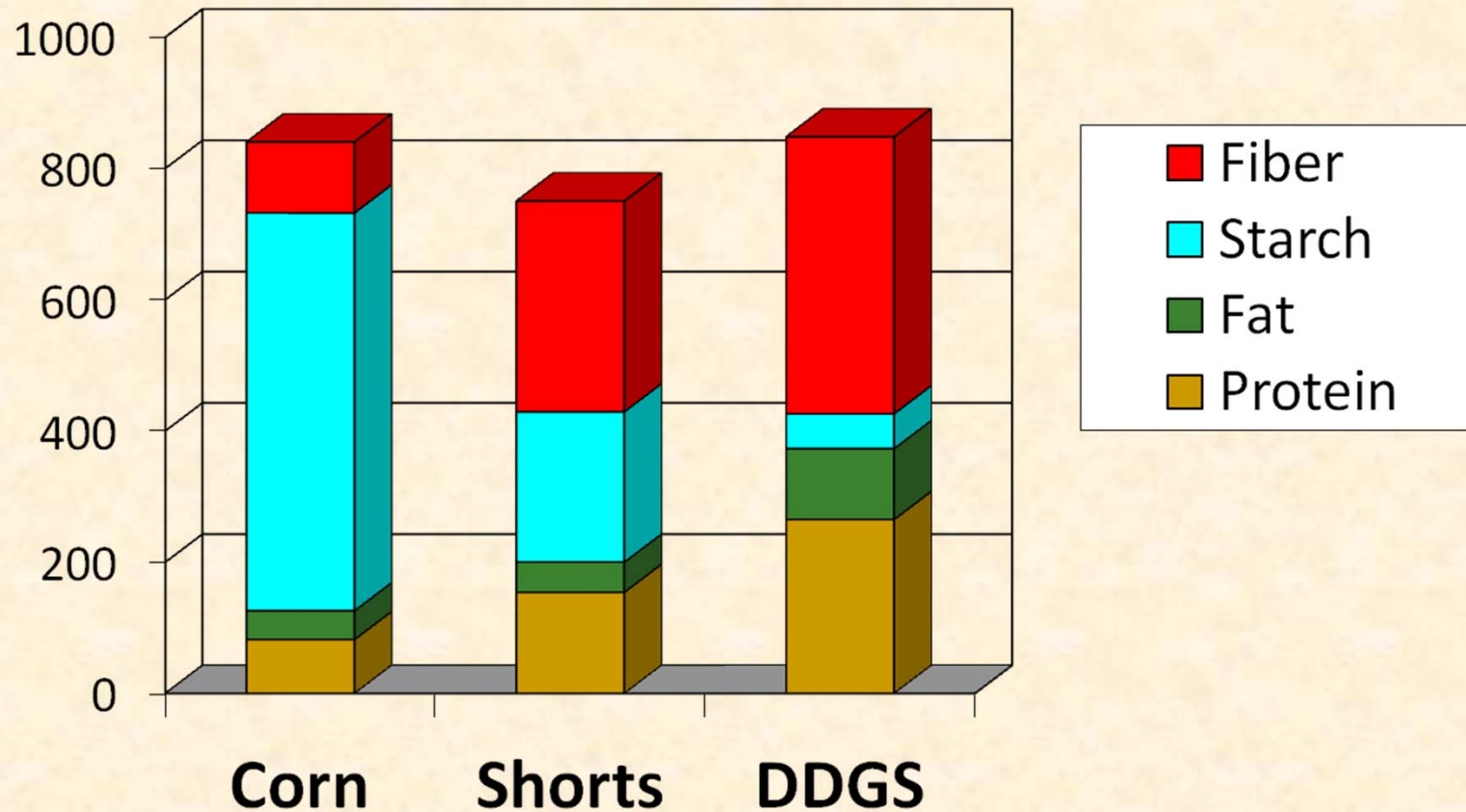
Variability in nutritional value of (Ontario) corn DDGS

Conclusions & implications:

- Substantial between and within processing plant differences
- Conventional amino acid analyses overestimate reactive (potentially available) lysine by about 17%
- L* color value: < 45 = reduced lysine content & potential availability
- *In vitro* DM digestibility associated with L* color value: darker color better in this study?
- Further assess variability in nutrient availability in Ontario DDGS (& impact on carcass and meat quality)
- Explore means to enhance the nutritional value of DGGS (and other high fiber co-products)

Increasing nutritional value of dry co-products

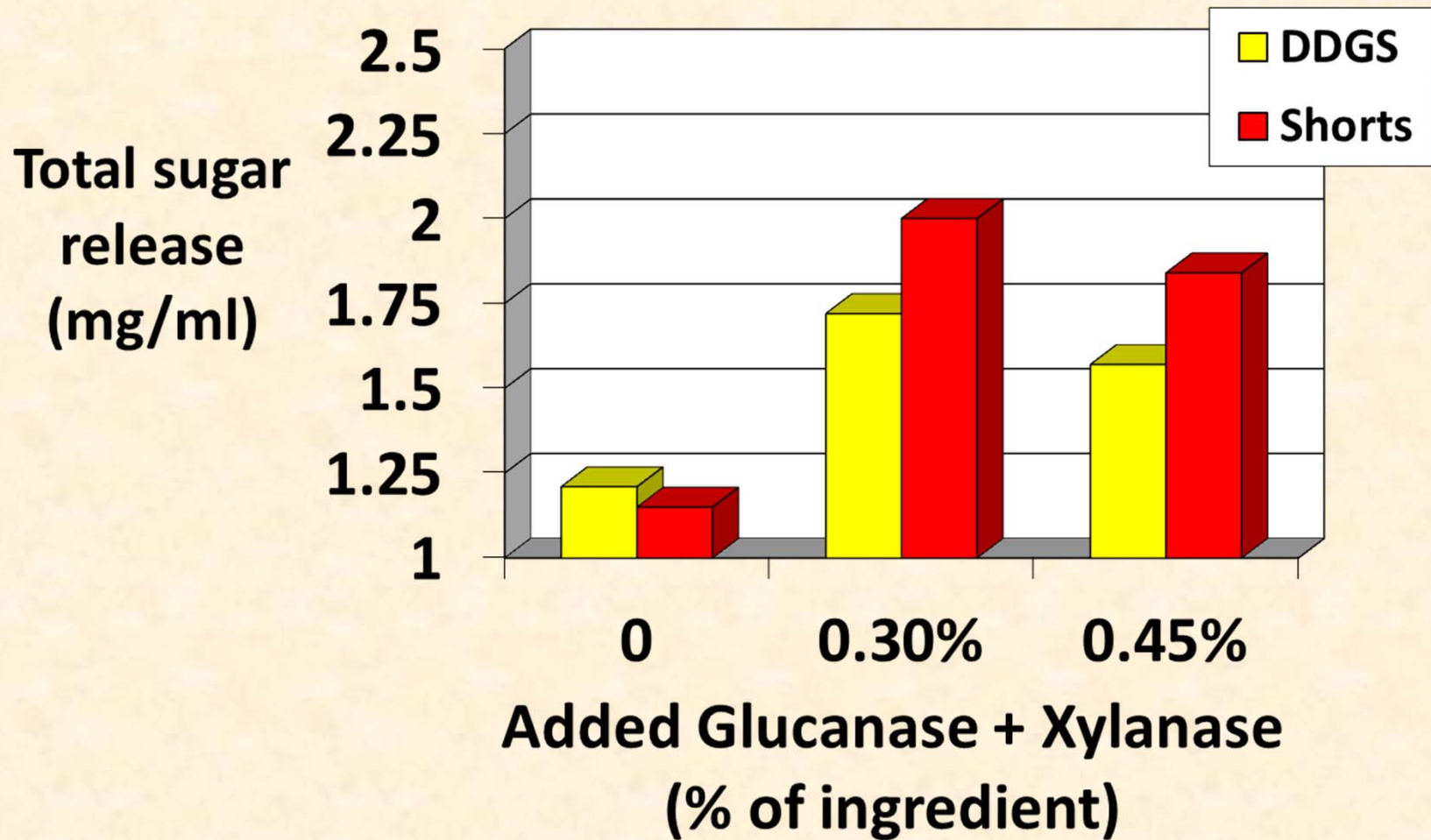
Main Organic Nutrients (g/kg)



Enhancing nutritional value of feed ingredients: **liquid feeding**

- Liquid feeding improves feed efficiency of GF pigs fed corn based diets slightly (de Lange et al., 2006, 2007)
- Use of liquid co-products reduces overall processing costs (drying) and waste disposal
- Pre-treatment of feed ingredients is more effective in liquid feeding than in dry feeding:
 - Phytase enhances feeding value of liquid fed HM Corn and corn steep water (Niven et al., 2006; Columbus et al., 2010a,b)
 - New opportunities for high-fiber dry co-products in liquid feeding (steep with enzymes & microbial inoculants)?

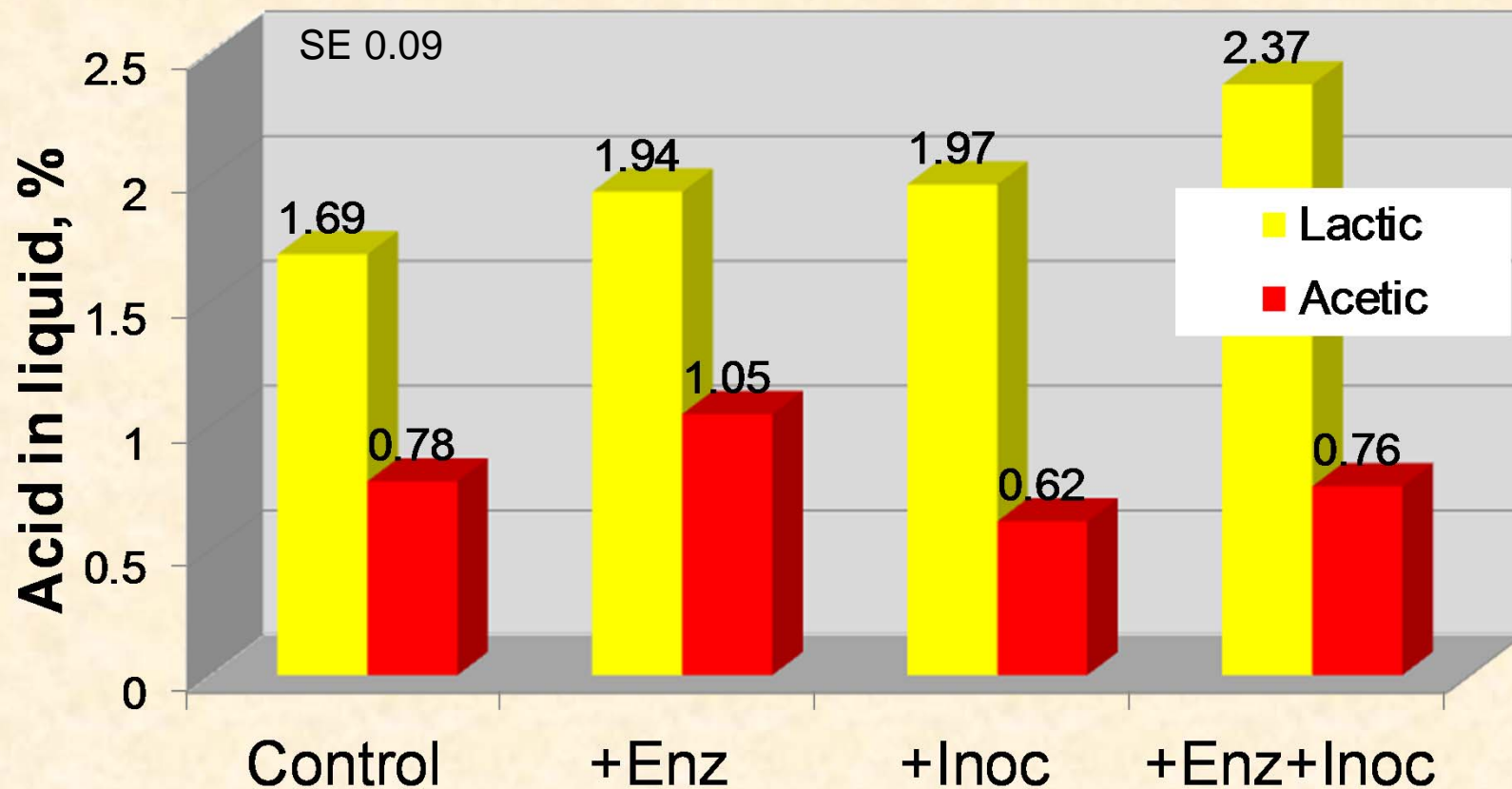
Response to enzymes in DDGS & wheat shorts



Within treatment CV <6%; all treatment means differ; Univ. of Guelph; unpublished

Enzymes and inoculants stimulates favourable fermentation of DDGS:

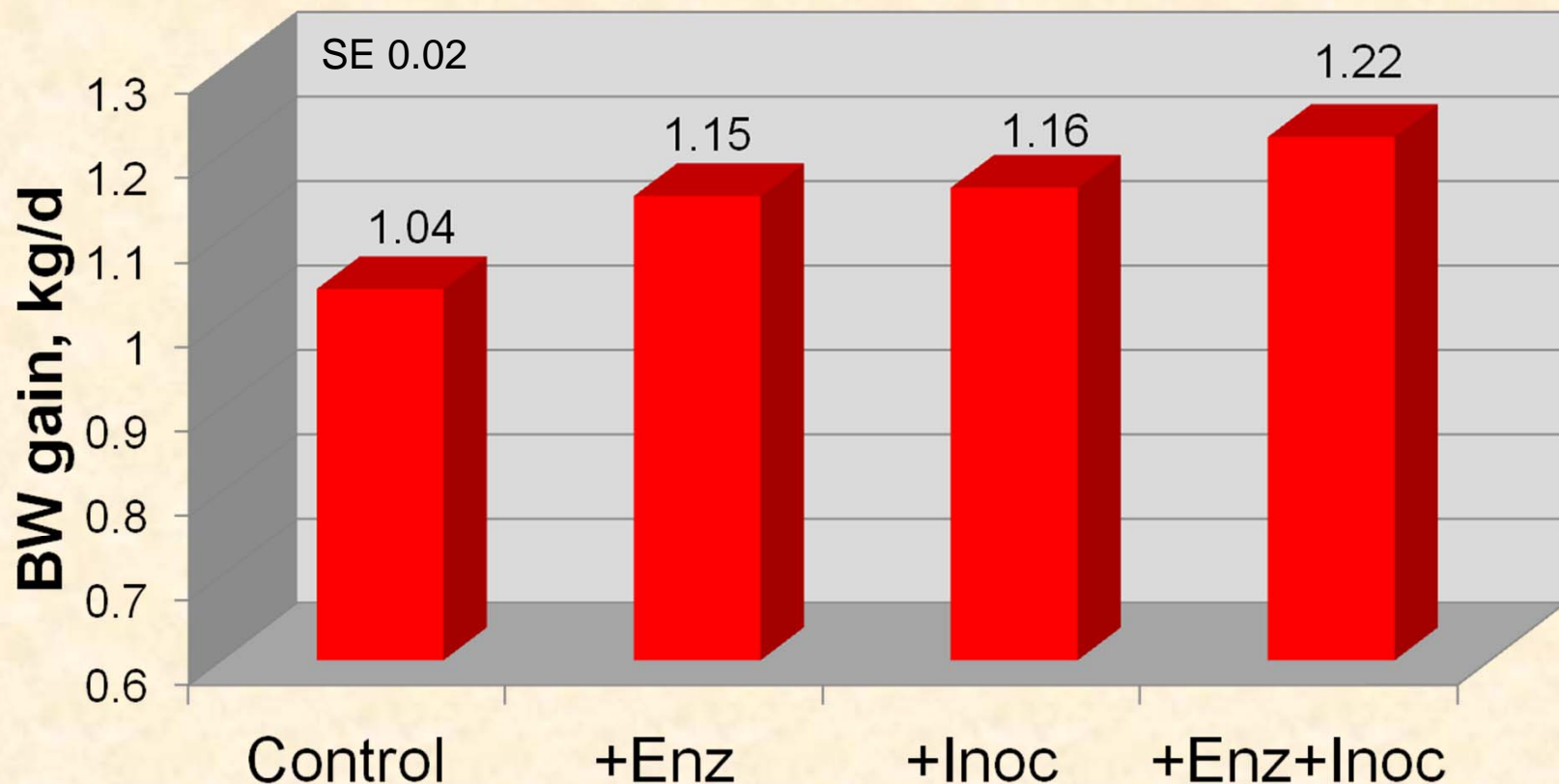
Enzymes alone yield (too) much acetic acid



DDGS mixed with water (17%DM) in 2500 kg fermentation tanks; Zhu et al. (2011)

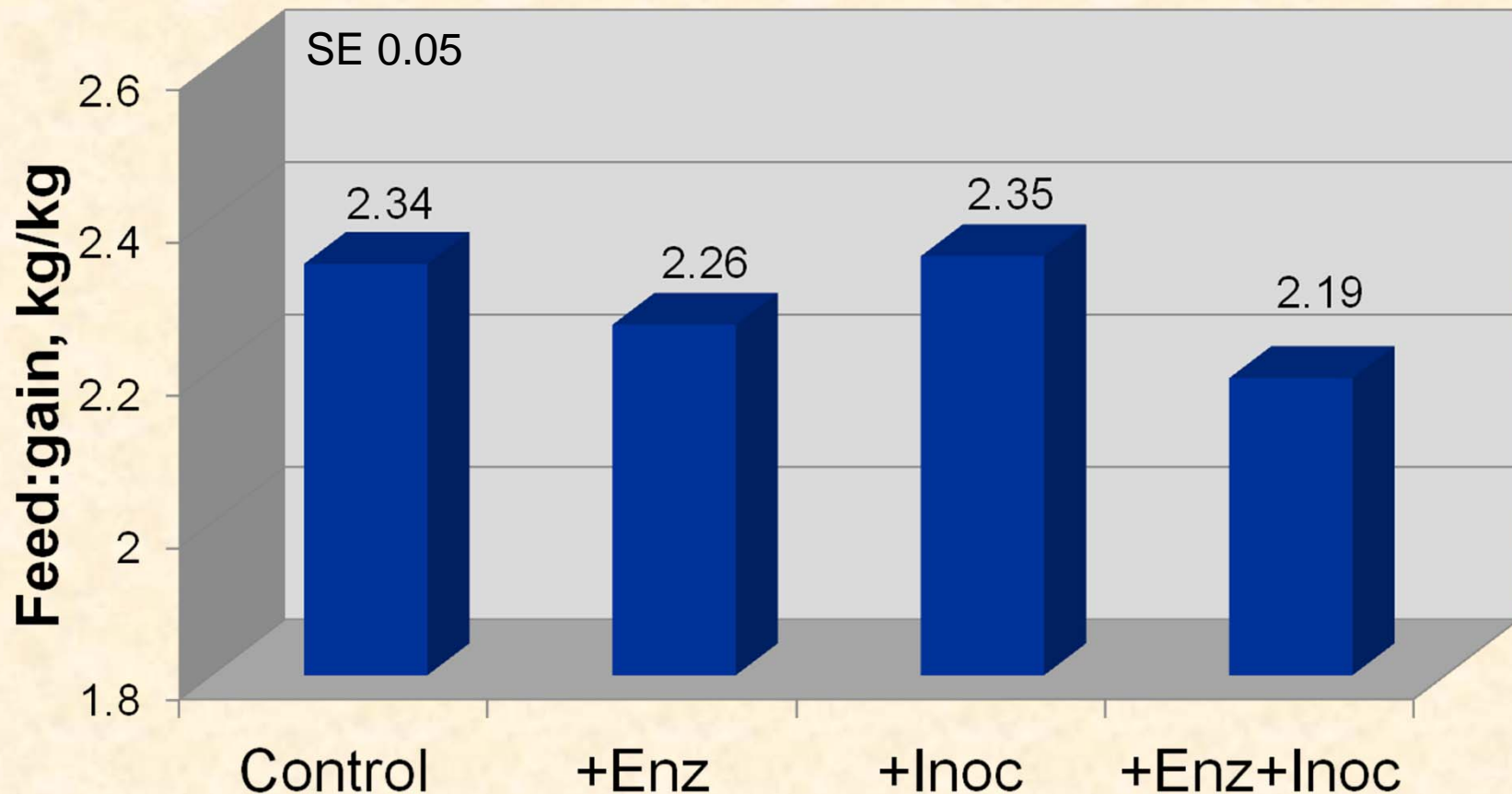
Both enzymes ($P<0.01$) and inoculants ($P<0.01$) improve BW gain of finishing pigs fed steeped DDGS

(no interactive effect; $P>0.10$)



30% DDGS in diet DM; 6 pens of 8 pigs per treatment; 65-110 kg BW; Zhu et al. (2011)

Enzymes ($P < 0.05$) but not inoculants ($P > 0.10$) improve feed:gain (DM basis) of finishing pigs fed steeped DDGS (no interactive effect; $P > 0.10$)



30% DDGS in diet DM; 6 pens of 8 pigs per treatment; 65-110 kg BW; Zhu et al. (2011)

Enhancing nutritional value of feed ingredients: liquid feeding

Conclusions & implication:

- Substantial opportunity to use enzymes and inoculants to enhance the nutritional value of high-fiber co-products in liquid feeding, reducing feed costs and nutrient losses into the environment
 - Explore other high fiber feed ingredients
 - Extrapolate benefits to conventional fry feeding
- Attend the annual swine liquid feeders association meeting Monday February 21, Stratford Ontario (www.slfa.ca)

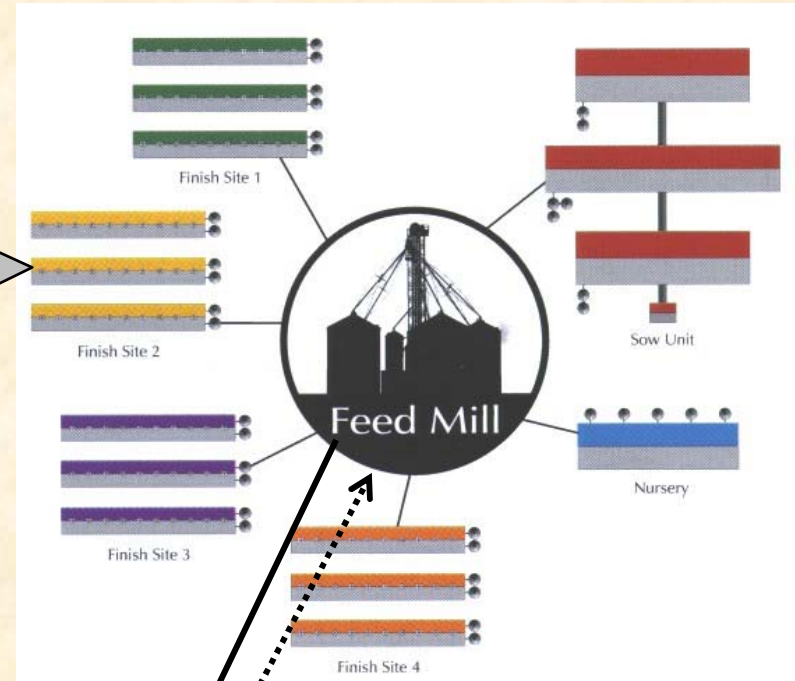
DSS to evaluate the environmental & financial impacts of alternative management strategies



Pig unit with BW, feed intake & environment monitoring systems



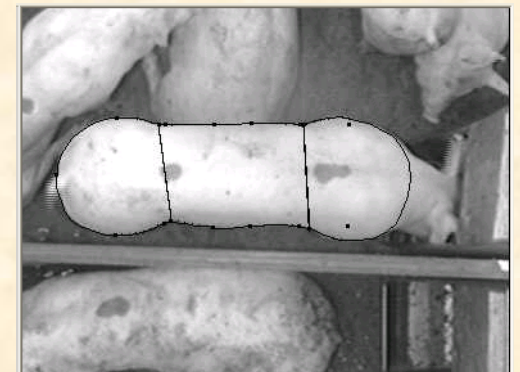
Carcass and meat quality data from packing plant



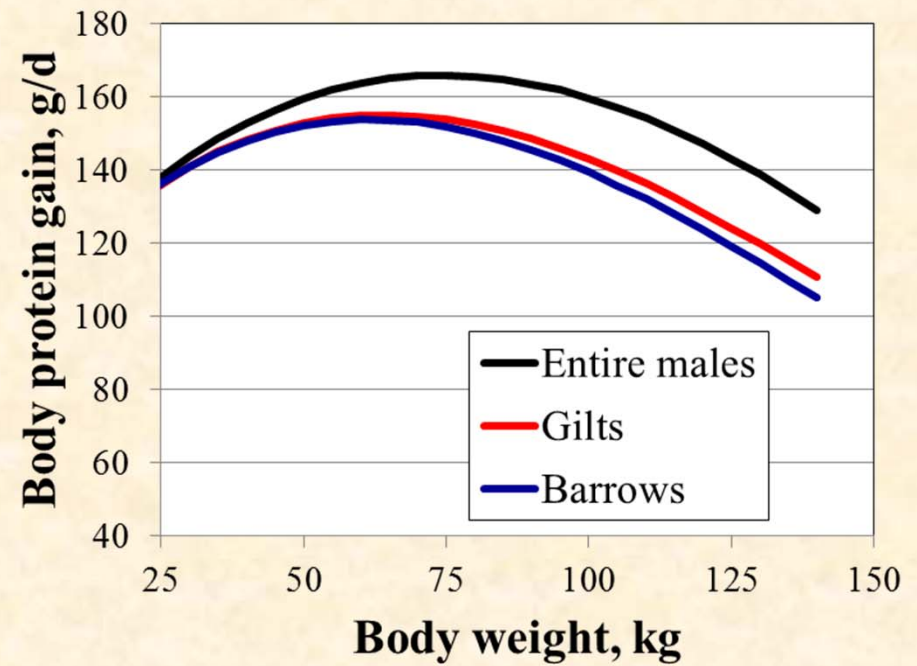
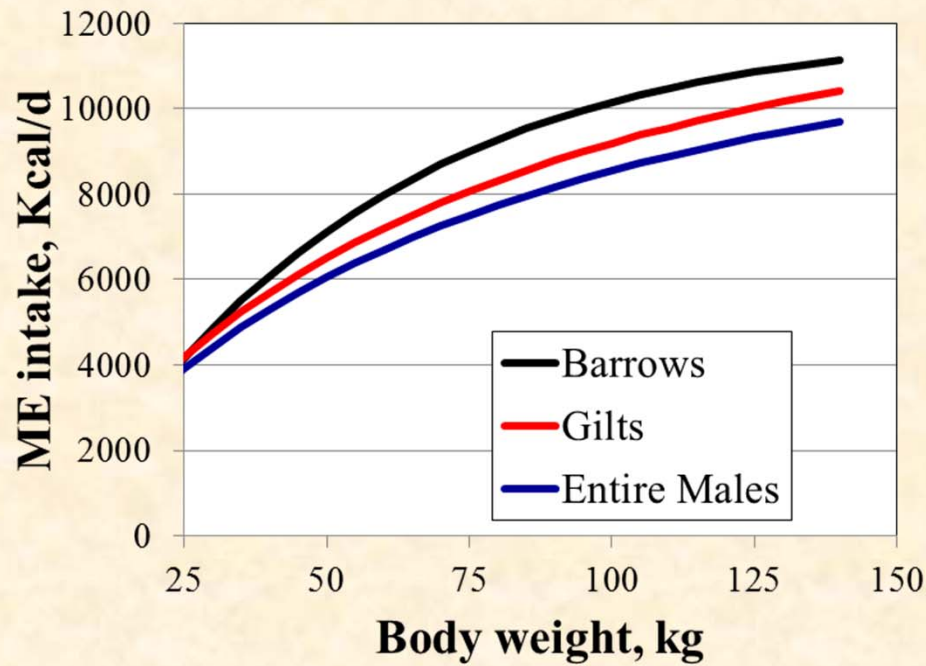
Identify & implement optimum management strategy

Current involvement of University of Guelph in development of DSS for pigs

- Further develop the pig growth model developed by the **International Pig Growth Modelling Group** (University of Guelph; Massey University, New Zealand; Wageningen University, The Netherlands; Agribands/Cargill International, Ontario Pork, Great Lakes Nutrition/Wallenstein Feeds)
- Lead the development of models for “Nutrient requirements of swine” (NRC, 2012; will include estimates of N, P, C losses)
- Explore aspects of nutrient utilization:
 - Males immunized against GnRF (Huber et al.)
 - Environmental impact (and associated costs) of using corn DDGS (Skinner, Weersink et al., 2012)
 - Explore video imaging as a non-invasive means to monitor growth in groups of growing-finishing pigs (Love et al.)



Typical energy intake and body protein deposition curves (GF model; NRC, 2012) **DRAFT**



- Energy intake & protein gain curves: key determinants of growth performance, amino acid and phosphorus requirements & nutrient losses to the environment
- Simple adjustments can be made to adjust curves to unique farm conditions, including Ractopamine & immunization against GnRF

Conclusions & implications

1. Reducing post-weaning feeding costs has little impact on performance up to market weight and carcass quality, representing a means to improve profits; physiology to be explored
2. There is still considerable variation in the nutritional value of Ontario Corn DDGS, requiring further evaluation
3. The combination of enzymes and microbial inoculants represents a means to increase the nutritional value of corn DDGS for liquid fed pigs; to be explored further with other fiber containing ingredients and conventional dry feeding
4. Various programs will become available to assist in informed decision making for developing cost-effective and more environmentally friendly feeding programs

Acknowledgements

- Canadian Swine Research and Development Cluster (CSRDC), Ontario Pork, Pfizer Inc. Evonik Degussa AG, OMAFRA, CanAdapt, NSERC, many industrial partners of the swine liquid feeding association (slfa.ca)
- Supporters of International Pig Growth Modelling Group: Agribrands/Cargill, Massey University, University of Guelph, NSERC, AAFC, Ontario Pork, Great Lakes Nutrition/Wallestein feeds
- Post-docs, graduate students, technicians:
C. Levesque, H. Martinez-Ramirez, A. Rakhshandeh, L.D. Skinner, S. Skinner, M. Rudar, L. Huber, N. Litvak, J.E. Love., D. Columbus, J. Zhu, D. Wey, K. de Ridder
- Colleagues: P. McEwen, I. Mandell, J. Squires, M. Fan, J. Gong, A. Weersink