The research goal is to develop practical technologies resulting in improved gastrointestinal and whole-animal nutrient utilization and a modified microbial ecology (including pathogens) leading to a reduction of the impact of livestock production on the soil, water, and air environment.

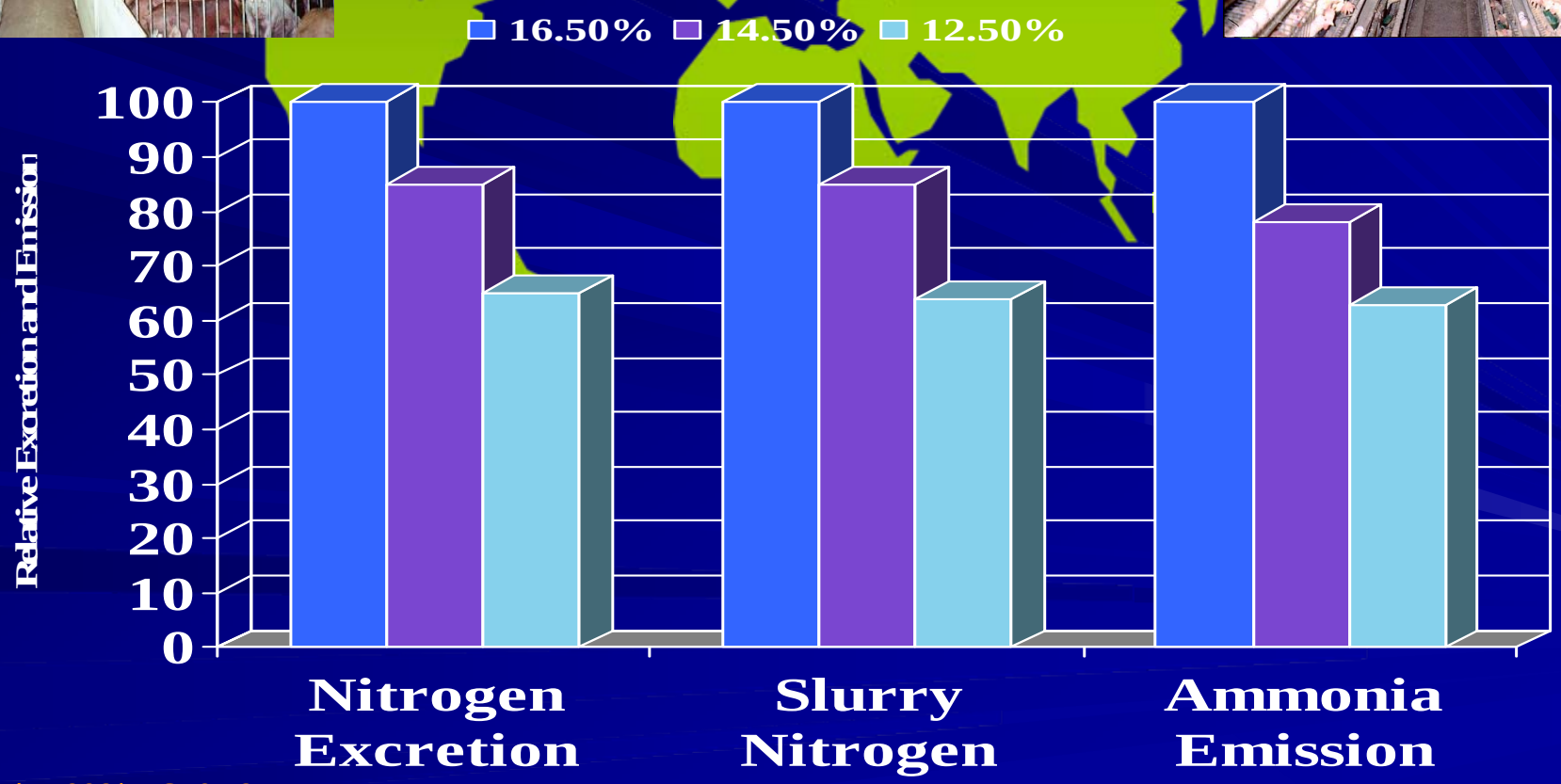
Key Odorants in Swine Manure and Aerial Emissions						
Compound	Formula	Characteristic	*H*[1]	*G*[2]	*Y*[3]	*Z*[4]
Acetic Acid	$C_2H_4O_2$	Pungent/Vinegar	X	X	X	*X*
Propionic Acid	$C_3H_6O_2$	Fecal	X	X	X	X
Butyric Acid	$C_4H_8O_2$	Fecal/Stench	X	X	X	*X*
Isobutyric Acid	$C_4H_8O_2$	Fecal	X	X	X	*X*
Isovaleric Acid	$C_5H_{10}O_2$	Fecal	X	X	X	X
n-Valeric Acid	$C_5H_{10}O_2$	Fecal	X	X	X	*X*
Heptanoic Acid	$C_7H_{14}O_2$	Pungent				*X*
Phenol	C_6H_6O	Aromatic	X	X	X	*X*
p-Cresol	C_7H_8O	Fecal	X	X	X	*X*
4-Ethyl Phenol	$C_8H_{10}O$	Pungent	X	X	X	*X*
Hydrogen Sulfide	H_2S	Rotten Eggs	X	X	X	X
Dimethyl Trisulfide	$C_2H_6S_3$	Nauseating	X		X	X
Ammonia	NH_3	Sharp/Pungent	X	X	X	X
Indole	C_8H_7N	Fecal/Stench	X	X	X	X
3-Methyl Indole	C_9H_9N	Fecal/Nauseating	X	X	X	*X*

[1]Hobbs et al., 1995; [2]Gralapp et al., 2001; [3]Yasuhara et al., 1984; [4]Zahn et al., 2001

INPUT APPROACHES TO IMPACT MANURE COMPOSITION AND AERIAL EMISSIONS FROM MANURE STORAGE FACILITIES AND LIVESTOCK OPERATIONS

Element	Dietary Input	Feed Ingredient
Carbon	**Carbohydrates / Fiber / Starch & Non-starch polysaccharides**	**Starch (Corn), Fat, Wheat and Wheat Products, Barley, Beet Pulp, Distillers Dried Grains, Soy Hulls [digestibility impact]**
Nitrogen	**Proteins / Amino Acids**	**Corn, Soybean Meal, Animal Protein Products, DDGS, Crystalline Amino Acids [digestibility and utilization impacts]**
Sulfur	**Proteins / Macro & Micro Minerals**	**Corn, Soybean Meal, Animal Protein Products, Dicalcium & Deflourinated Phosphate, Sulfate-Based Trace Minerals [digestibility and utilization impacts]**

FOR EACH ONE PERCENTAGE UNIT REDUCTION IN DIETARY CRUDE PROTEIN, TOTAL NITROGEN LOSSES CAN BE REDUCED BY APPROXIMATELY EIGHT PERCENT (Kerr 2003 / DPP 1:139)



Canh et al., 1998/LPS56:181

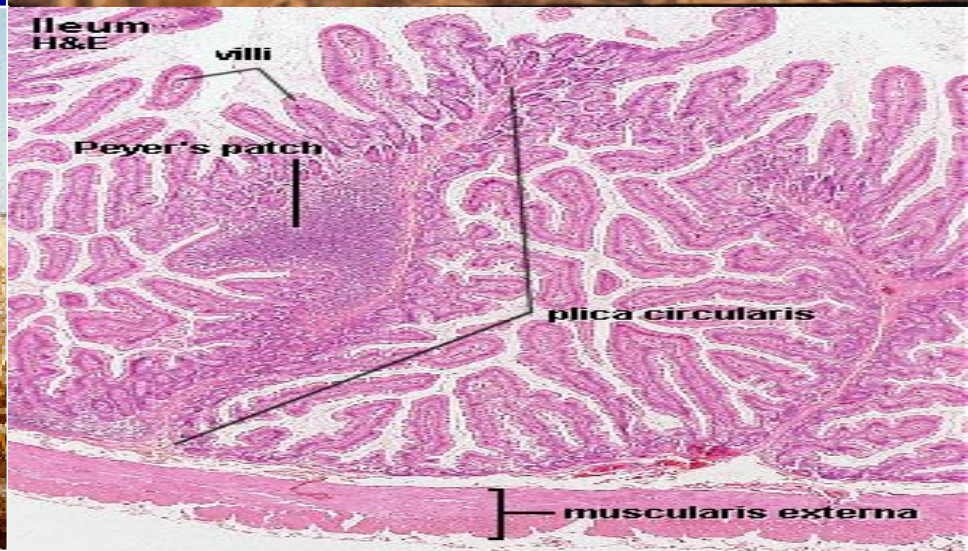
Corn-Soybean Meal Based Diet Formulations

Ingredient	A	B	C	D	E	F
Corn	62.05	63.58	66.70	67.58	73.08	74.35
SBM	30.55	28.95	25.65	24.70	18.75	17.35
Other	7.400	7.423	7.477	7.498	7.624	7.655
AA Addition						
L-Lys	-	.047	.146	.175	.351	.393
DL-Met	-	-	.027	.035	.084	.095
L-Thr	-	-	-	.012	.085	.102
L-Trp	-	-	-	-	.026	.032
L-Ile	-	-	-	-	-	.023
L-Val	-	-	-	-	-	-
CP, %	20.70	20.06	18.77	18.41	16.14	15.62

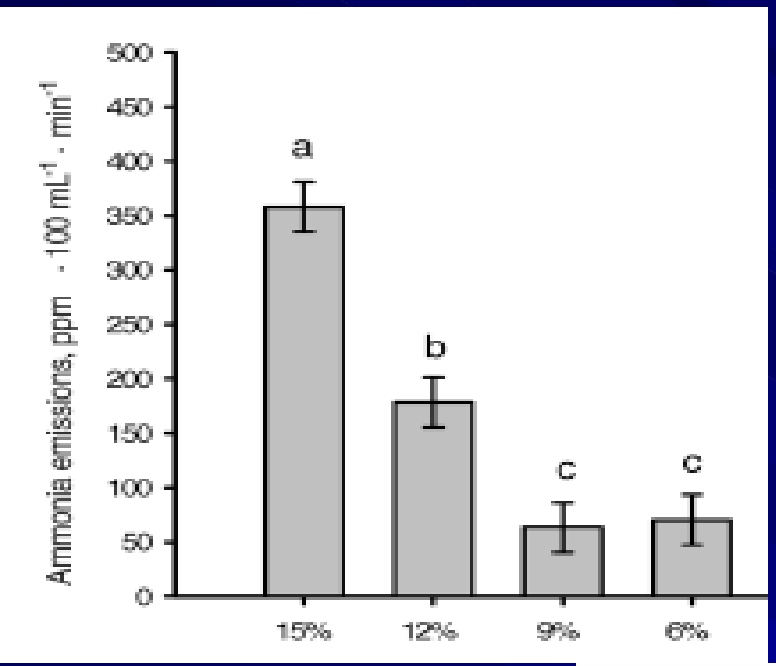
d Lys = .90, Ile:Lys = .60, SAA:Lys = .60, Thr:Lys = .595, Trp:Lys = .170, Val:Lys = .680

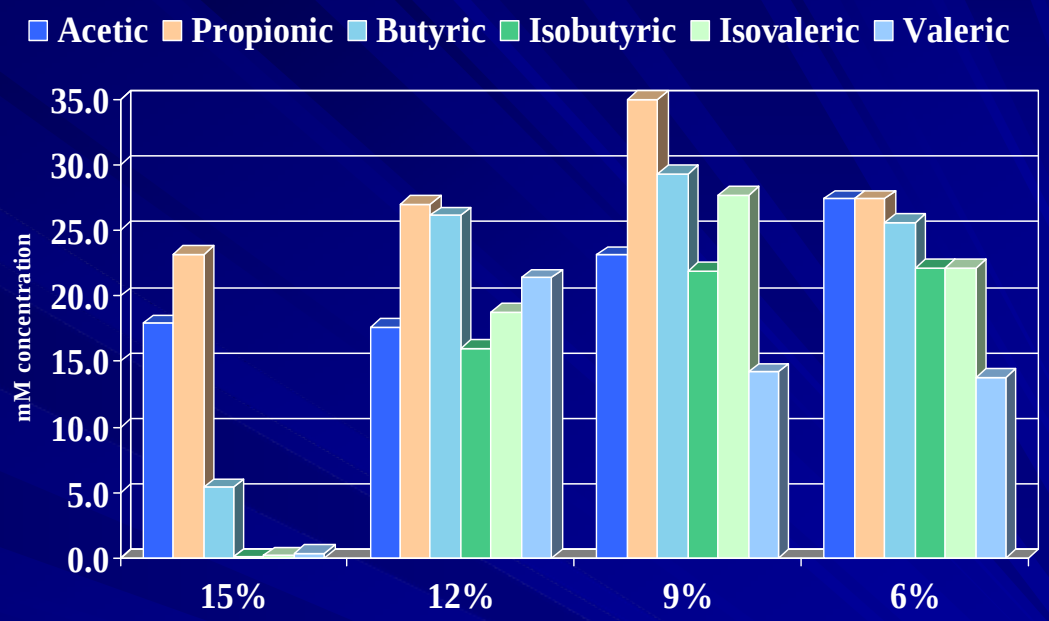
Low CP-AA Fortified Diets

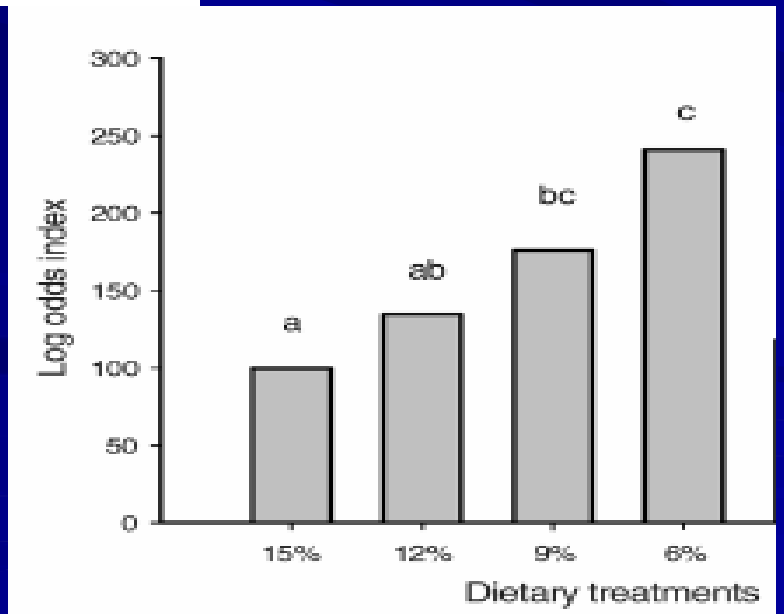
- Minimization of N excretion and subsequent NH_3 emissions (-10% for each 1%U reduction in CP)
- Reduction in the energetic cost of excess amino acid deamination (NE effect)
- Reduction in water consumption (manure volume)
- Reduction of intestinal ammonia and amine concentration (gut health?)
- Odor impacts?



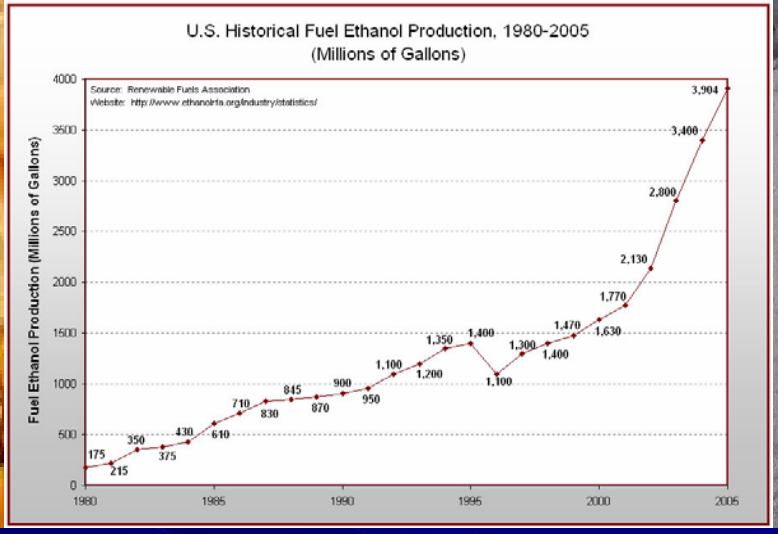
Low CP Diets and Fecal VFA





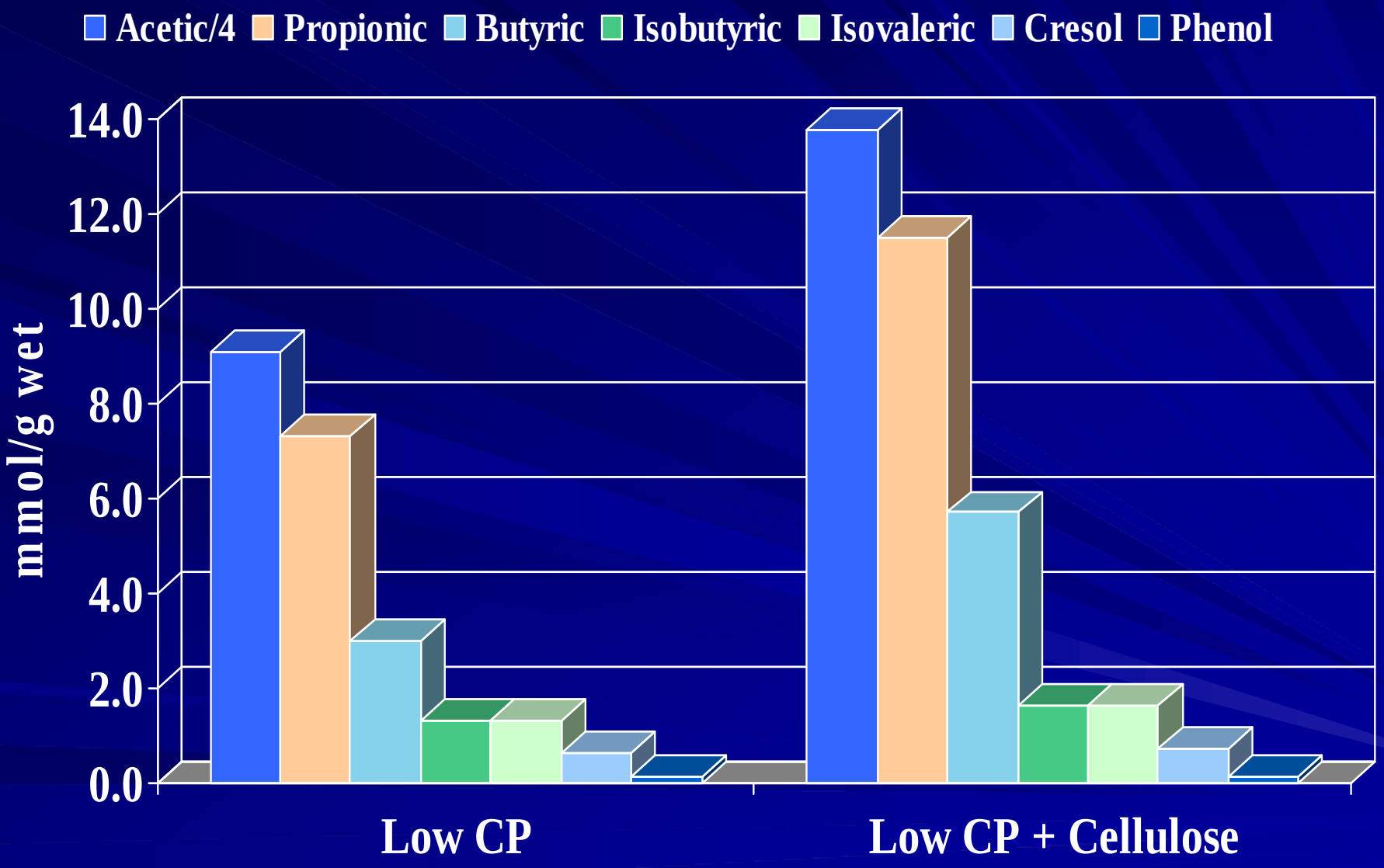


Otto et al., 2003 / JAS 81:1754

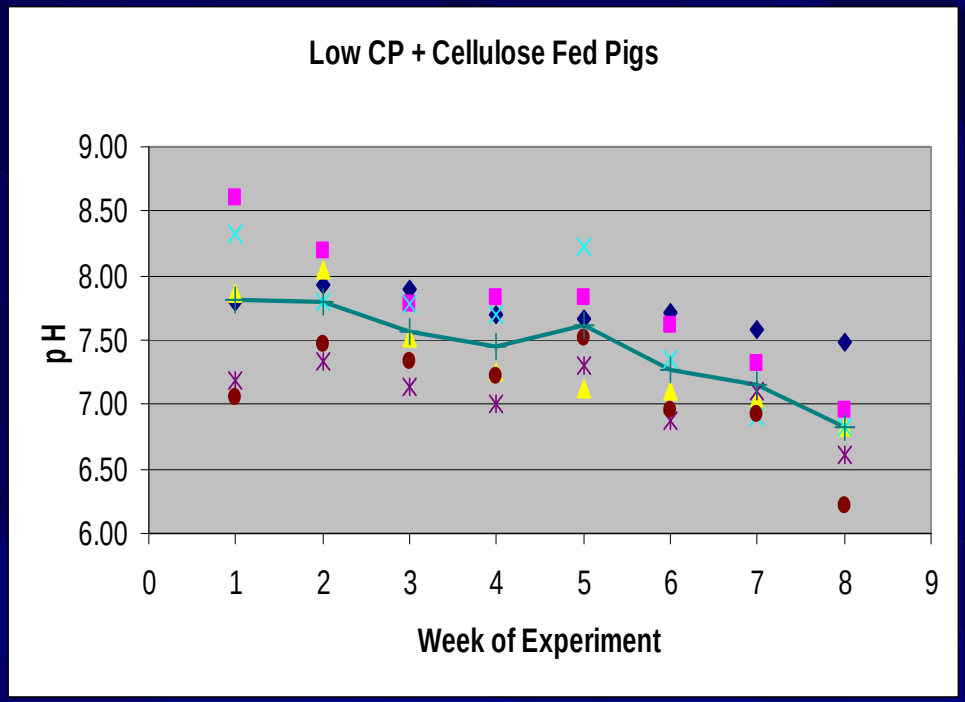


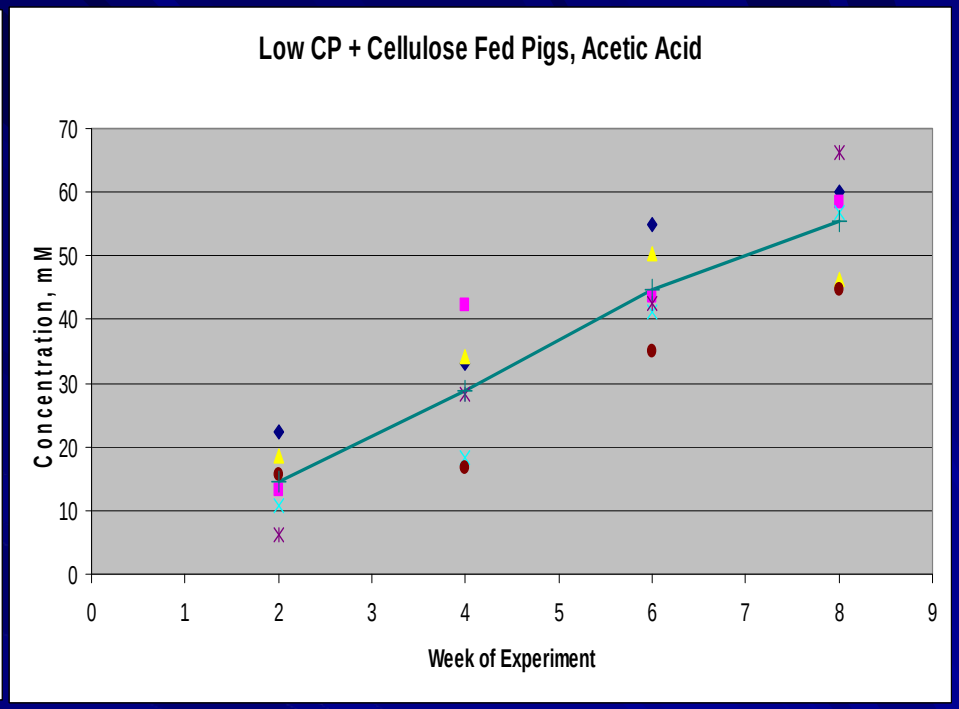
Corn	Nutrient	DDGS
57.1	Starch	7.2
7.2	Crude Protein	28.3
6.7	Neutral Detergent Fiber	24.2
0.20	Phosphorus	0.58
0.10	Sulfur	0.60

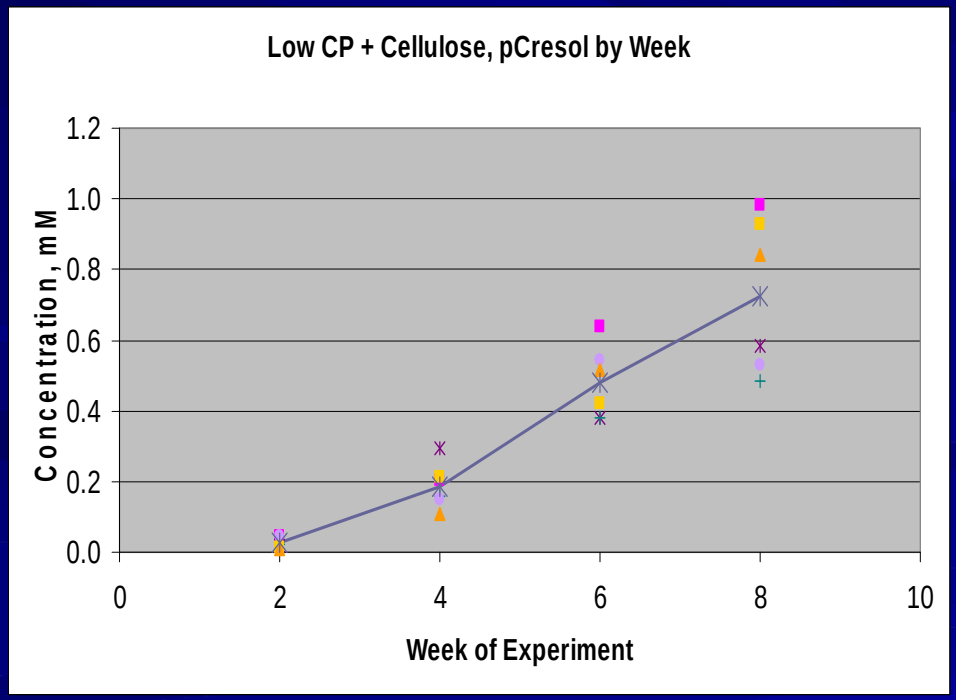
Fiber Effects on Manure Composition

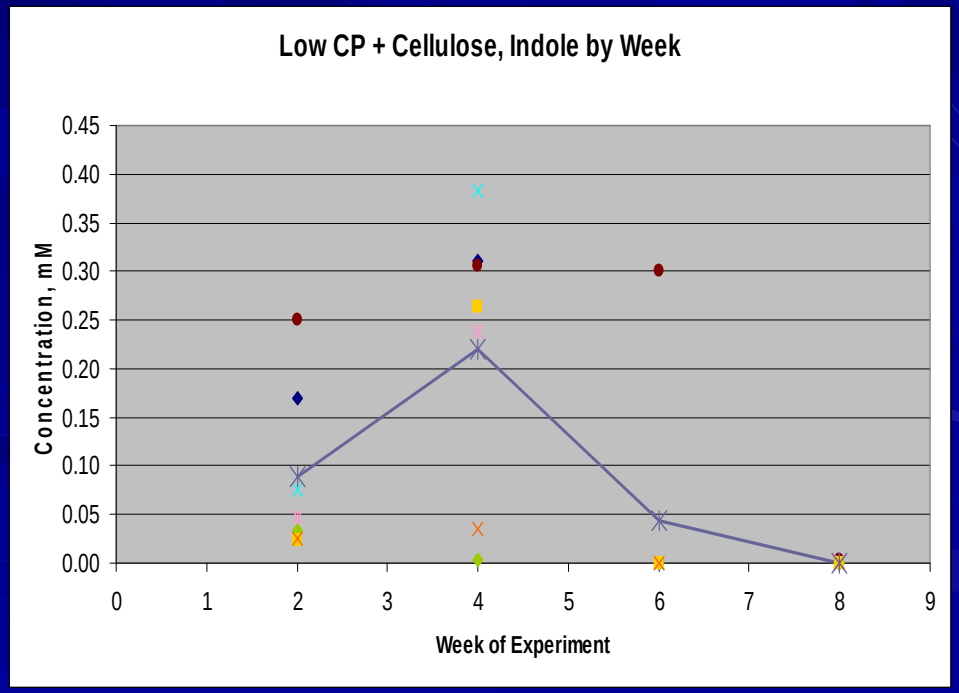


Kerr et al., 2006 / JAS 84:1584

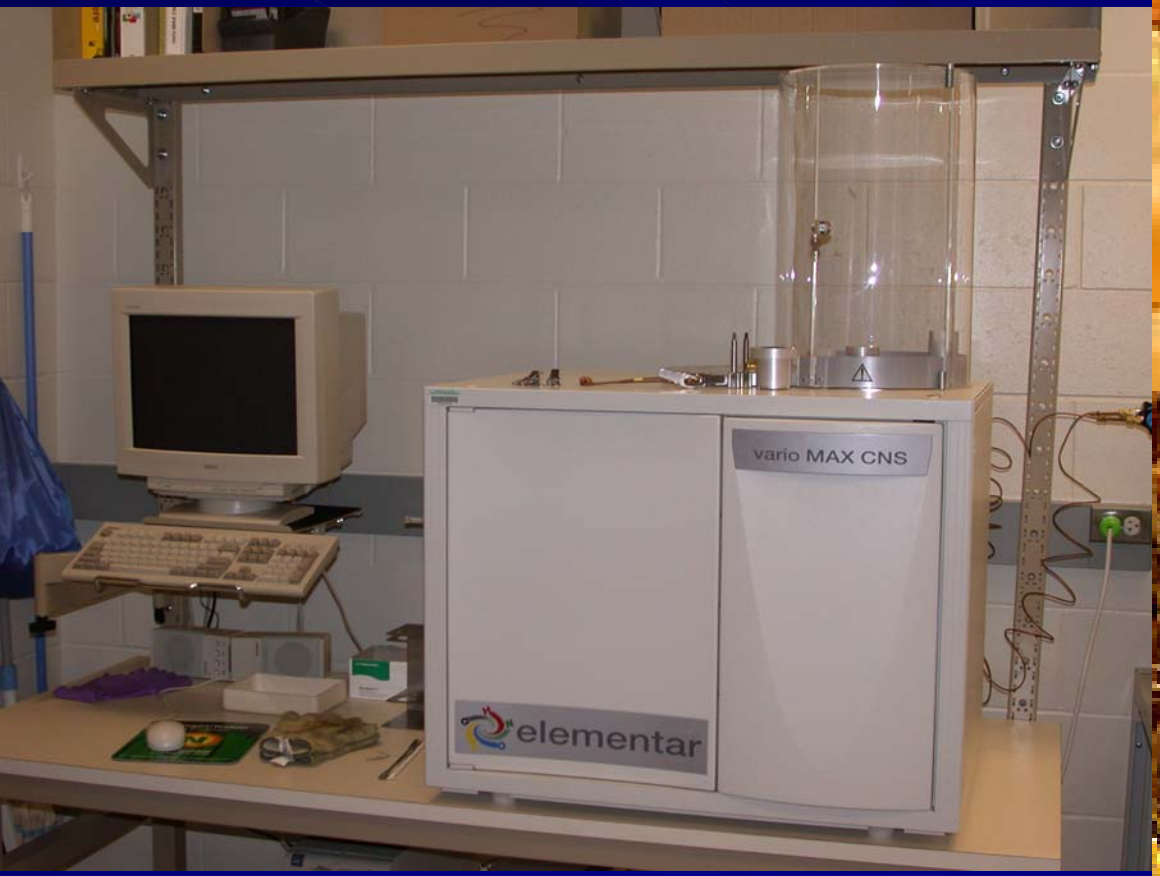

Low CP + Cellulose Fed Pigs
pH
9.00
8.50
8.00
7.50
7.00
6.50
6.00
0
1
2
3
4
5
6
7
8
9
Week of Experiment


Low CP + Cellulose Fed Pigs, Acetic Acid
Concentration, mM
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
Week of Experiment


Low CP + Cellulose, pCresol by Week
Concentration, mM
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
Week of Experiment


Low CP + Cellulose, Indole by Week
Concentration, mM
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
1
2
3
4
5
6
7
8
9
Week of Experiment

Sulfur Concentration of Feedstuffs



S retention is approximately 65%

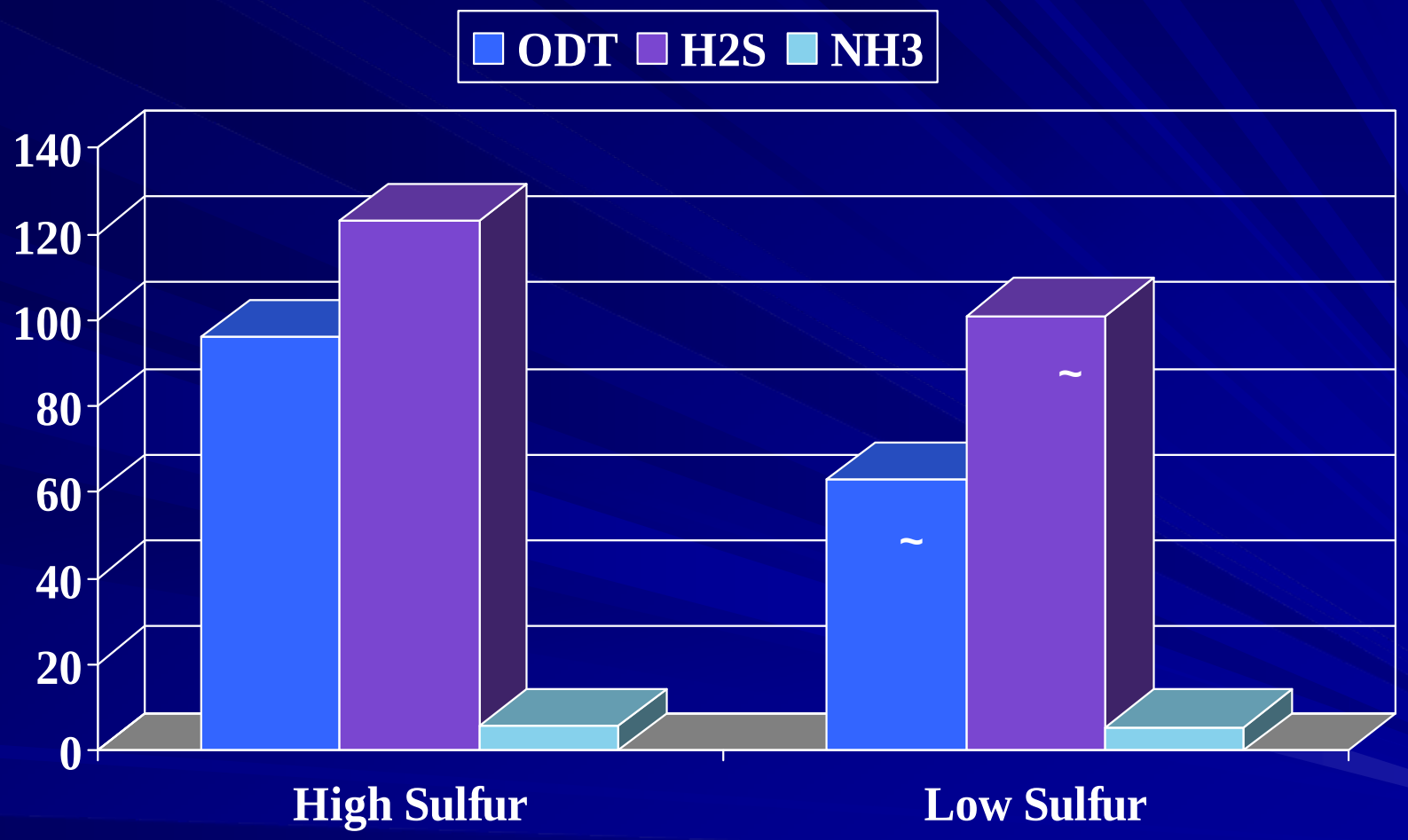
Total Sulfur Content of Ingredients

ppm

- Corn: 974
- DDGS: 6,039
- Soybean meal: 4,110
- Dical and monocal P: 10,575
- Defluorinated P: 565
- Zinc sulfate: 185,545
- Zinc oxide: 1,221

Impact of High- or Low-Sulfur Diets on Odor Components

Whitney et al., 1999 / JAS 71(S1):70abstr



- No effect of low S diets on 7 to 21 kg (Whitney et al., 1999) or 80 to 108 kg pig performance (Apgar et al., 2002)

Crude Glycerin in Livestock Feeds

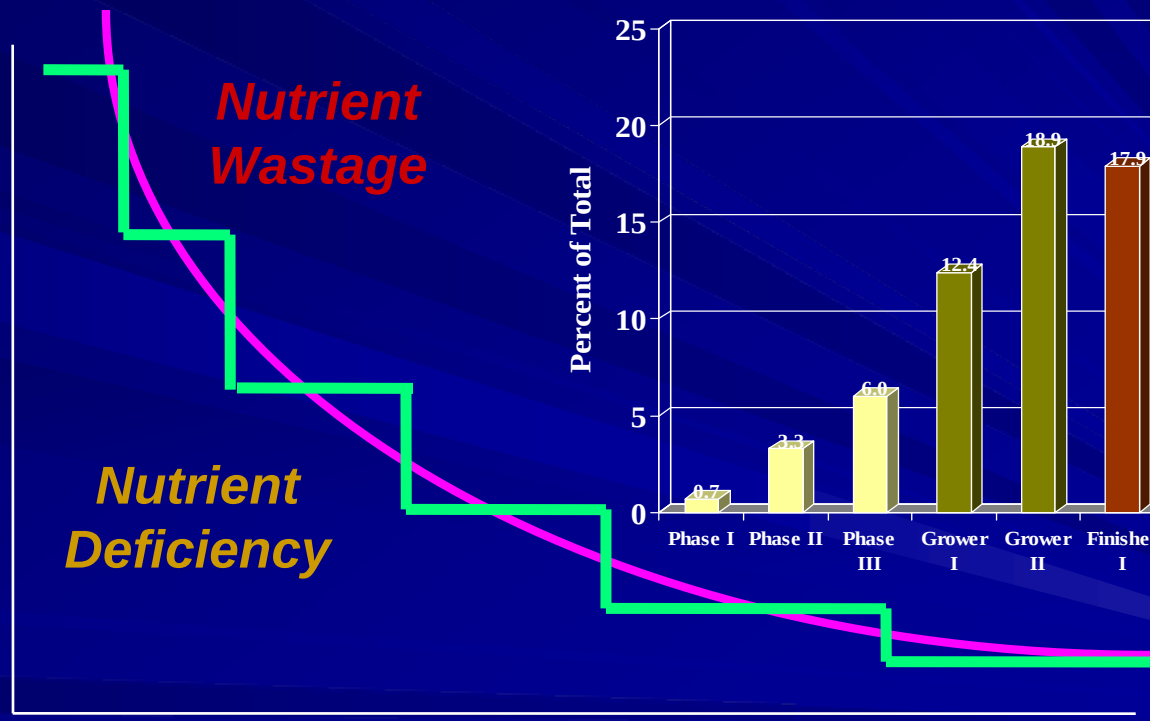
Precision Feeding

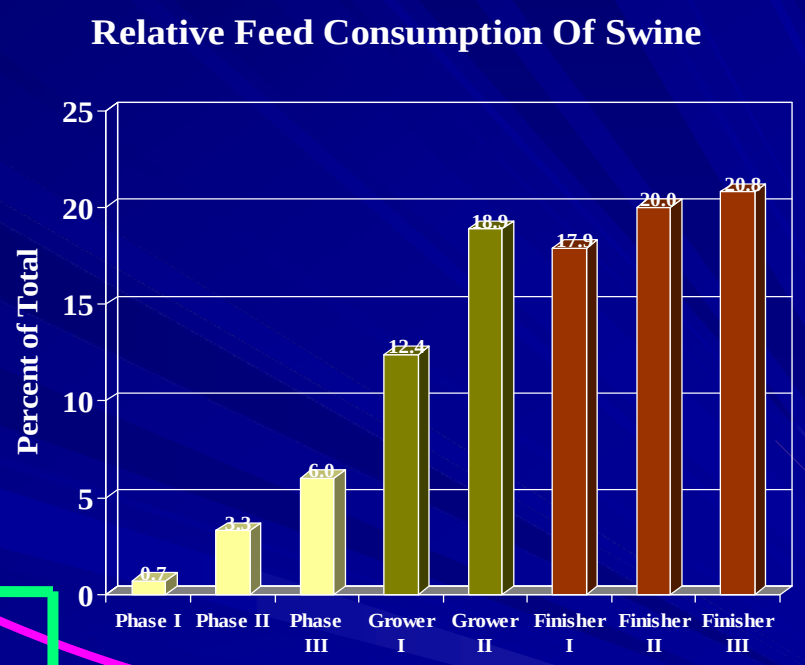
(Rapid Determination of Ingredient Profiles > NIR [variability, digestibility, availability])
(Rapid Determination of "Nutritional" Requirements > Metabolic Indices [PUN])

Nutrient Requirement, %

For Which Parameter ?

- Gain
- Feed Efficiency
- Nutrient Retention
- Immune Function
- Bone Strength
- Meat Quality
- Behavior Modification





Age or Weight

Le et al., 2005 / NRR 18:3

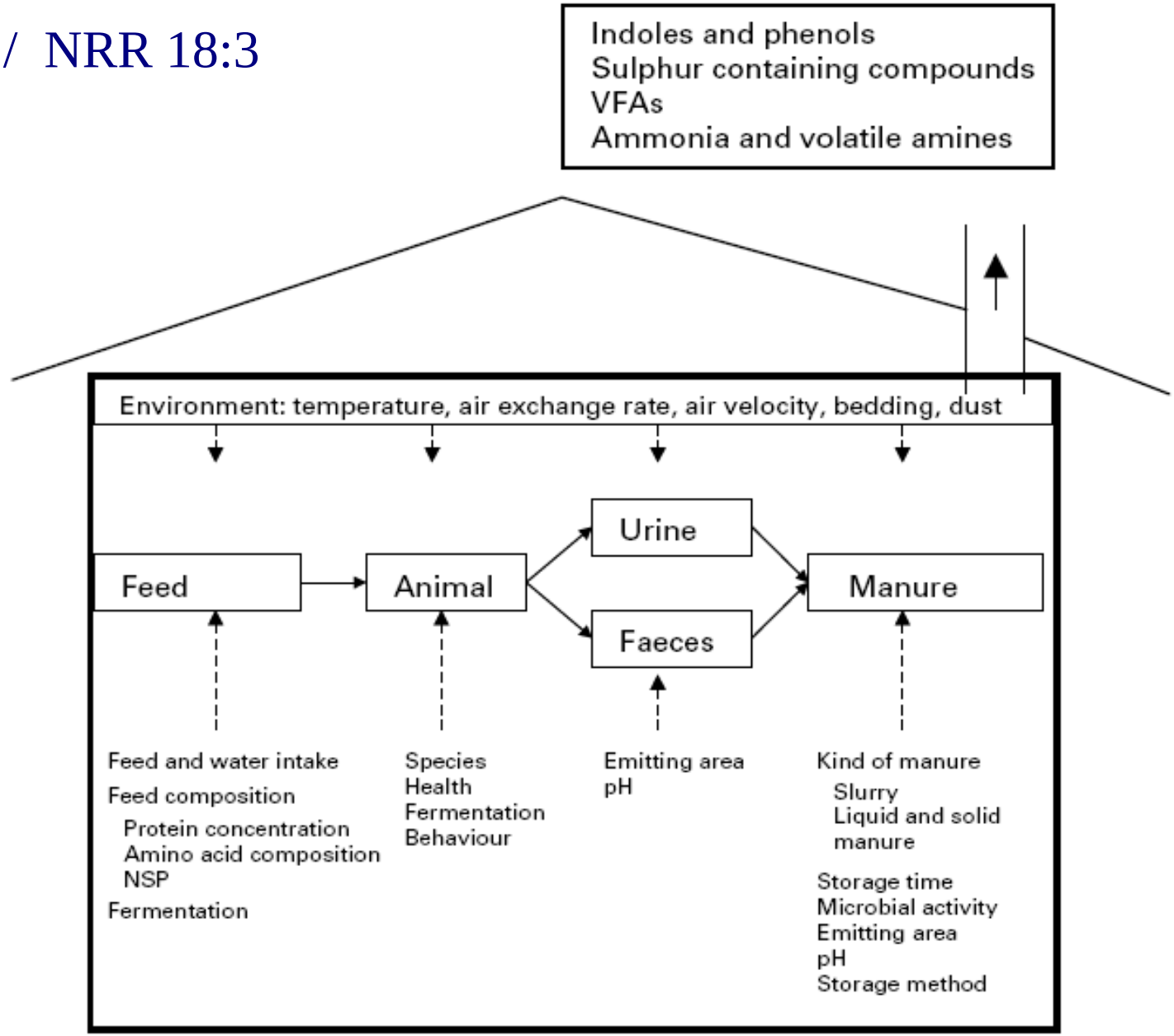


Fig. 1. Sources of odour and the factors influencing odour.

How to Measure Odor in Air?

Human Panelists
Dilution Threshold

GC-Olfactometry “Key Compounds”

Chemical Analysis
Analytical Threshold

Human Panelist

- Odor is greater than sum of its parts
- Field Olfactometer
  - Expensive
- Dynamic Dilution Olfactometry (Odor Panels)
  - Expensive
  - Produce Artifacts (Off-gassing of VOC)
  - Bias against agricultural odorants (Trabue et al. 2006)
  - Storage Stability (Choi et al. 2004; Kuster and Golan 1987)

Chemical Analysis

- **No single analytical method to quantify all odorants**
- Physical chemical properties of individual compounds
  - Range of volatility
  - Reactivity
  - Sorption to surfaces
  - Phases
- Air Matrix
  - Reactants (i.e., ozone, free radicals, etc.)
  - Temperature
  - Dust
  - Relative Humidity (water vapor)
- Sampling Equipment and Analytical Instruments
  - Inert surfaces
  - Calibration standards
  - Detection limits

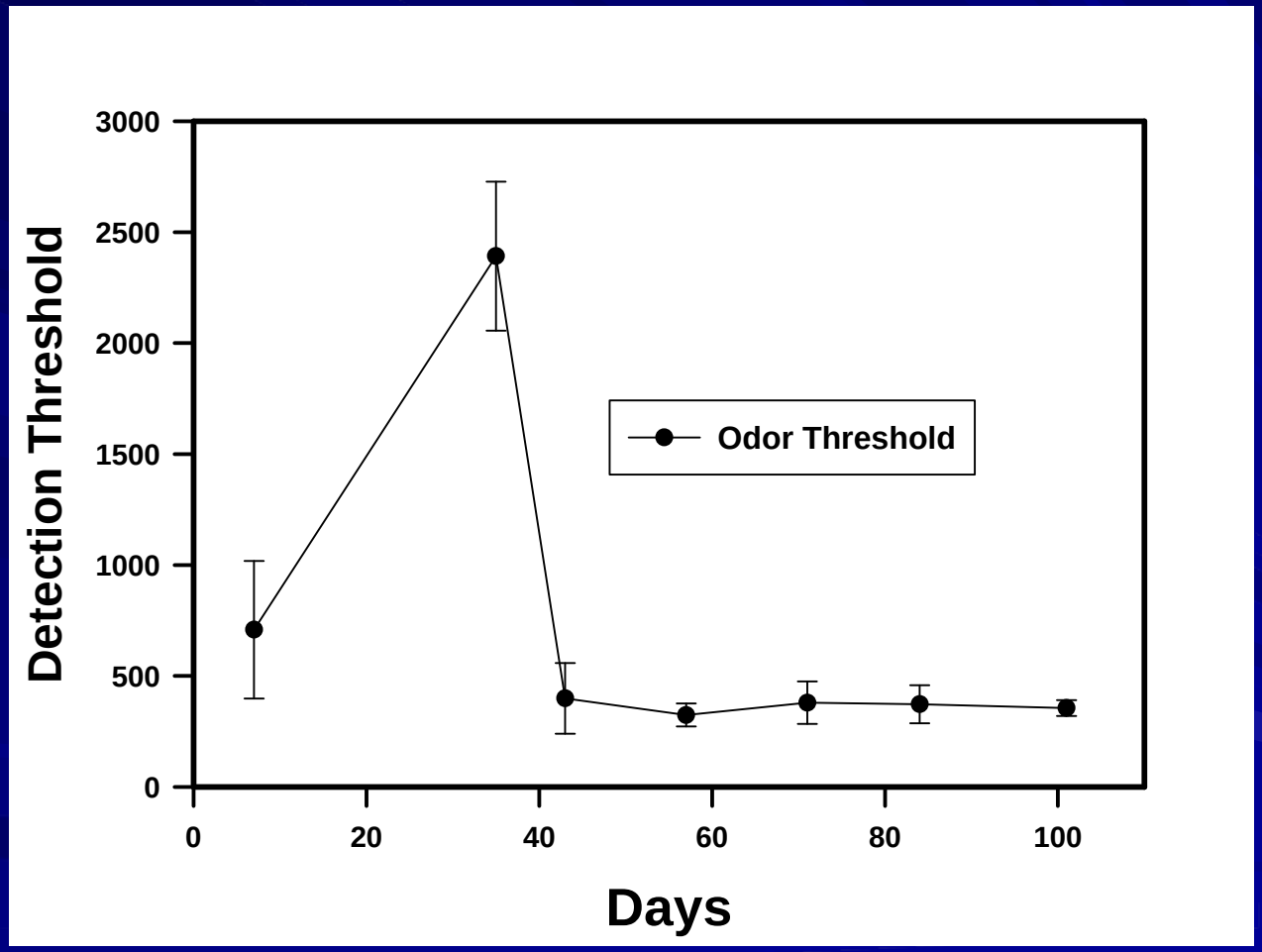
Variability

- Odor Panels
  - People
- Chemical Analysis
  - Time
  - Location

Swine Pit Simulation Study

- Monitored Odor via “Odor Panel” (ISU Olfactometry Lab)
- Monitored Odor via Chemical Analysis (VOC)

Odor Panel Variability



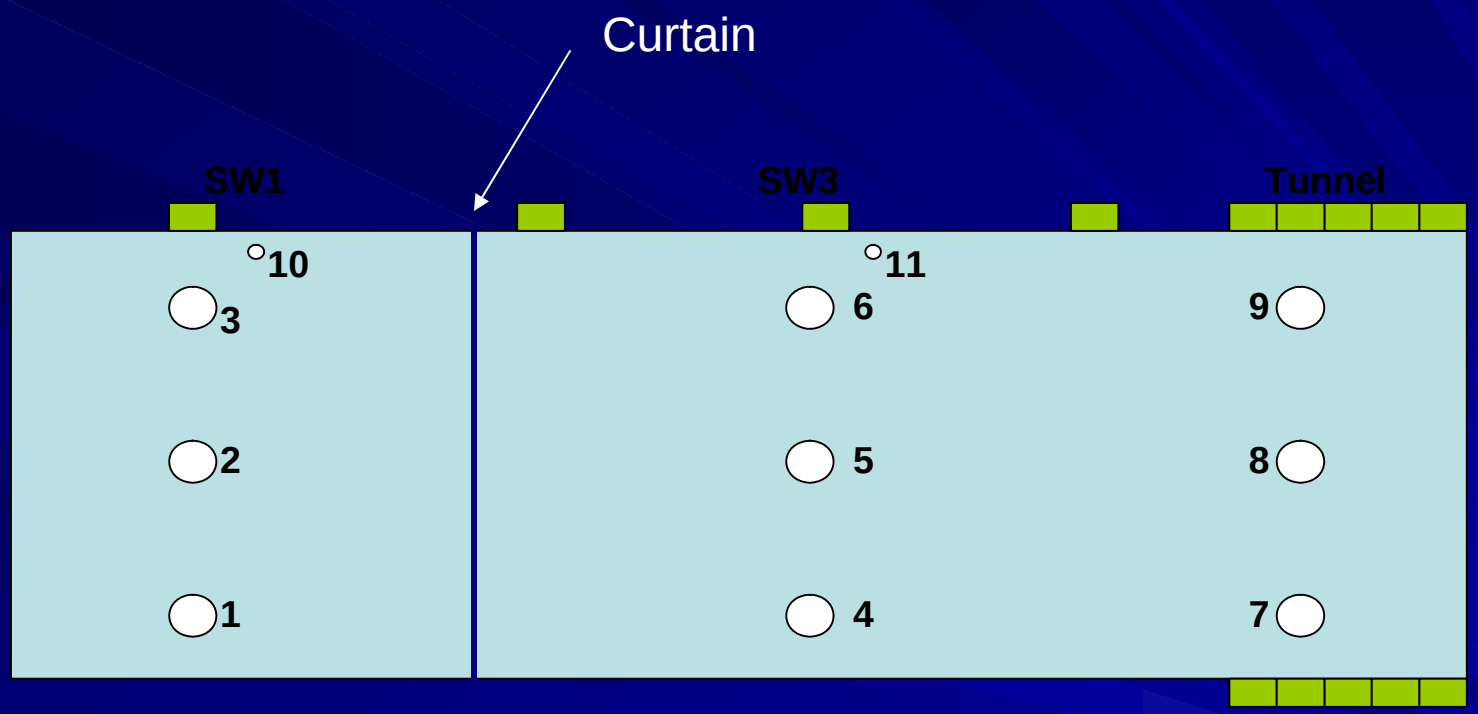
Variability in Air

- CV Measure of sample variability
- Swine Pit Simulated (CVs)
  - Volatile Fatty Acids (seven compounds)
    - Single Pit 86%; Multiple pits 134%
  - Phenols (three compounds)
    - Single Pit 50%; Multiple pits 78%
  - Indoles (two compounds)
    - Single Pit 52%; Multiple pits 76%

Poultry Facility Emissions

- Monitor VOC emission from poultry facility
  - Canisters
  - Sorbent tubes

Production Facility



Commercial broiler house. 43 x 510 ft.
Ventilation: 1) sidewall fans (four, 0.9-m d); or 2) tunnel fans (10, 1.2-m d).
Rice hull was used as the bedding material with caked litter being removed
The litter was allowed to accumulated 2-4 flocks of production.

Variability in Air

- Poultry Facility CVs
  - Canisters (Top 10 VOCs)
    Building 83%; Section 57%; Location 67%
  - Sorbent tubes (Top 10 VOCs)
    Building 170%; Section 83%; Location 61%
  - Odorants
    Building 191%; Section 114%; Location 66%