ANSC

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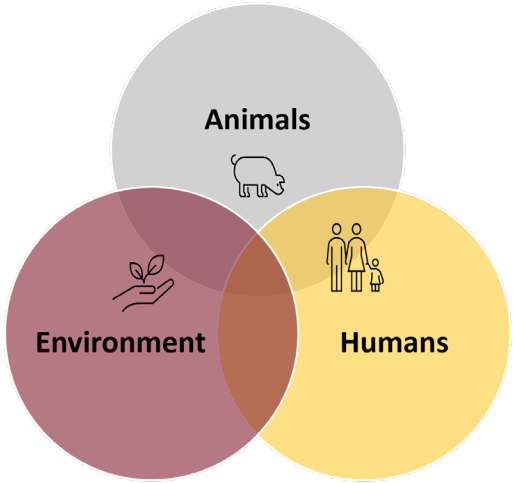
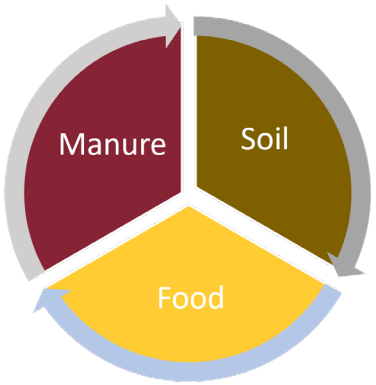
THE SUSTAINABILITY OF BIOCIRCULAR ECONOMIES

INTERNATIONAL RENDERING SYMPOSIUM

Challenges and opportunities for bio-circular economy of rendered products in livestock diets





Pedro E. Urriola

Livestock Sustainability Laboratory
Department of Animal Science
University of Minnesota

Outline

1

What is sustainable livestock production?

- **What is circular economy model?**
  - **How does it apply to livestock production?**

2

What are the challenges to using food waste and rendered products in livestock diets?

3

What are the opportunities for use of food waste and rendered products in livestock diets?

4

Resources

- LCA tools
- Feed formulators

Key messages

01

ENVIRONMENTAL FOOTPRINT OF FOOD PRODUCTION MUST DECREASE

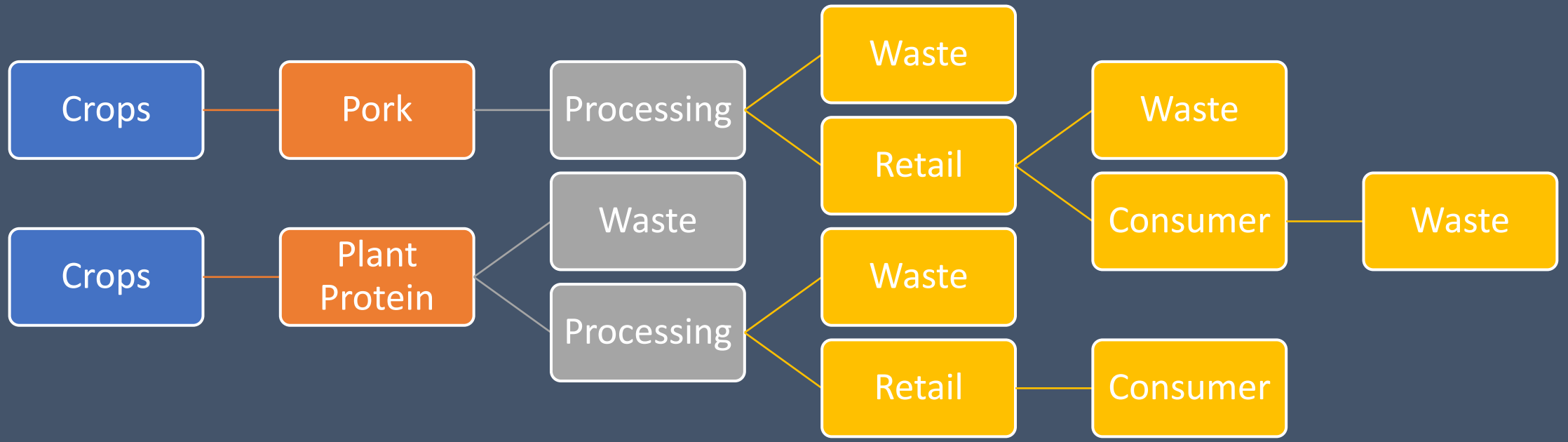
02

ANIMAL RESPONSE TO NUTRIENTS IS COMPLEX AND DYNAMIC

03

BEST USE OF RENDERED PRODUCTS WILL LEVERAGE PHYSIOLOGICAL BENEFITS

Plant derived proteins more efficient in linear food systems



What is circular economy and how to measure it?

- Inflow of virgin material is kept at minimum (ISO 59004)
  - Decreases waste
  - Conserves resources
  - Increases value of resources
- For animal feed coproduct and by-product
  - Quantifying energy for the virgin-sourced material
  - Based on nutritional equivalents from other sources or raw commodities

The goal of livestock production is to produce protein

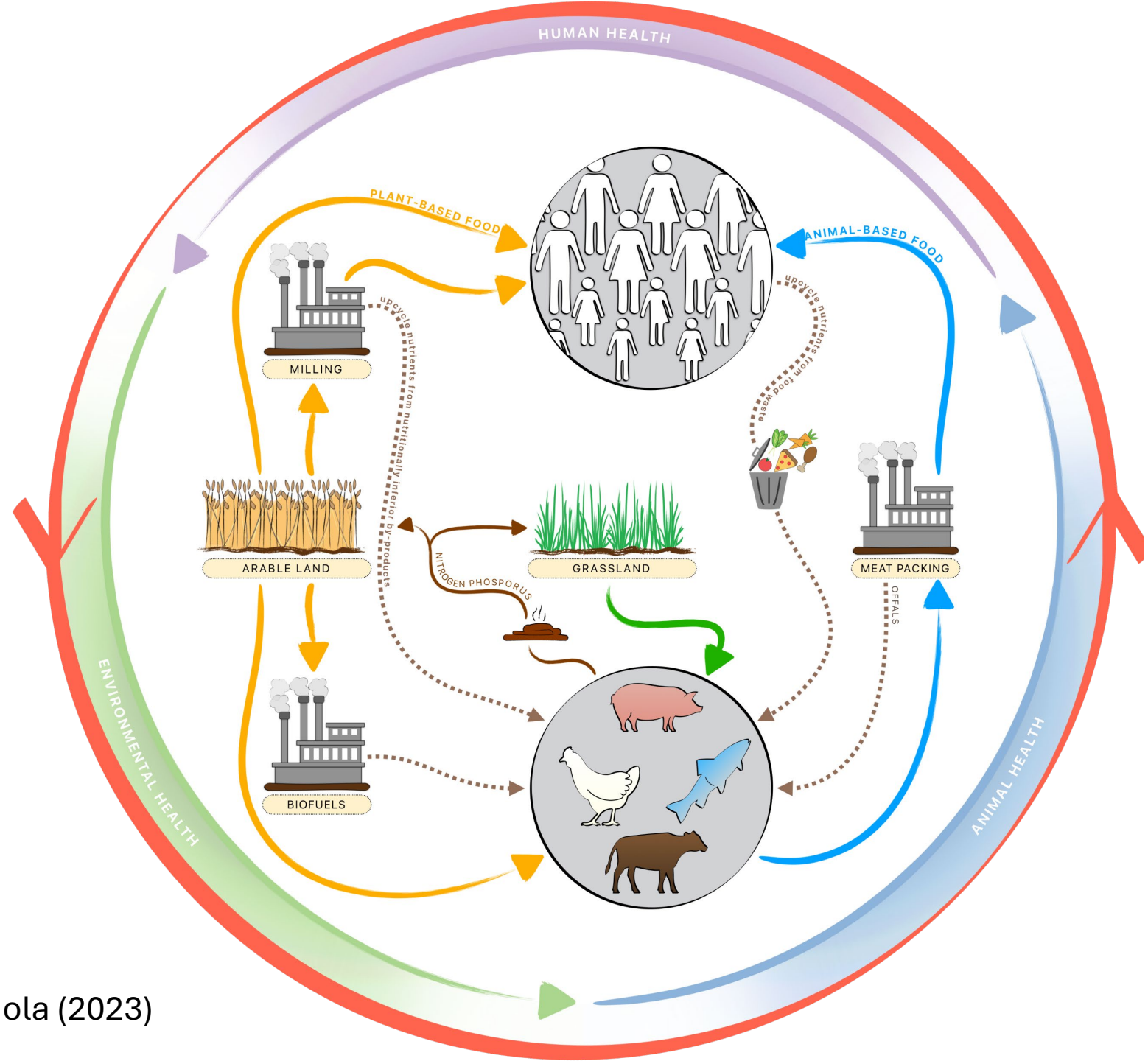
How do we measure quality of dietary proteins for humans?

Mouth → **Small intestine - Enzymes** → **Large intestine -Bacteria**

Ileal digesta
Standardized ileal digestibility
Dietary Indispensable Amino Acid Score

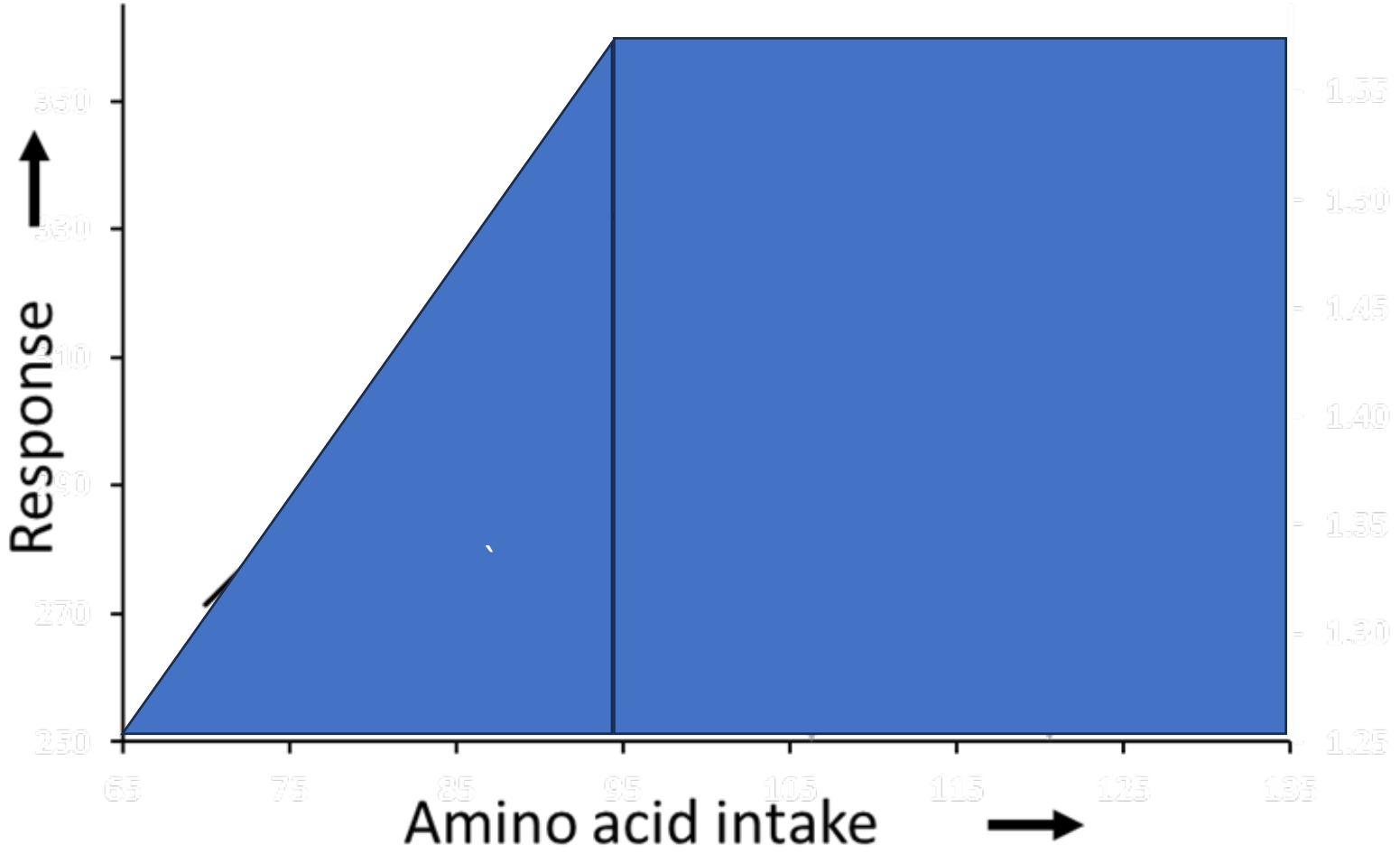
Fecal samples
Total tract digestibility of protein
Protein Digestibility Corrected Amino Acid Score

Rendering recovers valuable digestible nutrients (AA & Lipids) so that livestock animals can convert these nutrients into high value animal proteins to nourish humankind.



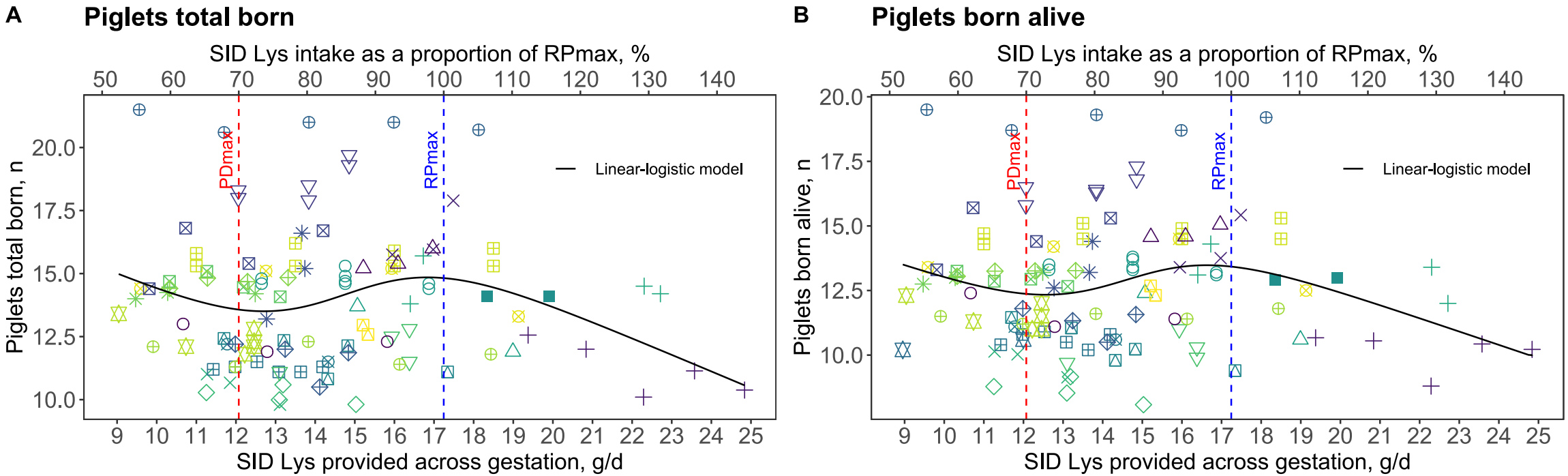
Shurson and Urriola (2023)

Responses of animals to nutrients vs. requirements



Ramirez-Camba & Levesque (2023)

Response of sows to amino acid intake (systematic review of 28 studies)



Life History Theory (response of animals to resource availability)

Require more emphasis is data-driven modeling

Nutrient responses are dynamic

Environmental programming of female respond to nutrients:

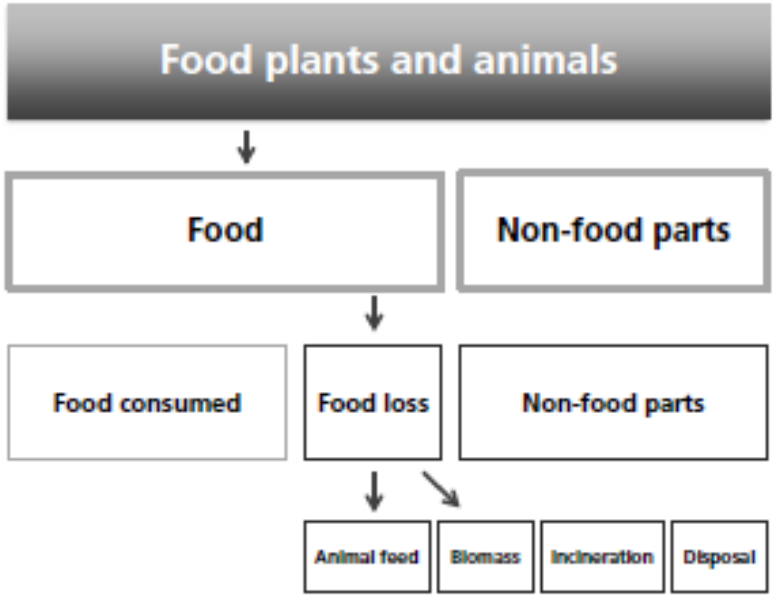
- At low nutrient intake total born may increase at the expense of offspring quality
- At intermediate intake levels, maternal development nitrogen retention may be prioritized
- At levels (greater than current NRC) sows may optimize maternal and offspring development

Use multi-objective feed formulation

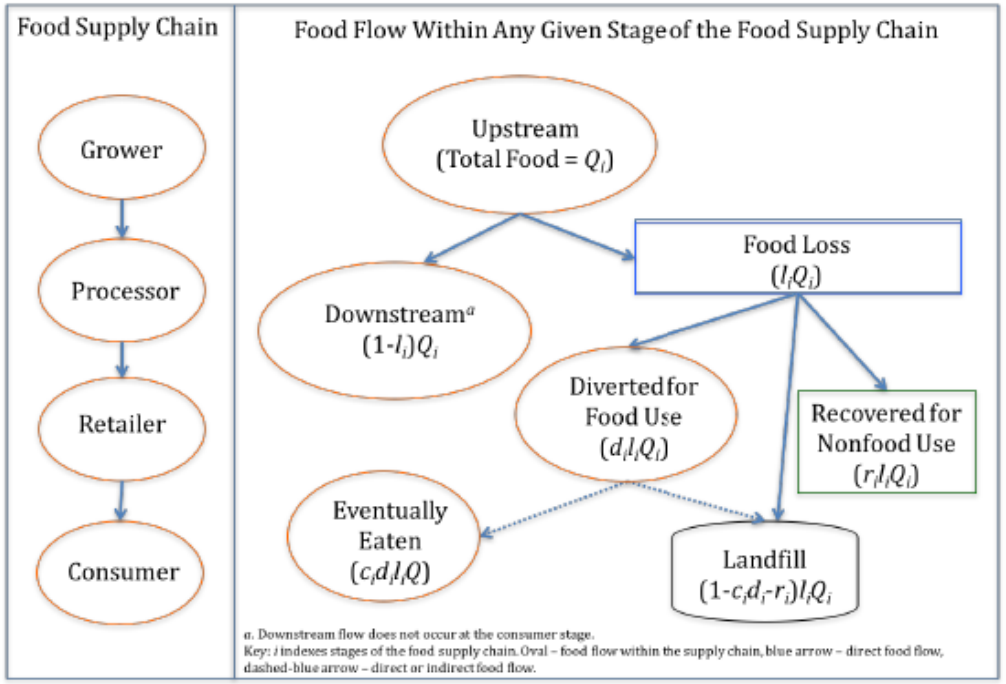
- Best cost
- Accurate nutritional values
- Nutrient utilization efficiency
- Environmental impacts

What is food waste or food loss?

- FAO - Definition
- "Not used for intended production"



- Bellemare et al. (2017) UMN
- "Not sent to a landfill"



Livestock as enablers of circularity in the US food system

- In the US, livestock consume about 258 MM t feed (40% coproducts from food and biofuels)
- This is equivalent to avoid 61 MM t CO_2 eq.
- About 28 MM t of material from rendering
- In EU, 3.5 MM t former foods are equivalent to saving 400K ha. of land for corn production

Nutritional value of rendered protein meals

Challenges and opportunities to use food waste for climate smart food production

RENDERED INGREDIENTS PRODUCED FROM PIGS

MEAT TO FEED PEOPLE

MEAT & BONE MEAL OR PORK MEAL

- Livestock Feed
- Poultry Feed
- Pet Food

BLOOD

DRIED RED BLOOD CELLS → BLOOD MEAL

- Aquaculture Feed, Dairy Feed, Poultry Feed
- Fertilizer
- Baby Pig Feed

SEPARATED → PLASMA PRODUCTS

- Livestock Feed
- Pet Food

CHOICE WHITE GREASE

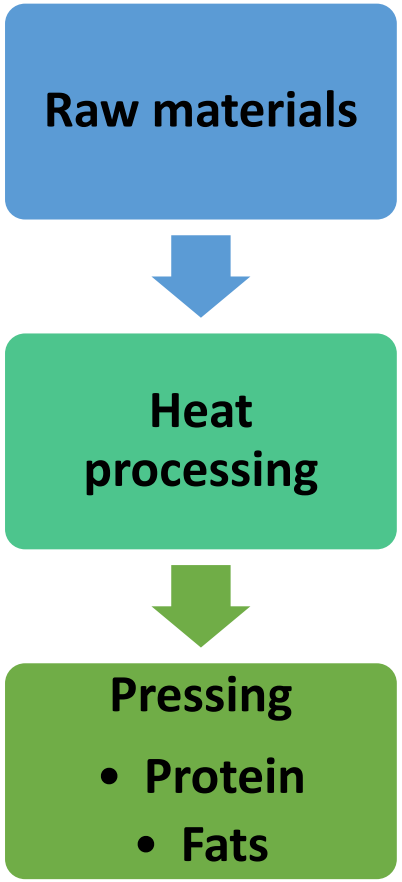
- Biofuel/ Green Energy
- Livestock & Poultry Feed, Pet Food
- Processed into milk replacer

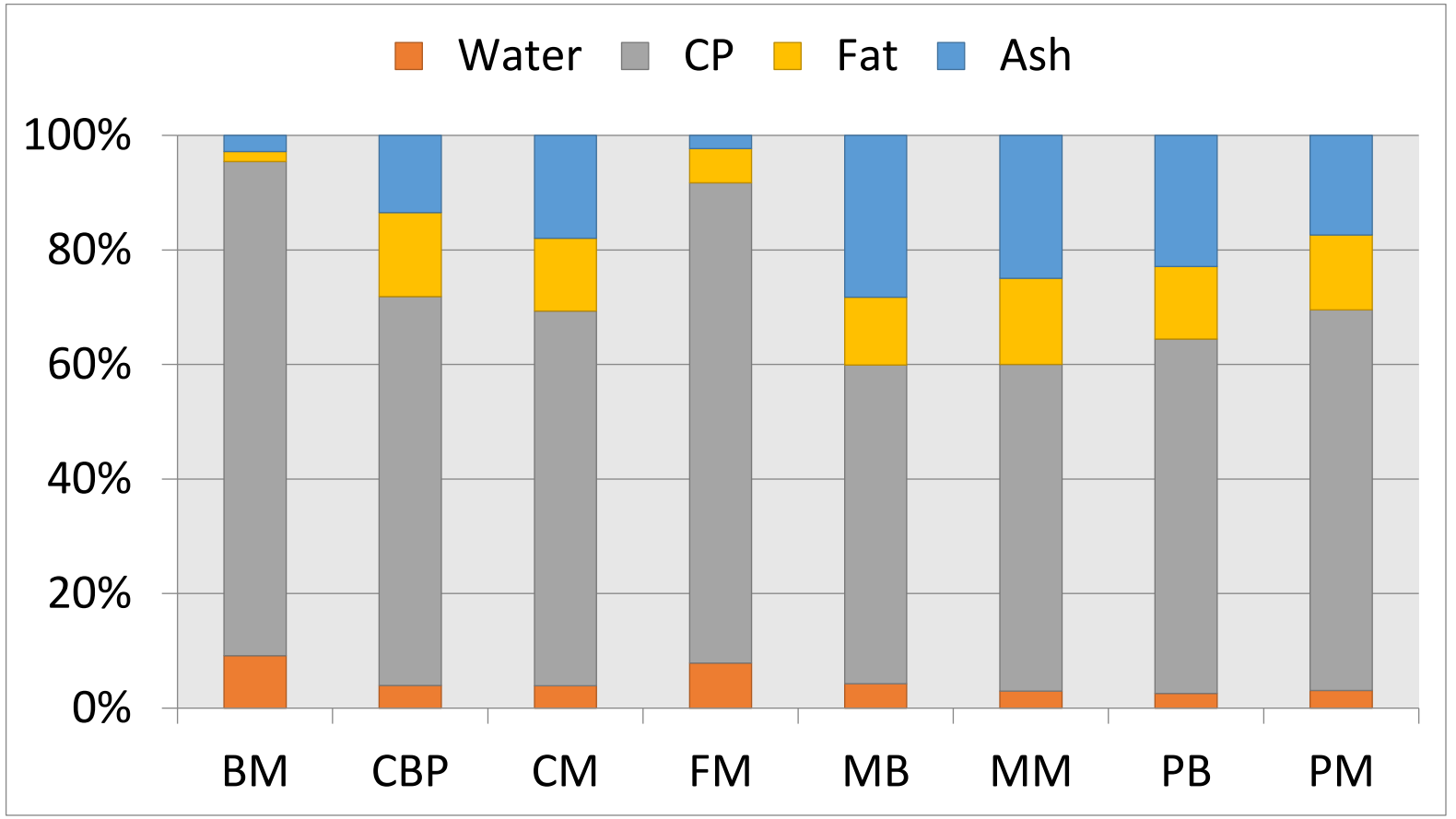
SPLITTING

OLEIC ACID	GLYCERIN	STEARIC ACID	LINOLEIC ACID
Lubricants, Textiles, Shampoo, Emulifiers, Cleansers, Creams	Inks, Glues, Solvents, Explosives	Rubber, Tires, Lubricant, Crayons	Lubricants, Paints

North American Renderers Association 500 Montgomery St, Suite 310, Alexandria, VA 22314 (703) 683-0155
www.nara.org • info@nara.org • Twitter: @Renderers • Facebook: North American Renderers Association

There is variation in the concentration of nutrients among by-products





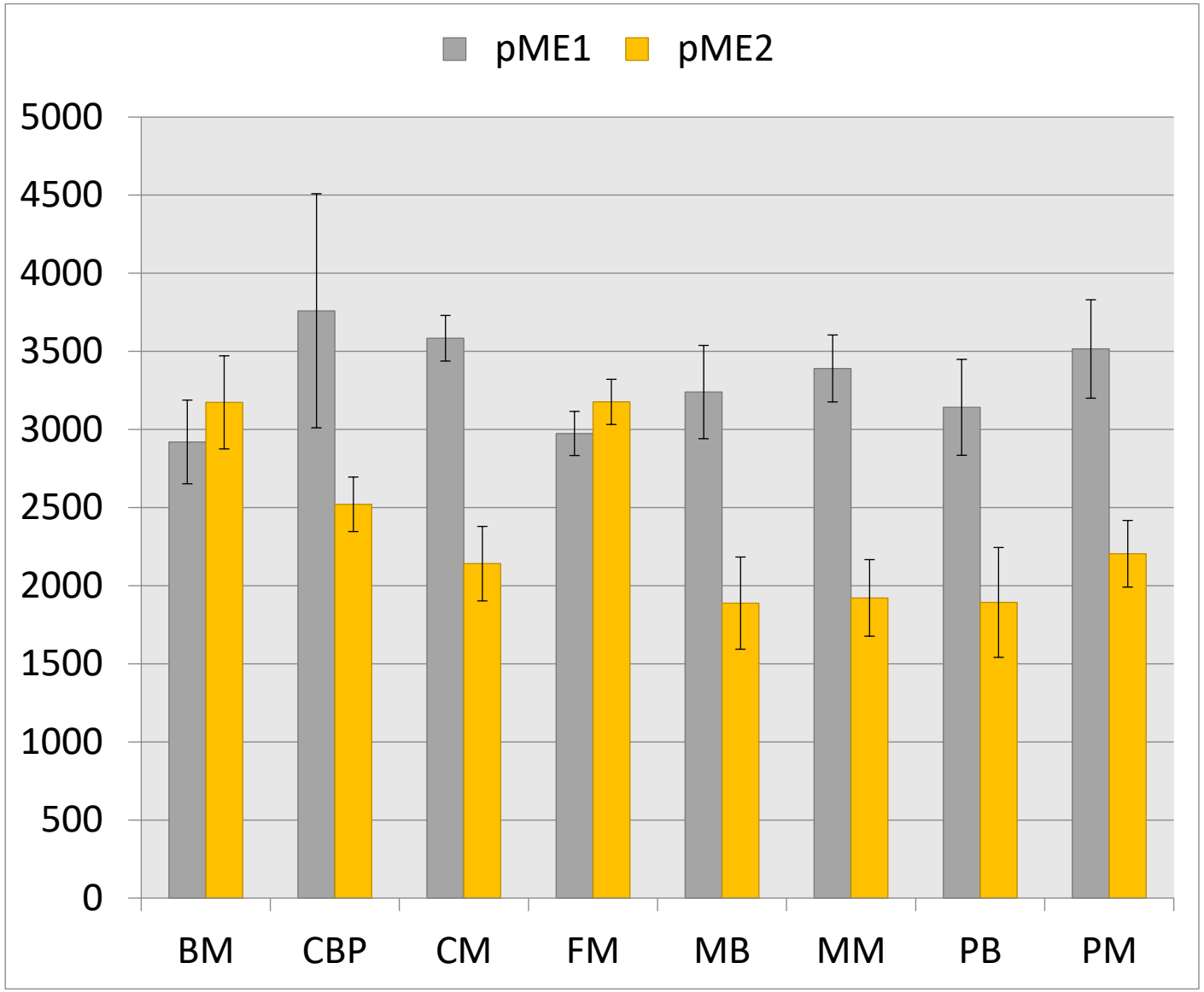
Kerr et al. 2017 J Anim Sci

Predicting energy content (kcal/kg) in animal protein meals

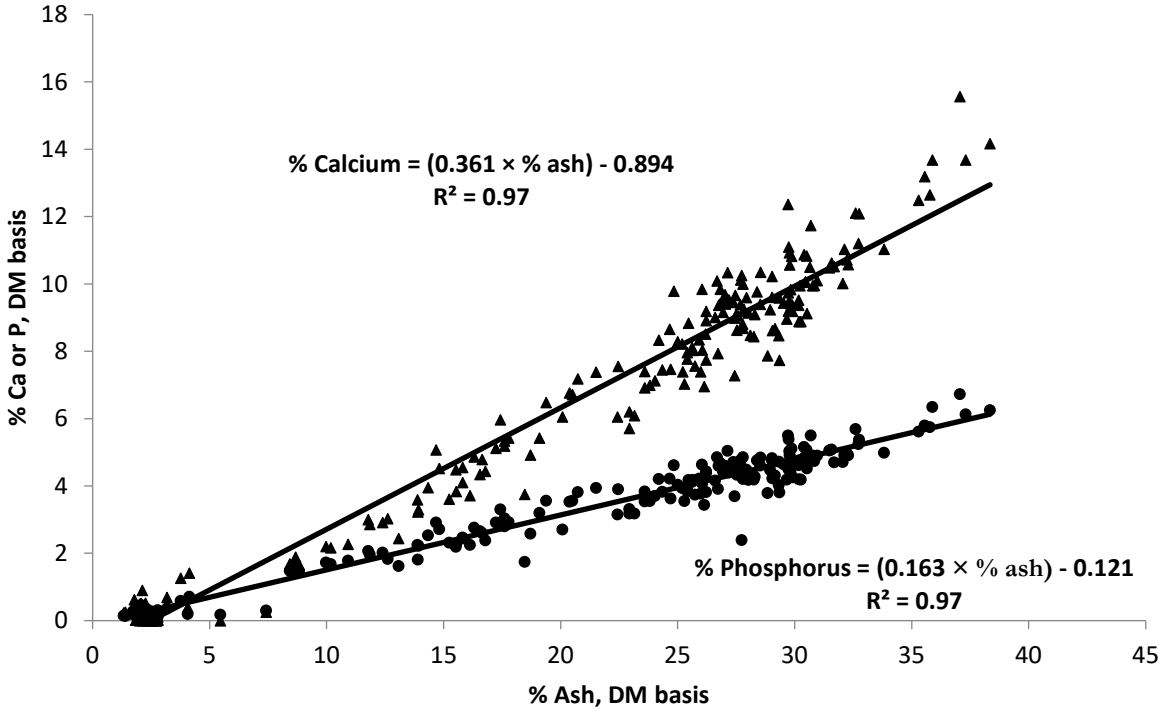
- ME 1 = 6,982 + (0.283 × **GE**, kcal/kg) - (6.26 × **CP**, g/kg) - (3.75 × **EE**, g/kg) + (129.47 × **P**, g/kg) - (54.91 × **Ca**, g/kg) - (6.57 × **ash**, g/kg); Adedokum and Adeola (2006).

- ME 2 = 13,587 - (1.25 × GE, kcal/kg) - (3.51 × CP, g/kg) + (3.51 × P, g/kg) - (16.4 × ash, g/kg); Olukosi and Adeola (2009).

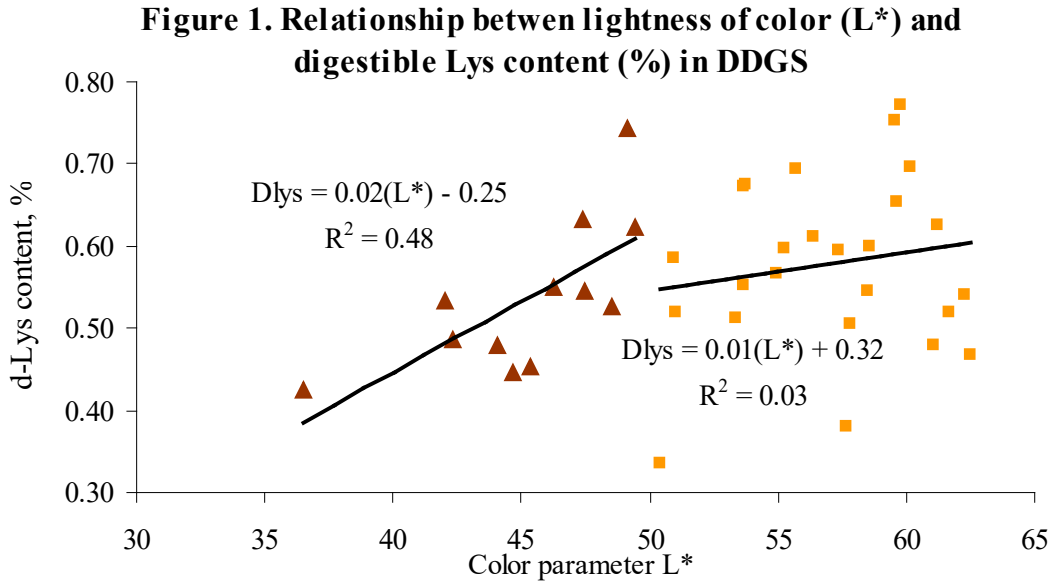
Kerr et al. 2017 J Anim Sci



Predicting concentration and digestibility – calculations and benchtop procedures

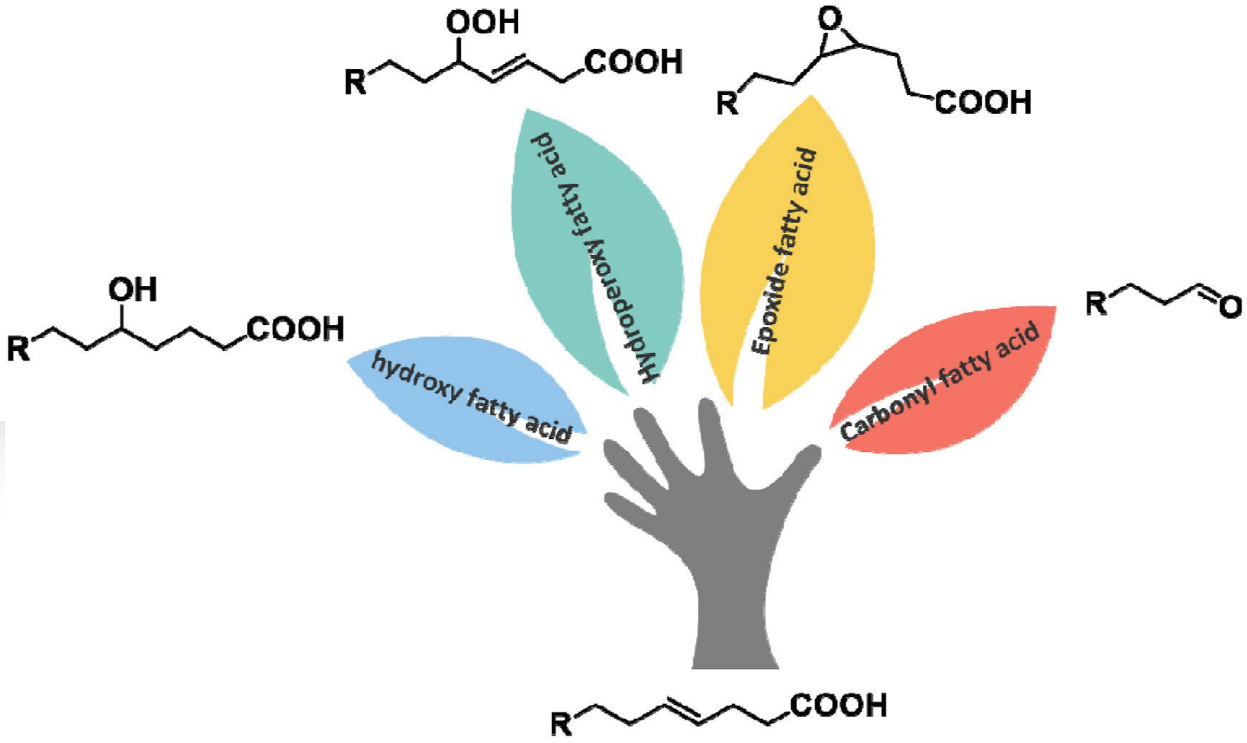


Kerr et al. 2017 J Anim Sci



Urriola et al. 2013 J Anim Sci

Lipid nutrition and oxidation

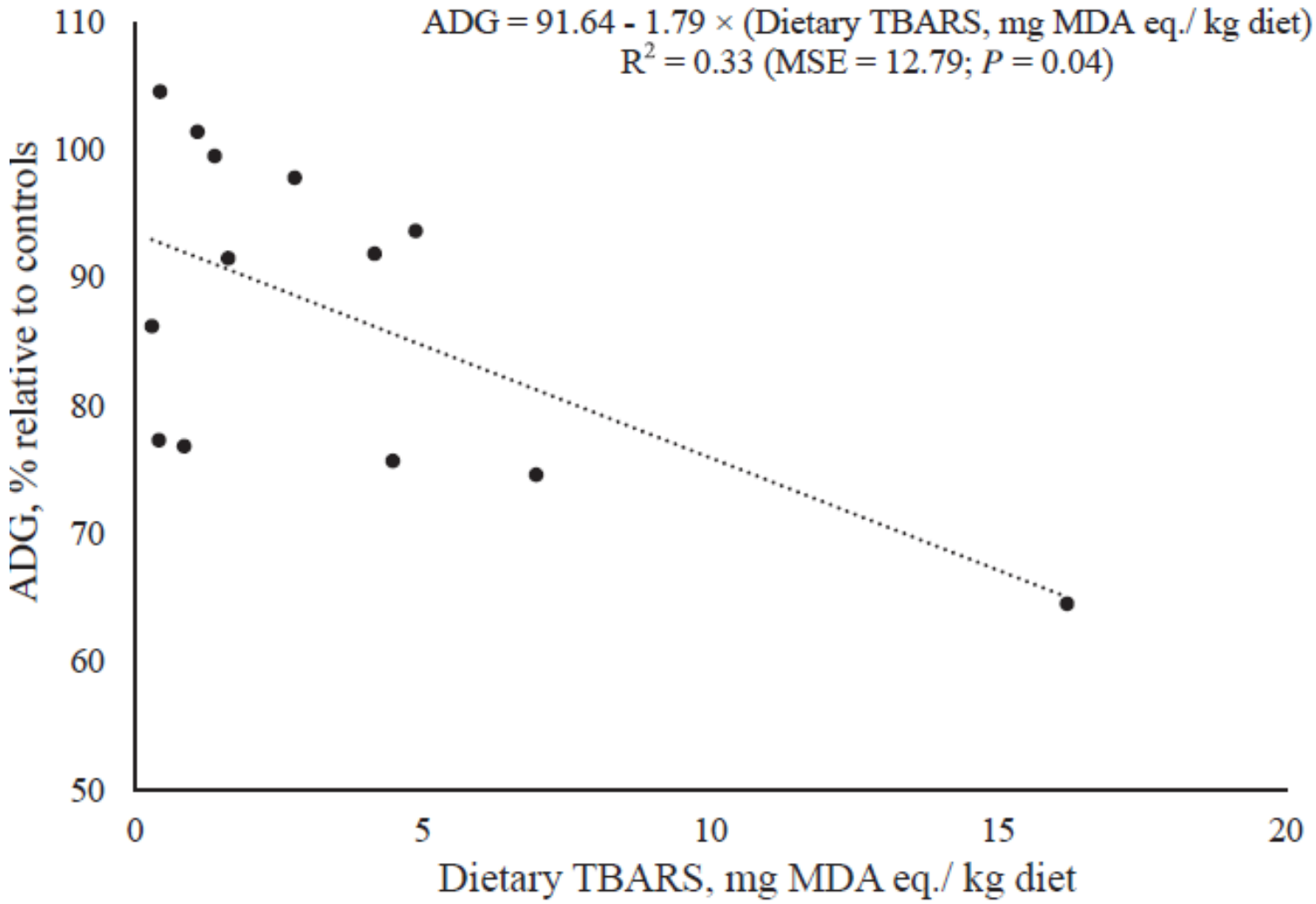


- Lipids are excellent source of dietary energy (> 90% use efficiency)
- Some fatty acids cannot be synthetized by animals and are dietary indispensable

- Lipids may be oxidized decreasing their nutritional value
- Oxidation is a complex process with diverse products
- Heating and oxygen exposure are major contributors to oxidation

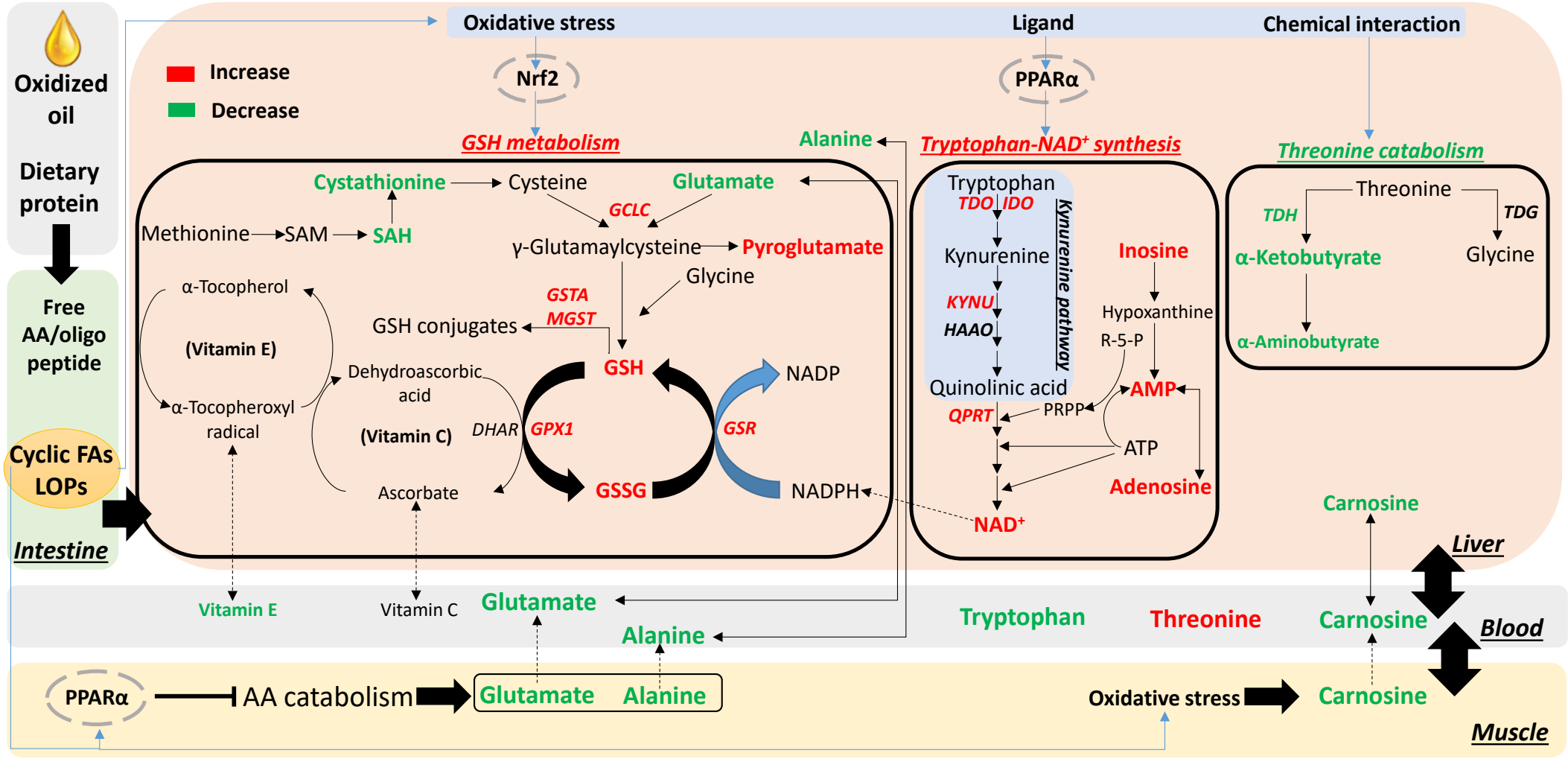
Hung et al., 2017

Impact of oxidized lipids on growth performance of pigs

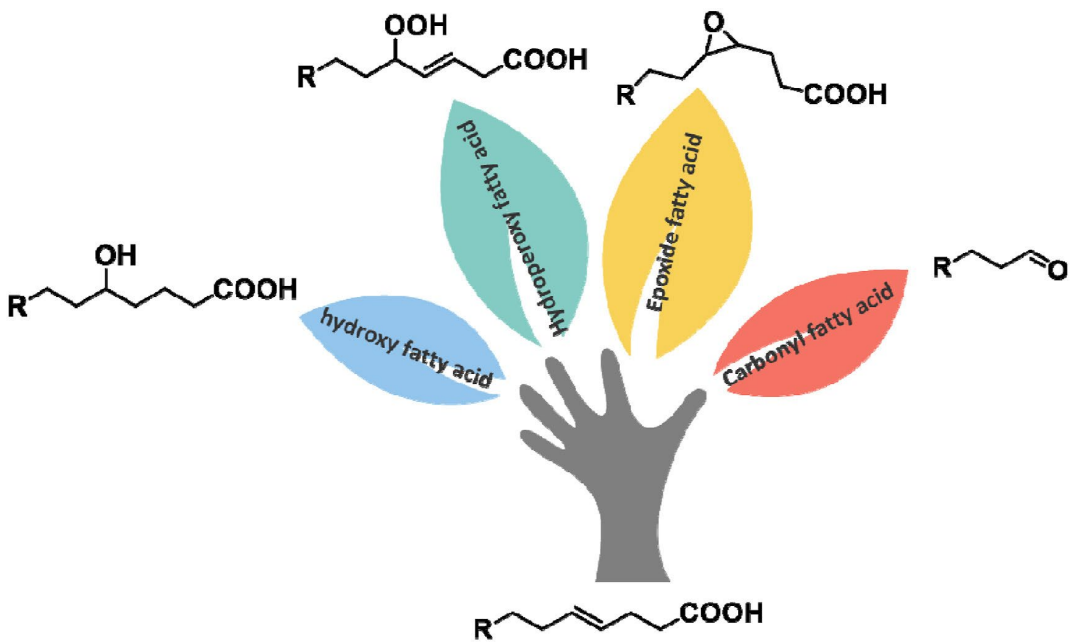


Amino acids are catabolized during metabolic antioxidant detoxification

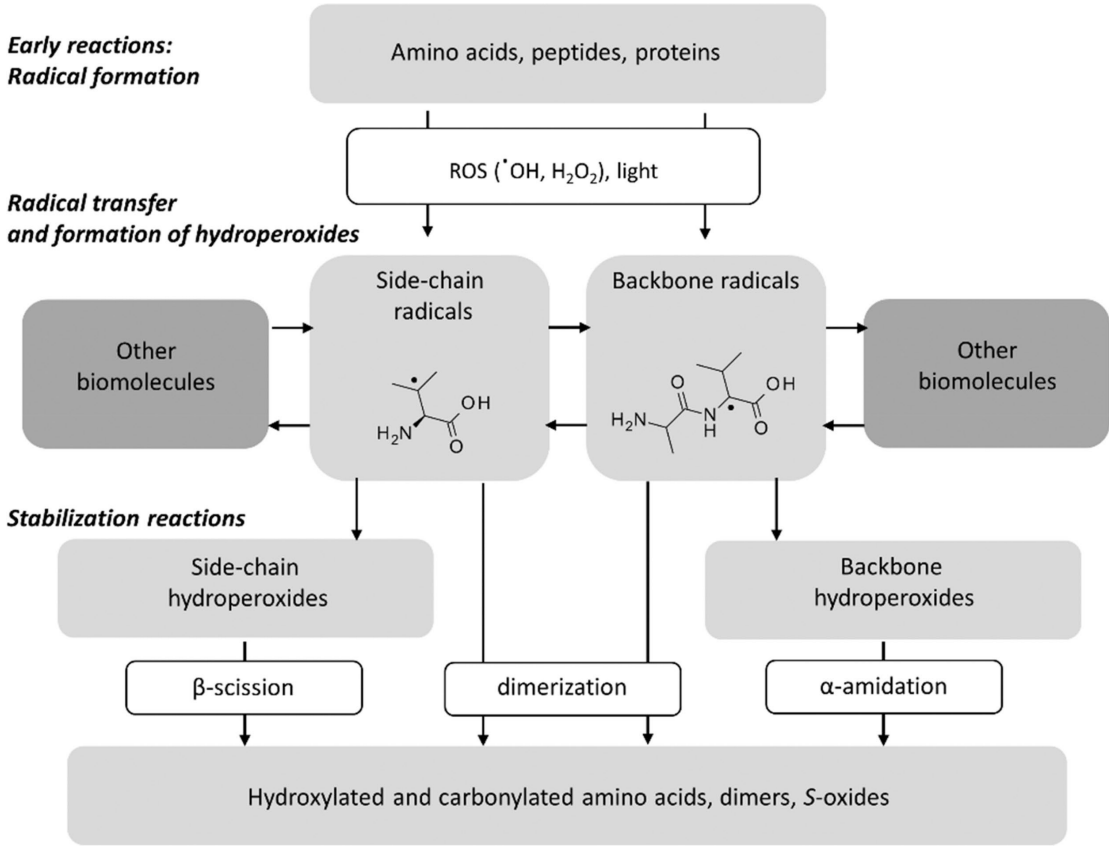
Guo et al. (2023)



Like lipids, proteins can also be oxidized during processing

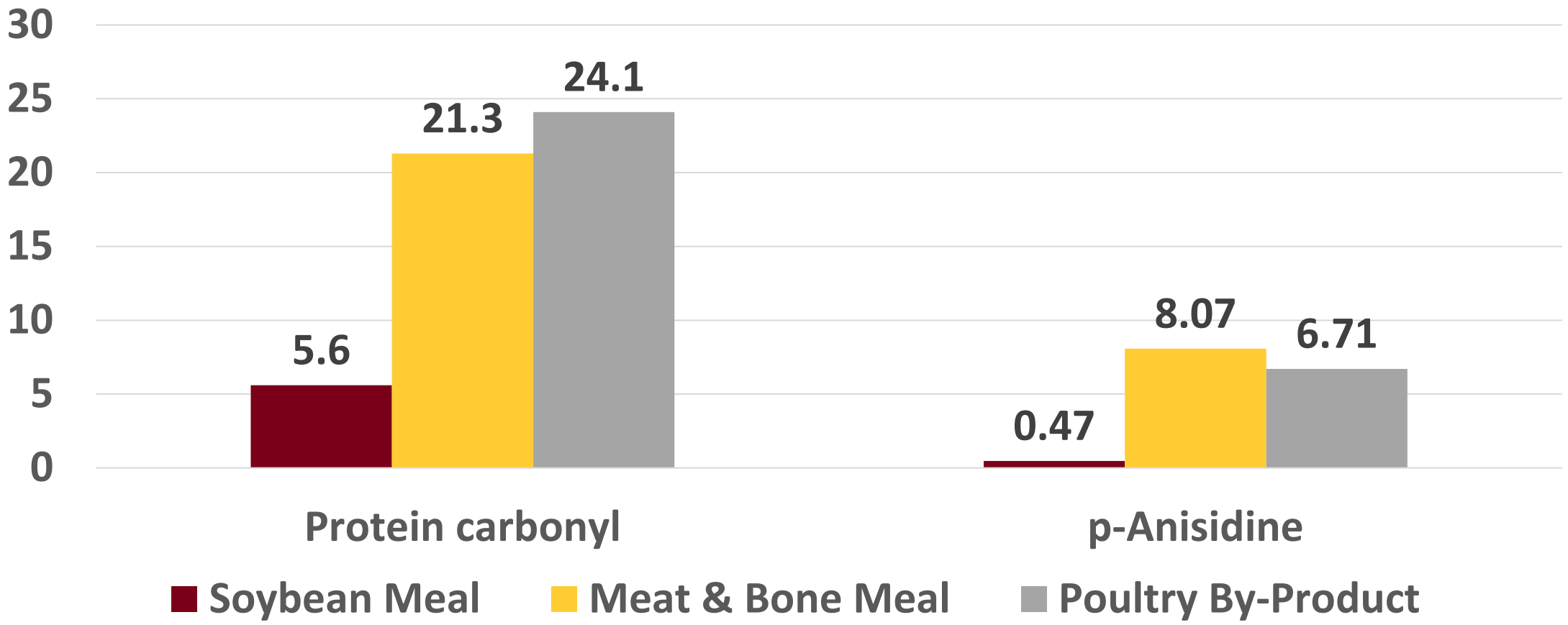


Lipid Oxidation

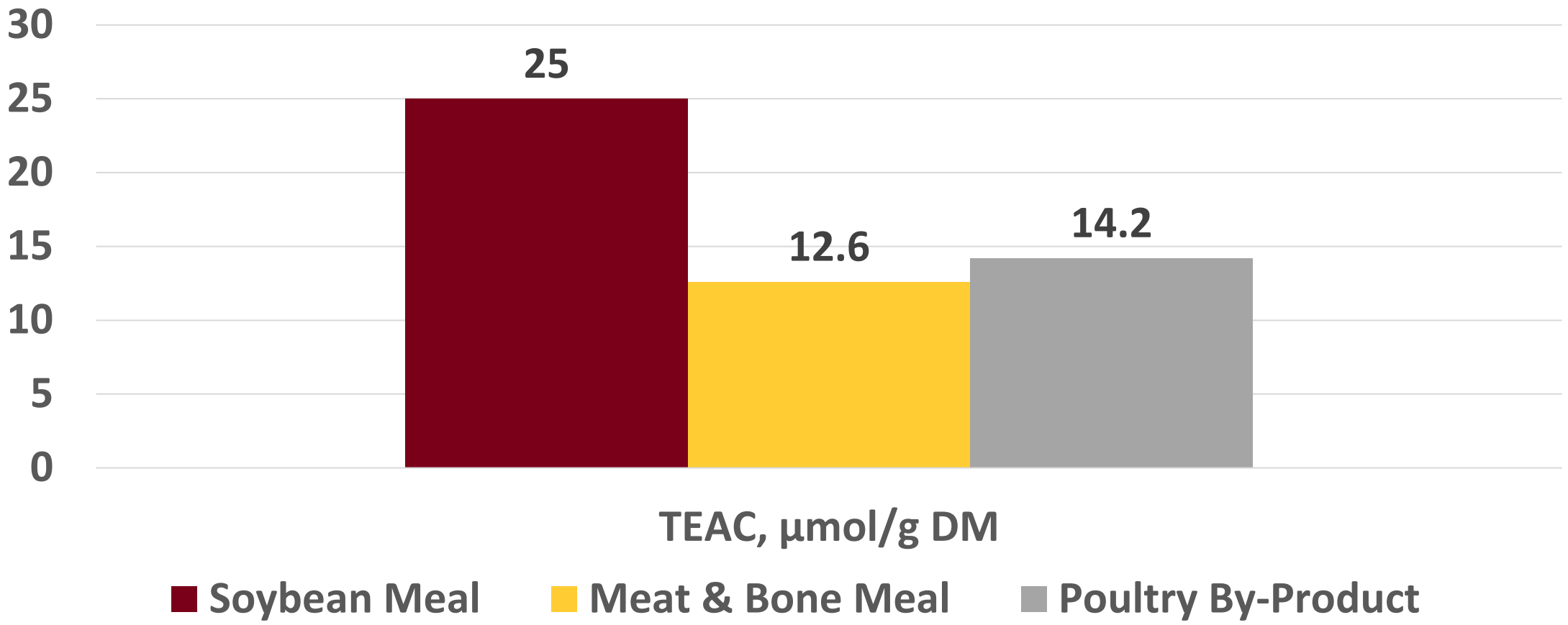


Protein Oxidation

Protein and lipid oxidation in feed ingredients



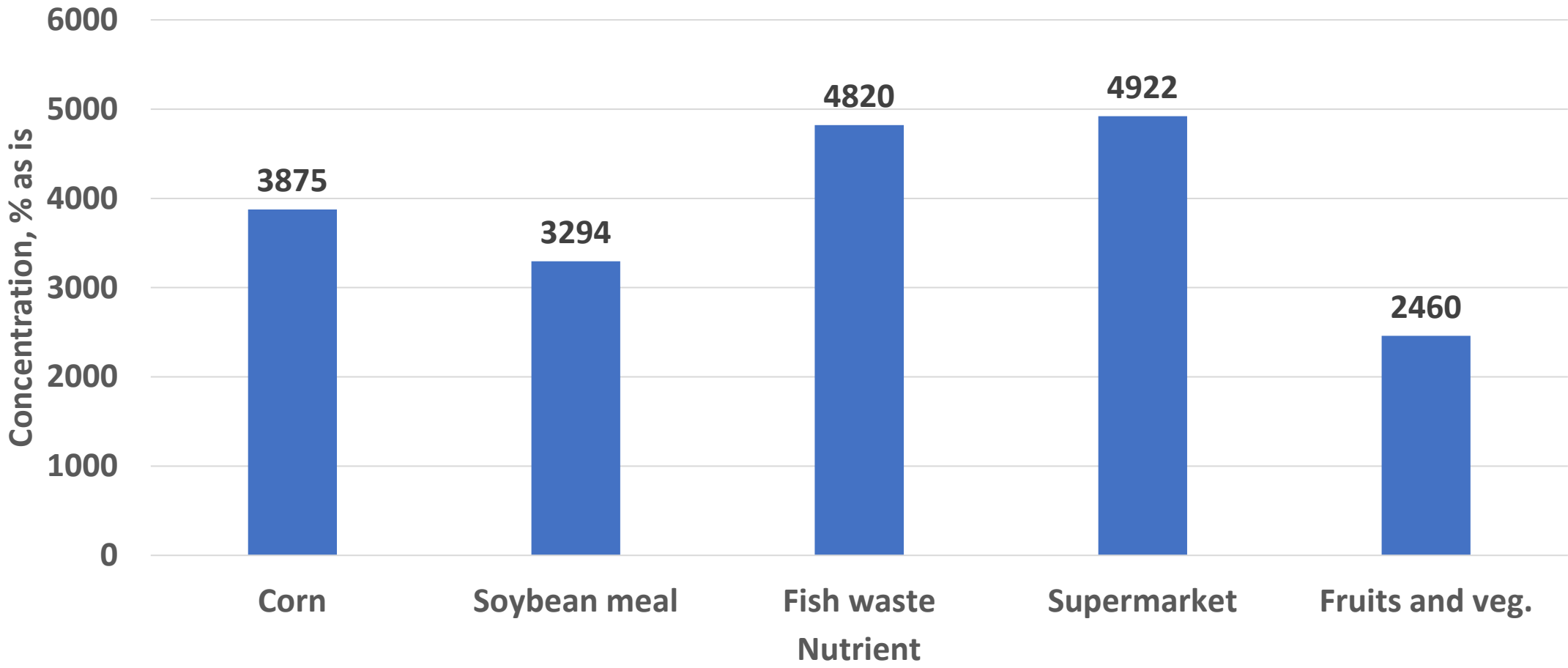
Trolox Equivalent Antioxidant Capacity (TEAC)



Pre-consumer and post-consumer food waste continues to be an underutilized source of nutrients

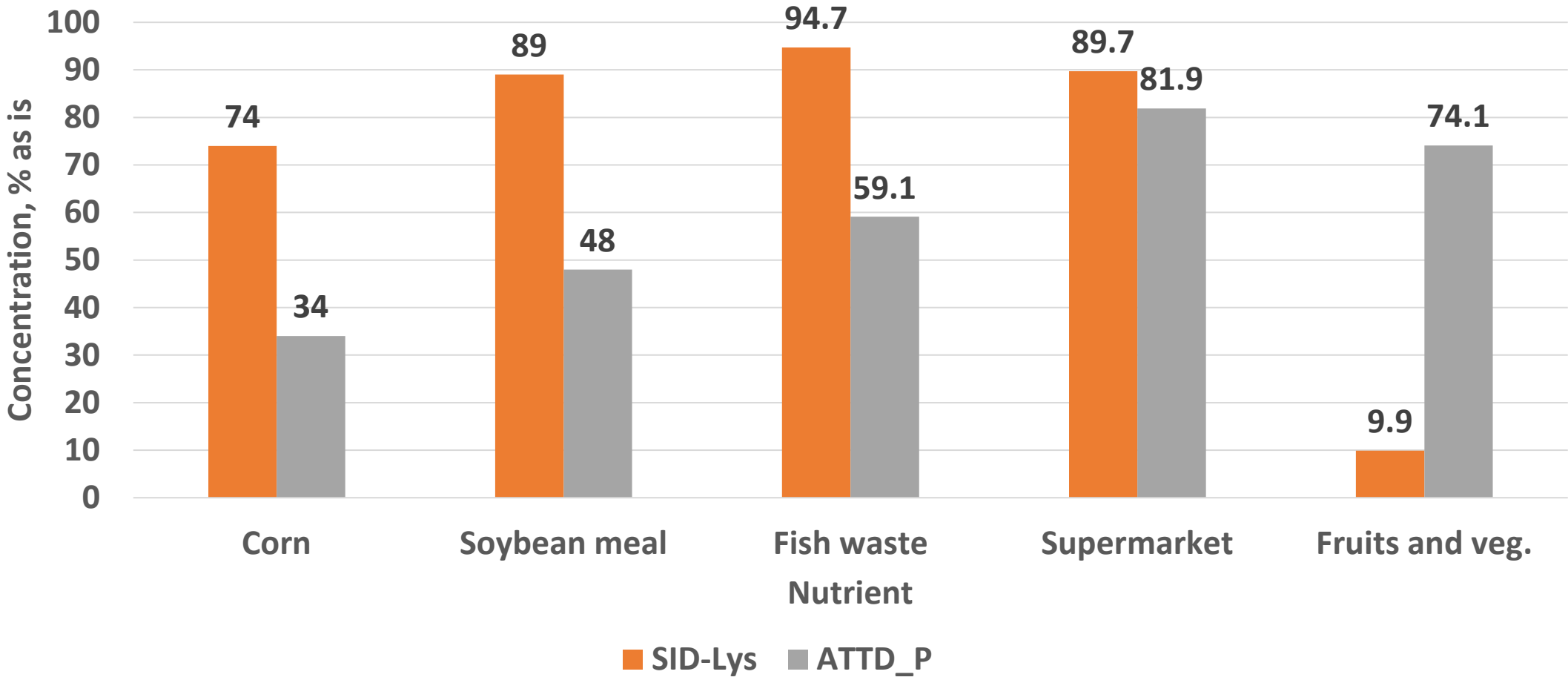
Nutrient	Pre-consumer Grocery Store	Post-consumer Residence Hall	Post-consumer Transfer Station	Corn	Soybean Meal
Crude protein, %	24.1 ± 13.5	16.3 ± 3.2	16.0 ± 6.9	8.2	47.7
Crude fat, %	29.9 ± 19.0	11.8 ± 3.4	10.1 ± 6.4	3.5	1.5
Starch, %	11.6 ± 13.5	42.1 ± 10.6	16.3 ± 9.6	62.6	1.9
Fiber-NDF, %	12.4 ± 8.1	6.7 ± 9.1	23.0 ± 12.5	9.1	8.2
Calcium,%	0.92 ± 1.0	0.21 ± 0.2	0.93 ± 0.9	0.02	0.33
Phosphorus, %	0.61 ± 0.6	0.26 ± 0.07	0.42 ± 0.4	0.26	0.71

Metabolizable energy in food waste for growing pigs



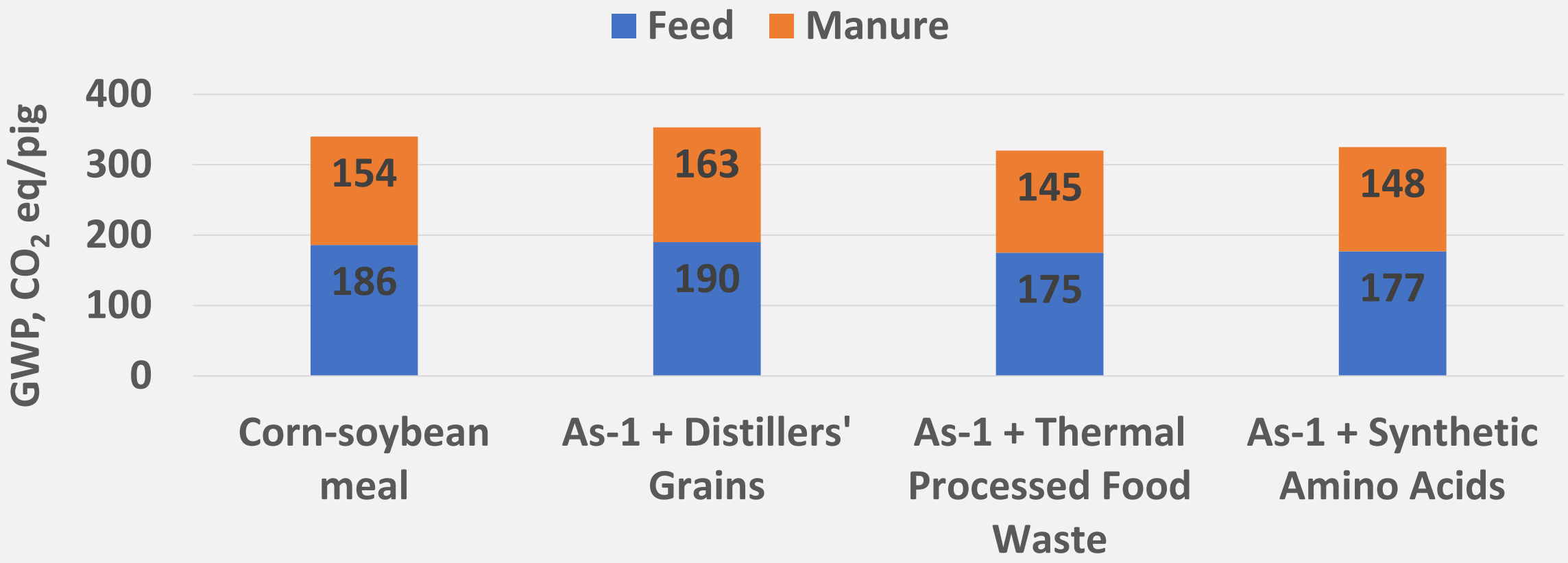
Source: Fung et al., 2019 J. Anim. Sci.

Digestibility of Lysine and Phosphorus in food waste for growing pigs



Source: Fung et al., 2019 J. Anim. Sci.

Feeding programs to decrease feed and manure related emissions (CO_2 eq/pig) of greenhouse gases of pigs

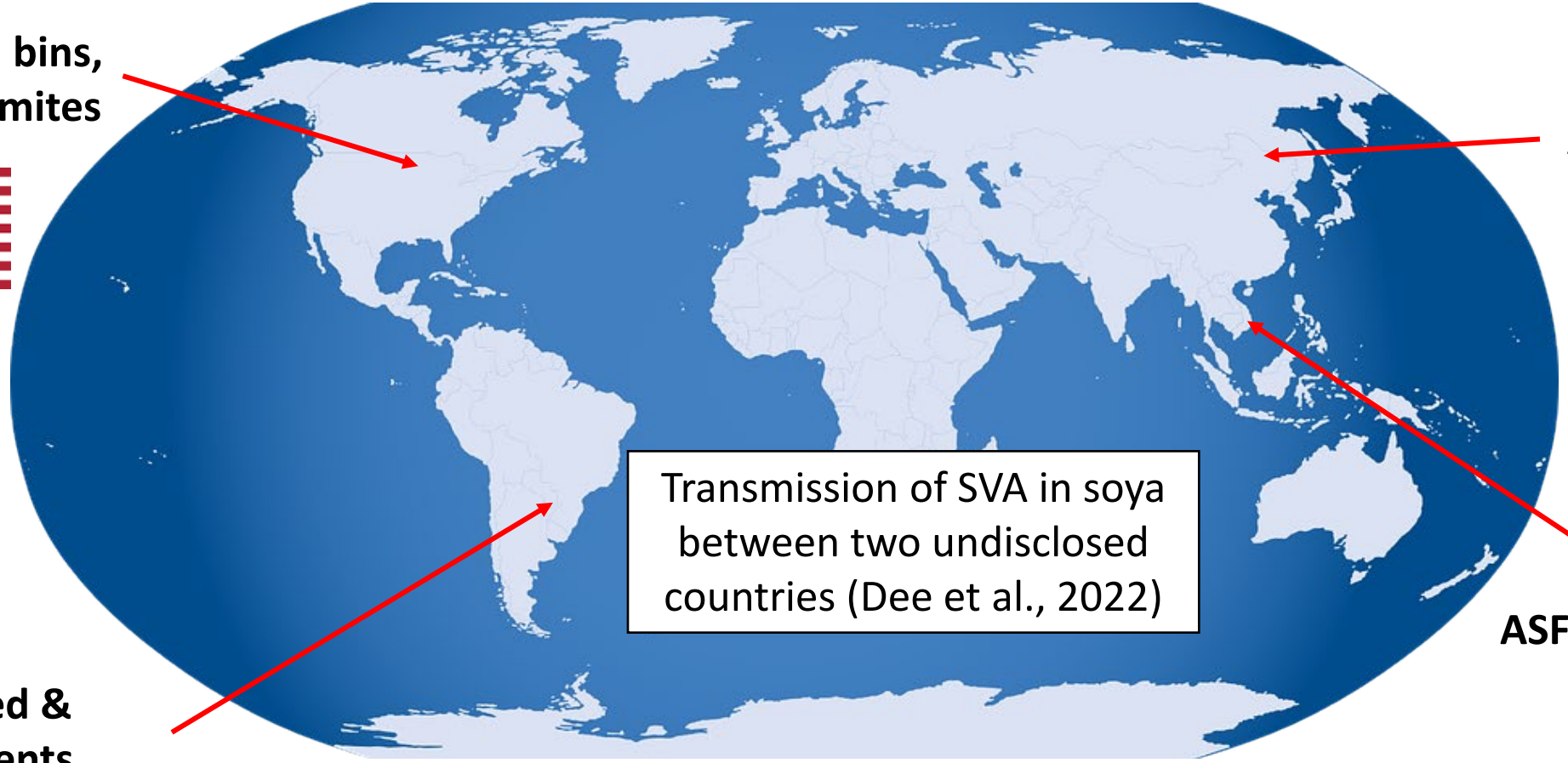


Shurson et al. (2023)

Foreign animal diseases – a challenge to upcycle nutrients

Sustainability of Pork Production

Virus contaminated feed, ingredients, and equipment are associated with outbreaks of diseases



Shurson et al. (2021)

Quantitative risk assessment model of the presence of swine viruses in spray-dried porcine plasma

Sampedro-Parra et al. (2023; in progress)

Environmental and animal health benefits of by-products

Spray dried porcine plasma

- Source of high biological value proteins
  - Improved health without use of antibiotics or pharmacological zinc
- Lower environmental footprint than other proteins
  - GFLI: 2.28 vs. 6.82 g CO_2 eq/kg in soybean protein concentrate

Animal meal (e.g., meat and bone meal)

- GWP: 0.656 vs. 2.644 g CO_2 eq/kg in soybean meal

Objective and methodology

A PO for SDPP batch with absence of any infectious viral particle

ASFV in raw plasma at 0.6 log HAD50/mL (0.1-1.4, 95% CI) pre-outbreak

Processing scenarios

- baseline: spray-drying + heated storage
- baseline + ultraviolet (UV) radiation
- baseline + dry-heat

Microbiological risk assessment

Performance objective:	Maximum frequency and/or concentration of a hazard in a food at a specified step in the food chain before the time of consumption that provides or contributes to an FSO or ALOP, as applicable
Feed safety objective:	Maximum frequency and/or concentration of a hazard in a food at the time of consumption that provides or contributes to the appropriate level of protection (ALOP)
Appropriate level of protection:	1, 10, 1000 pigs

Percent of batches compliant with performance objective

Ho (viral load plasma)	Mean (log $TCID_{50}$/g)	Sd
	0.6	0.3
Processing inactivation		
Ultraviolet	-6.8	0.1
Increase due to plasma concentration*	0.5	-
Spray-Drying	-4.1	0.2
Heated storage	-7.0	0.8**
	SD + storage	SD + UV + storage
Final concentration SDPP (log $TCID_{50}$/g)	-16.8±0.9	-10.0±0.9
Prob. PO 20 mt batch (-7.3 log) (%)	100	100

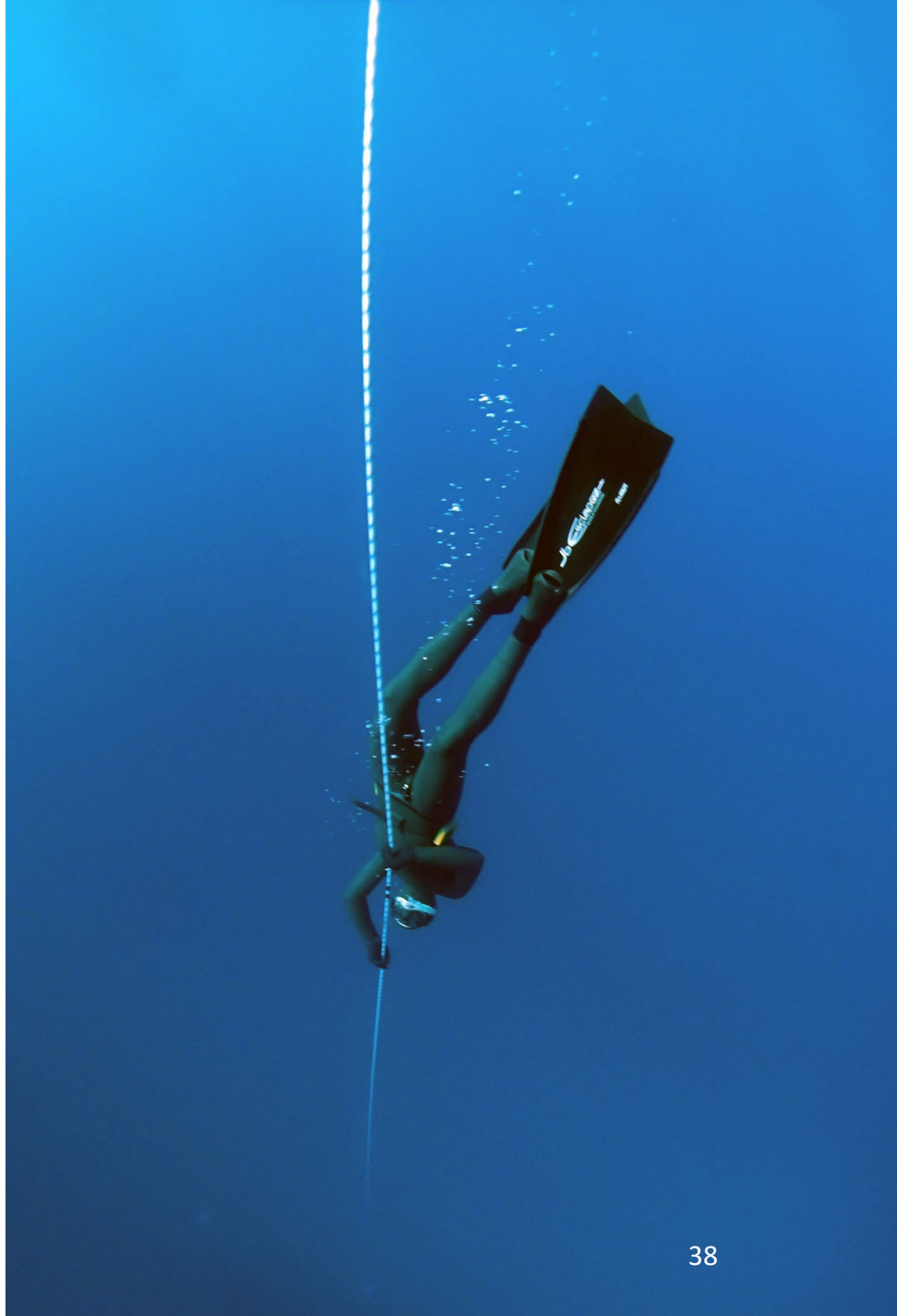
African Swine Fever an Update and Gaps in Feed Safety

IPPE, 2025

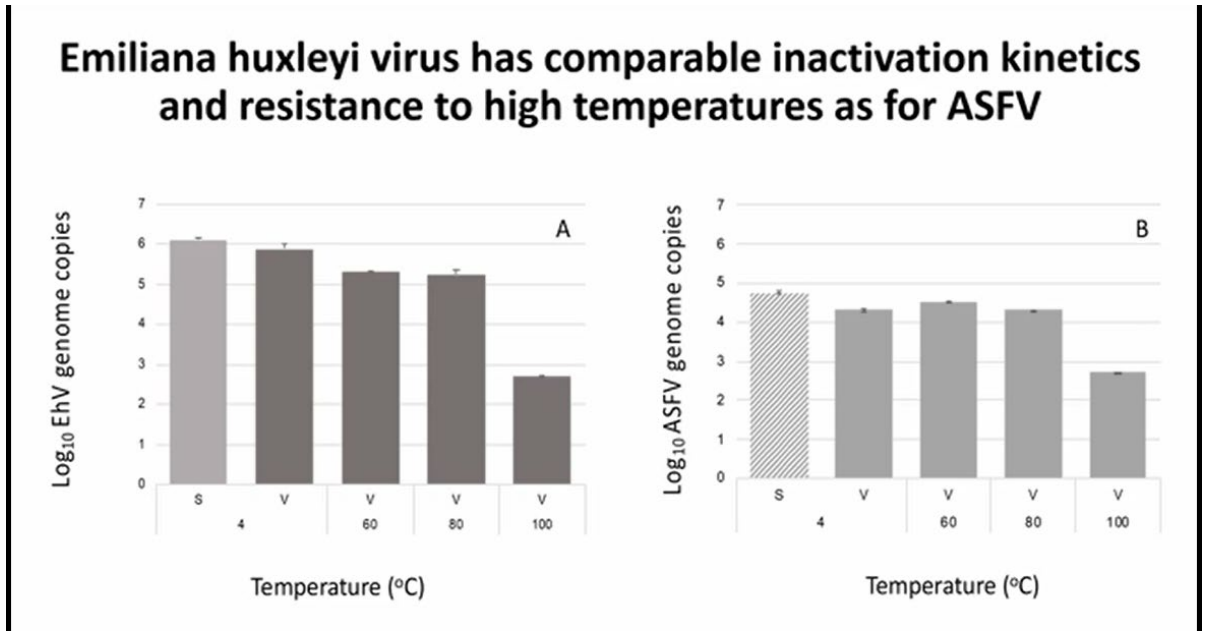
Risk Management

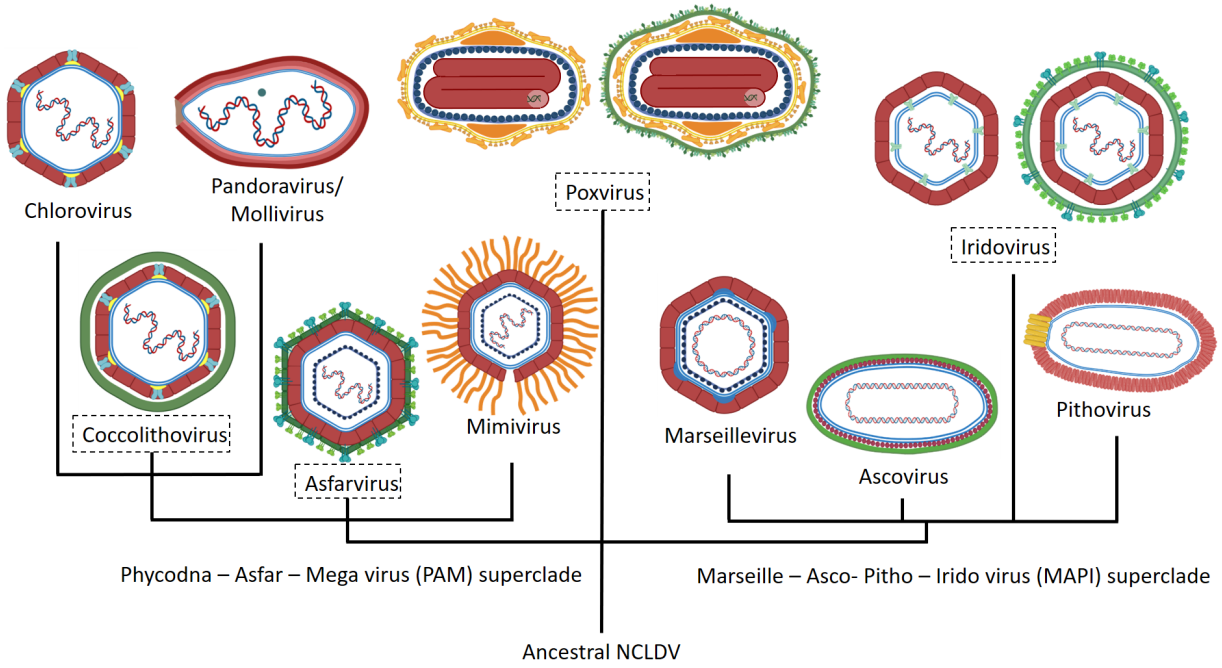
Feed mitigants in endemic vs. foreign animal diseases

Endemic diseases	Foreign
PRRS	ASF
PED	CSF
SVA	FMD

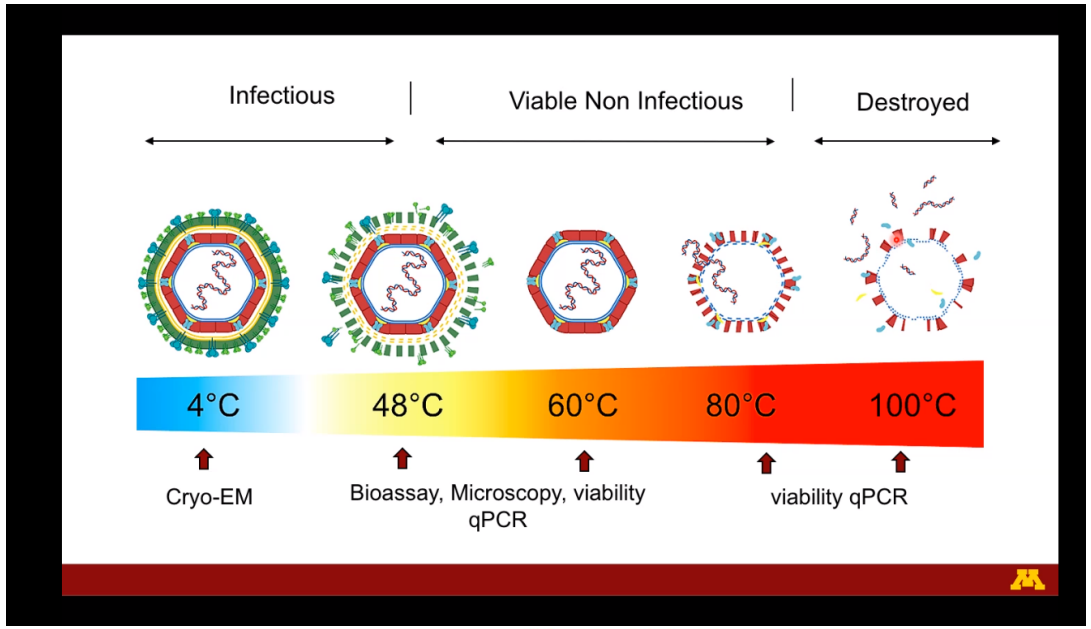


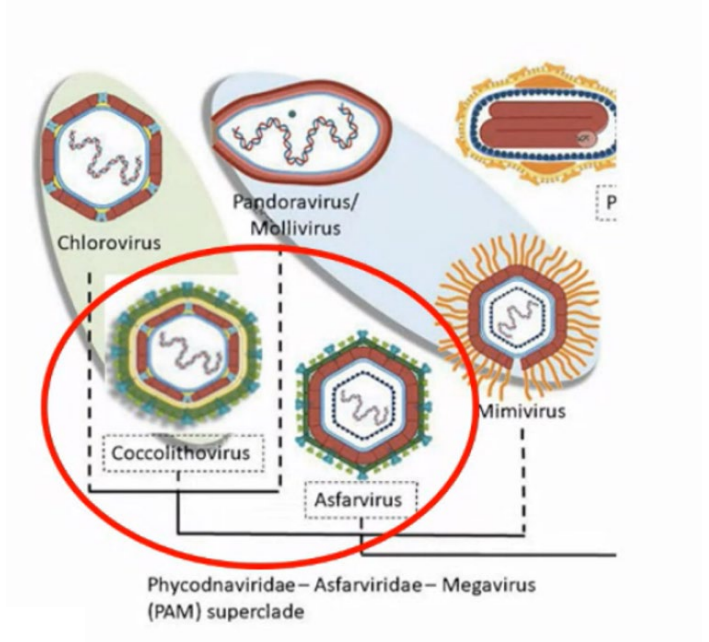
Emiliana huxleyi virus a surrogate for African swine fever virus

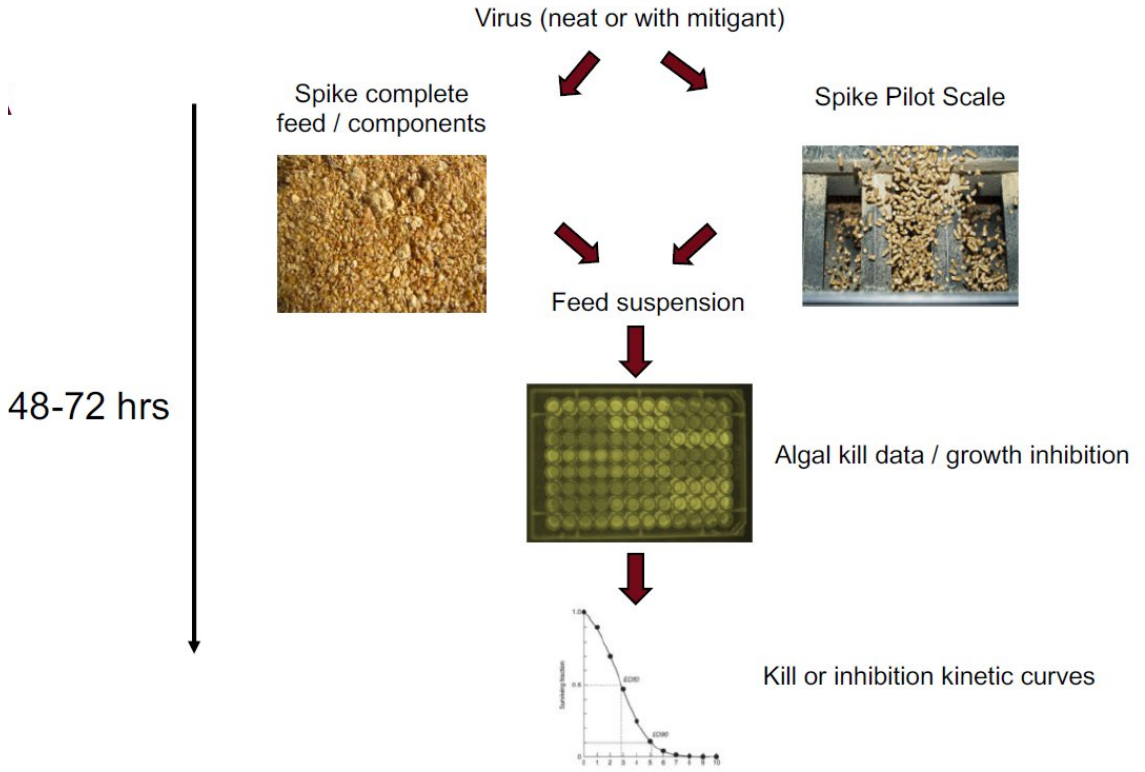


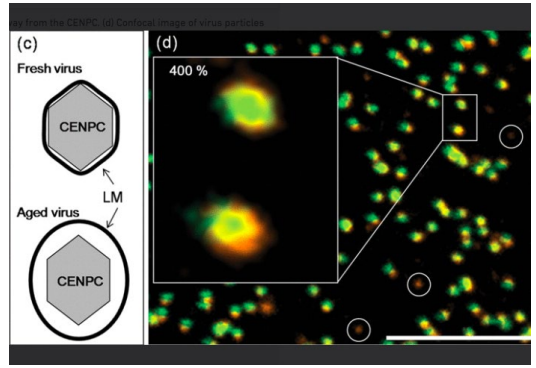


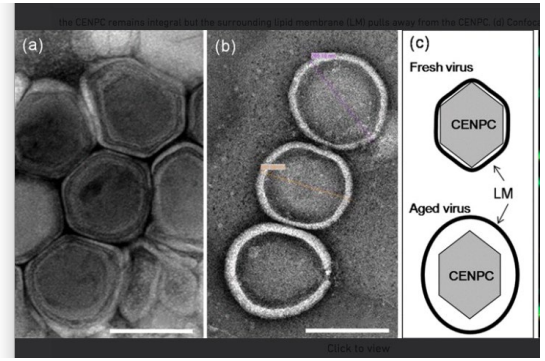
Risk-free *in situ* non-animal assay (RISNA)





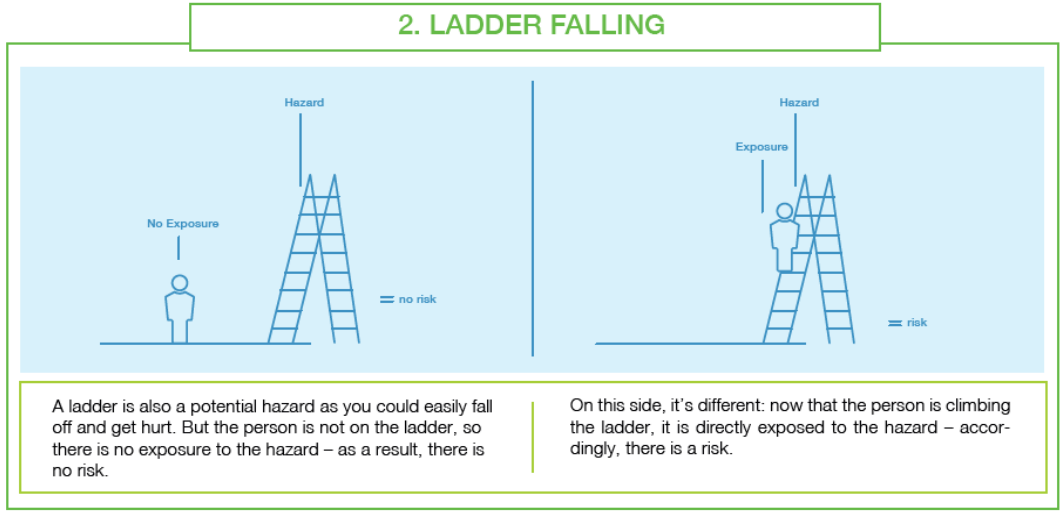






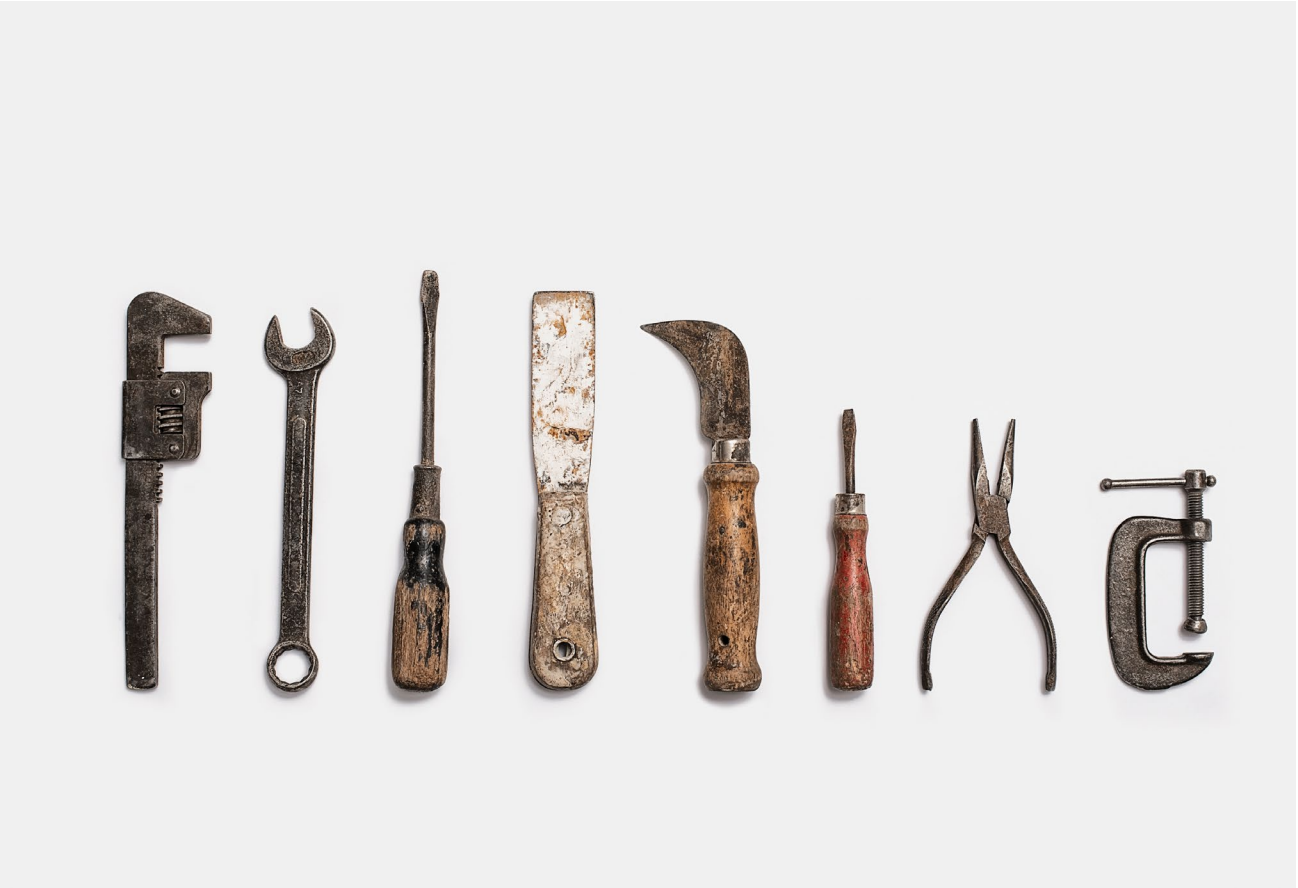
Risk communication

- Feeding animal derived by-products to animals is a major step towards reduction of the environmental impact of food production.
- Viruses are also known to survive in plant-based feed ingredients. Biosecurity is essential for ALL animal feed ingredients.
- There are risks in all human activities. We can mitigate it!



Resources

- Lifecycle database with US crops and by-products https://foodscubed.umn.edu/
- Center for Animal Health and Food Safety https://cahfs.umn.edu/
- 86th Minnesota Nutrition Conference:
  - September 17 & 18, 2025
  - Mankato, MN



Take home message

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ENVIRONMENTAL FOOTPRINT OF FOOD PRODUCTION MUST DECREASE

02

ANIMAL RESPONSE TO NUTRIENTS IS COMPLEX AND DYNAMIC

03

BEST USE OF RENDERED PRODUCTS WILL LEVERAGE PHYSIOLOGICAL BENEFITS

Thank you!

Animal Agriculture Environmental Sustainability Team





INSTITUTE ON THE ENVIRONMENT

CFANS
College of Food, Agricultural and Natural Resource Sciences

African Swine Fever and Foreign Animal Disease Response Team



College of Veterinary Medicine
University of Minnesota

ANSC




Integrated Animal Systems Biology Team

New feed processing and Manure Management



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SSR
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Real Pork Trust Consortium