

NUTRITIONAL GUIDE TO FEEDING SORGHUM



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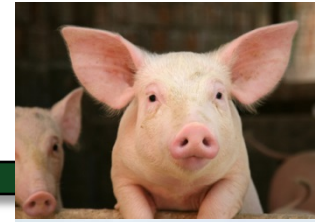
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Department of Animal, Rangeland, and Wildlife Sciences



OVERVIEW

- **Why feed U.S. Sorghum?**
- **Feeding sorghum to non-ruminants**
 - Swine
 - Broilers
 - Ducks
 - Processing considerations
- **Feeding sorghum to ruminants**
 - Beef cattle
 - Dairy cattle
 - Processing considerations
- **Forage sorghum**
- **Take Home Messages**



WHY US SORGHUM?

- **Fits well in least cost formulation of feed rations**
- **Feed acceptance**
- **Non-GMO**
 - No current GMO traits are present in sorghum
- **Mycotoxins**
 - Low incidence of occurrence, but is possible
- **Tannin levels**
 - U.S. Sorghum is considered to have low/no tannins
 - 99% of all sorghums in the U.S. do not contain tannin
- **Ancient Grain / Gluten Free / antioxidants**
 - Potential consumer preference in food items
- **Continued research and end-use development**

IN SUMMARY

Sorghum can replace corn (or other grains) in rations

- **Know the differences in nutritional value**
- **Species specific (non-ruminant / ruminant)**

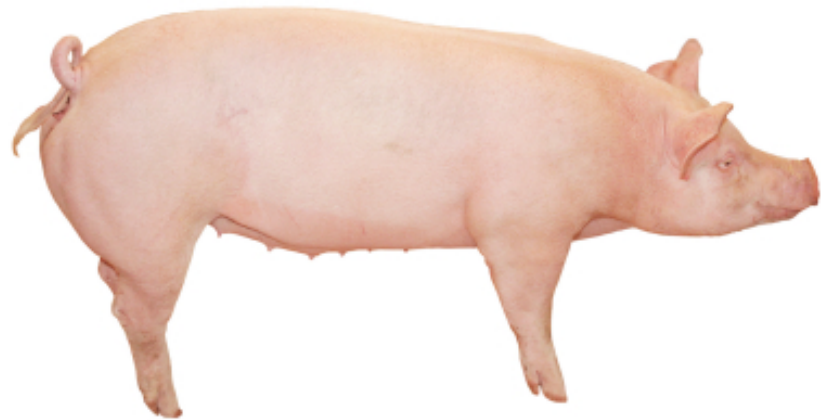
Key differences:

- **Amino acid profile / Crude protein values**
- **Fatty acid profile / Fat content**
- **Phosphorus**

Advantages to processing

- **Grinding / Heat + Pressure**

SORGHUM FOR SWINE



FEEDING SORGHUM TO SWINE

- **Sorghum is an excellent energy source**
- **Can completely replace corn or other grains in swine diets**
 - **Nursery and Finishing Pigs**
 - **Gestating and Lactating Sows**
- **Enhanced nutritional value:**
 - **Favorable digestible amino acid profile, available phosphorus content, and fatty acid profile**
- **Keys to utilization:**
 - **Slightly lower energy value**
 - **Need for proper grinding**



ADVANTAGES AND DISADVANTAGES OF FEEDING SORGHUM TO SWINE

- **Advantages:**

- Often a cheaper source of energy than corn
- Sorghum has approximately 98% the energy of corn
- Due to the slightly lower energy, feed efficiency is often poorer, but gain is similar
- Swine deposit a firmer carcass fat when fed sorghum

- **Disadvantages:**

- Can be more variable in nutrient content than corn because of growing conditions
- Fine grinding (3 to 4 mm) or rolling is needed for best utilization

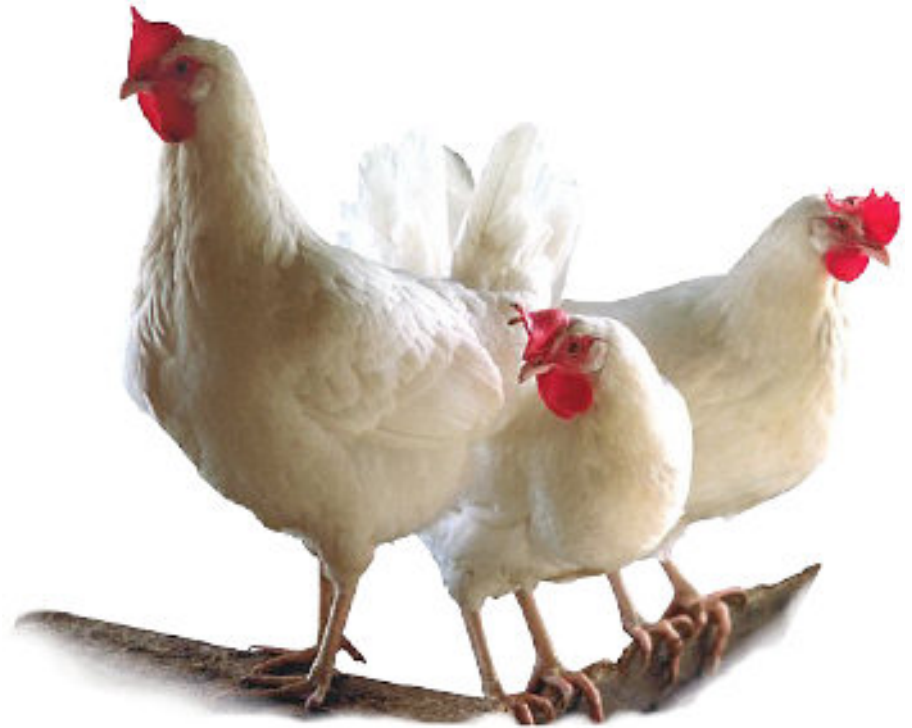
PARTICLE SIZE REDUCTION: OPTIMUM PARTICLE SIZE FOR SWINE

- **BALANCE: feed efficiency, processing cost, incidence of gastric ulcers & potential for bridging**
- **GOAL: Optimize both pig performance and milling efficiency**
- **Large swine operations in the U.S. grind to 650 μm**
- **Ideal range is 450-650 μm**
- **300 μm may result in ulcers**

- **Either hammer or roller mill will work with sorghum**
 - **Hammer mill = small screen size (1/8 inch; 3.2mm)**
 - **Roller mill = 14 to 16 corrugations per inch to aid in slicing**



SORGHUM FOR POULTRY



FEEDING SORGHUM TO POULTRY

- **Sorghum can replace corn in poultry rations**
 - Sorghum can comprise 70% of broiler and layer rations
 - Sorghum can be included up to 55% in turkey rations
- **Amino acid digestibility compares favorably to corn**
 - Sorghum AA digestibility averages 95-97% of corn AA
 - Methionine and Lysine values are lower for sorghum compared to corn
 - Synthetic AA or byproducts can compliment sorghum diets
 - Sorghum contains more protein than corn, which means the actual AA available for growth would be higher for sorghum compared to corn
- **Fat is slightly lower, but balances with meals/oils**

NUTRIENT COMPOSITION OF SORGHUM FOR POULTRY

	Sorghum, 8-10% Protein	Sorghum, > 10% protein	Corn
Dry matter, %	87	88	89
ME, kcal/kg	3,288	3,212	3,350
TME, kcal/kg	3,376	---	3,470
Protein, %	8.8	11.0	8.5
Ether Extract, %	2.9	2.6	3.8
Linoleic Acid, %	1.13	0.82	2.20
Crude fiber, %	2.3	2.3	2.2
Total Calcium, %	0.04	0.04	0.02
Non-phytate P, %	0.30	0.32	0.28
Phosphorus, %	---	---	0.08

Proximate analysis indicates similarities between corn and sorghum

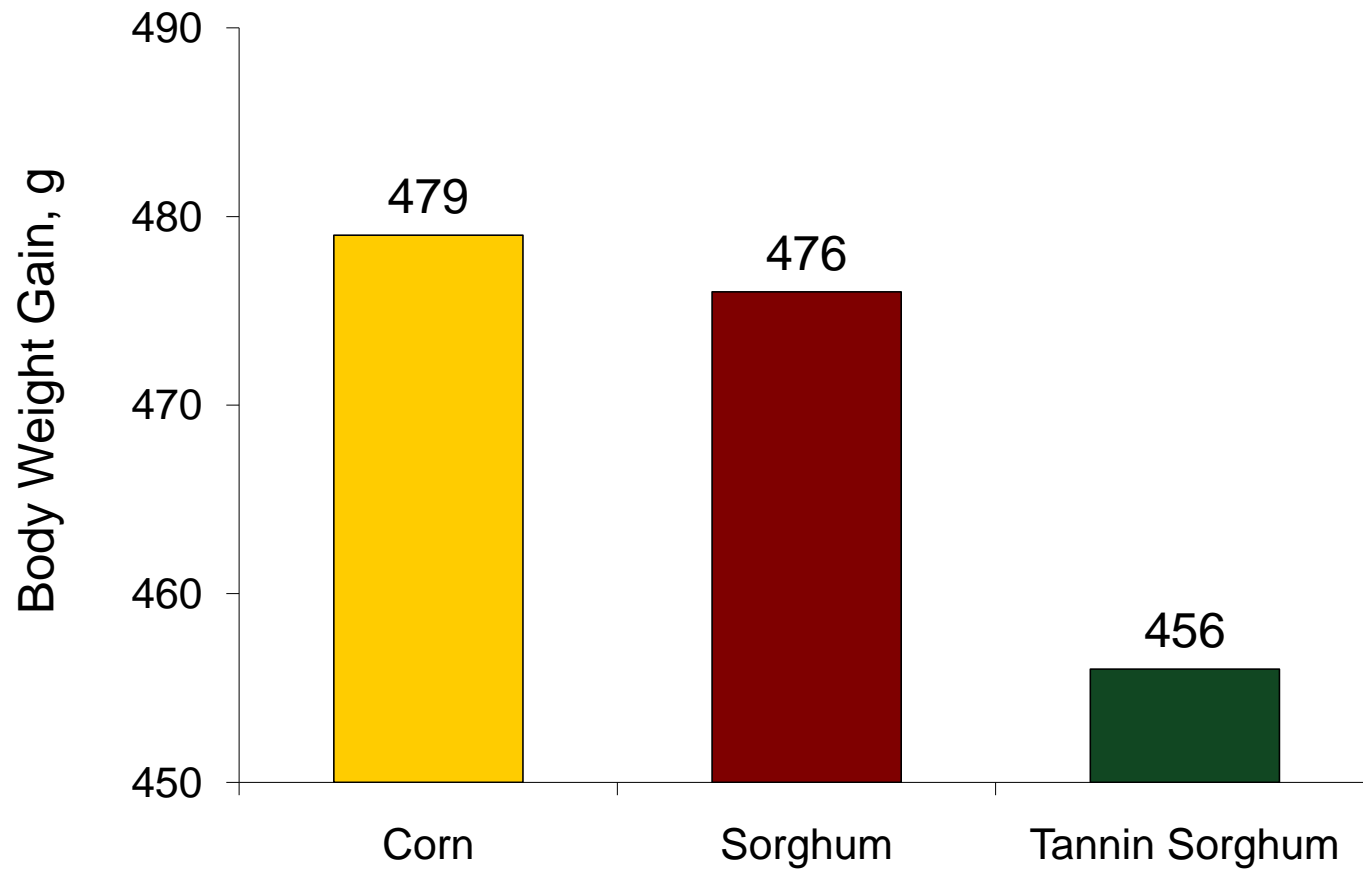
- Sorghum has reduced oil resulting in slightly less energy value
- Sorghum has more protein
- Sorghum has slightly more non-phytate phosphorus than corn



FEEDING SORGHUM TO POULTRY

- **Sorghum planted in the U.S. does not contain high tannin levels**
 - Data from 15 years ago undervalues sorghum
 - Reported sorghum to be 85-90% feeding value of corn due to high tannin content
- **Reduced tannins in current varieties greatly improves nutrient digestibility for poultry**
 - Low tannin varieties are grown in the U.S. to maximize the value of sorghum in animal rations

TANNIN AND GAIN IN BROILER CHICKS



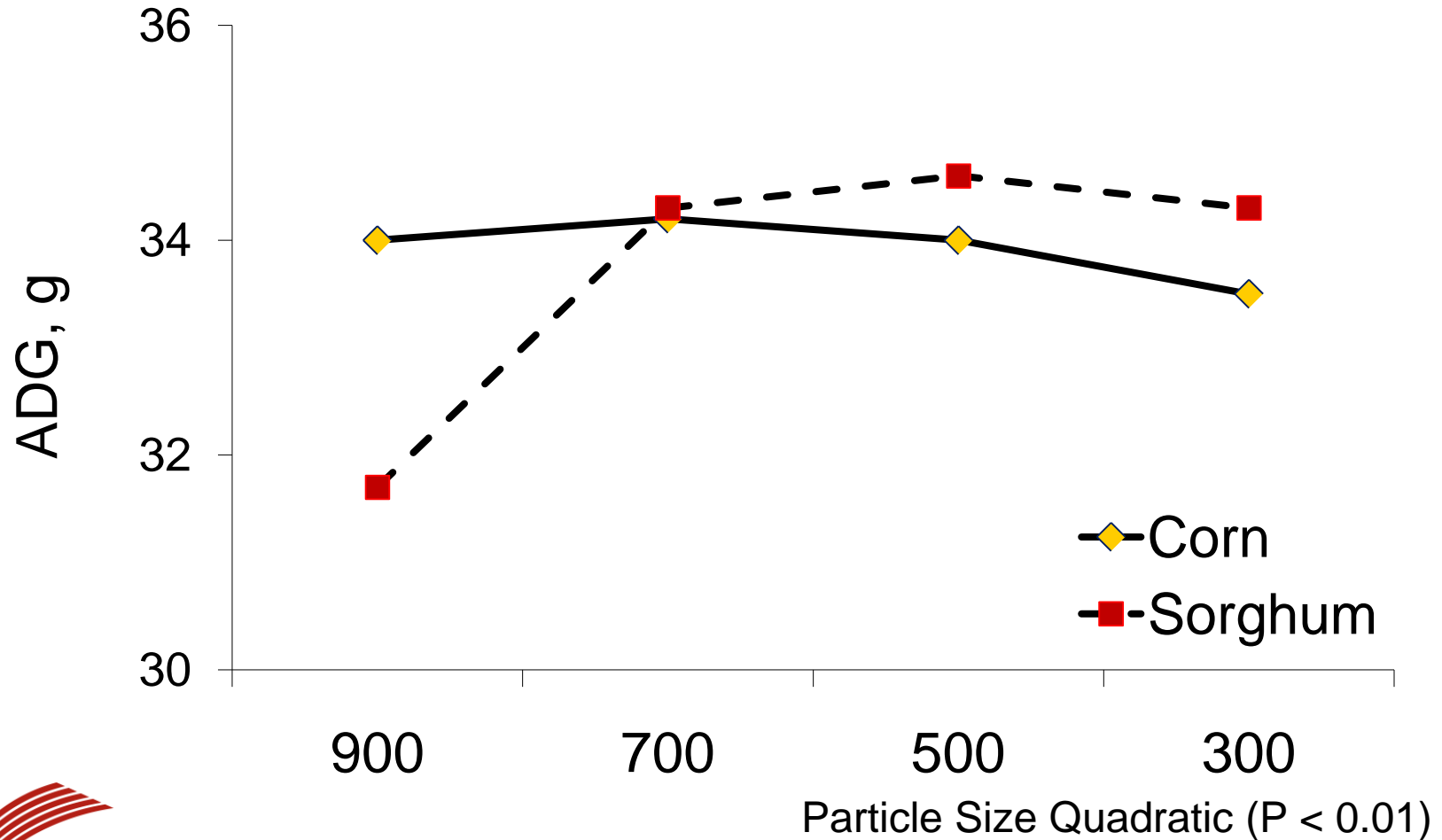
Sorghum vs Tannin Sorghum ($P < 0.10$)

FEEDING SORGHUM TO POULTRY

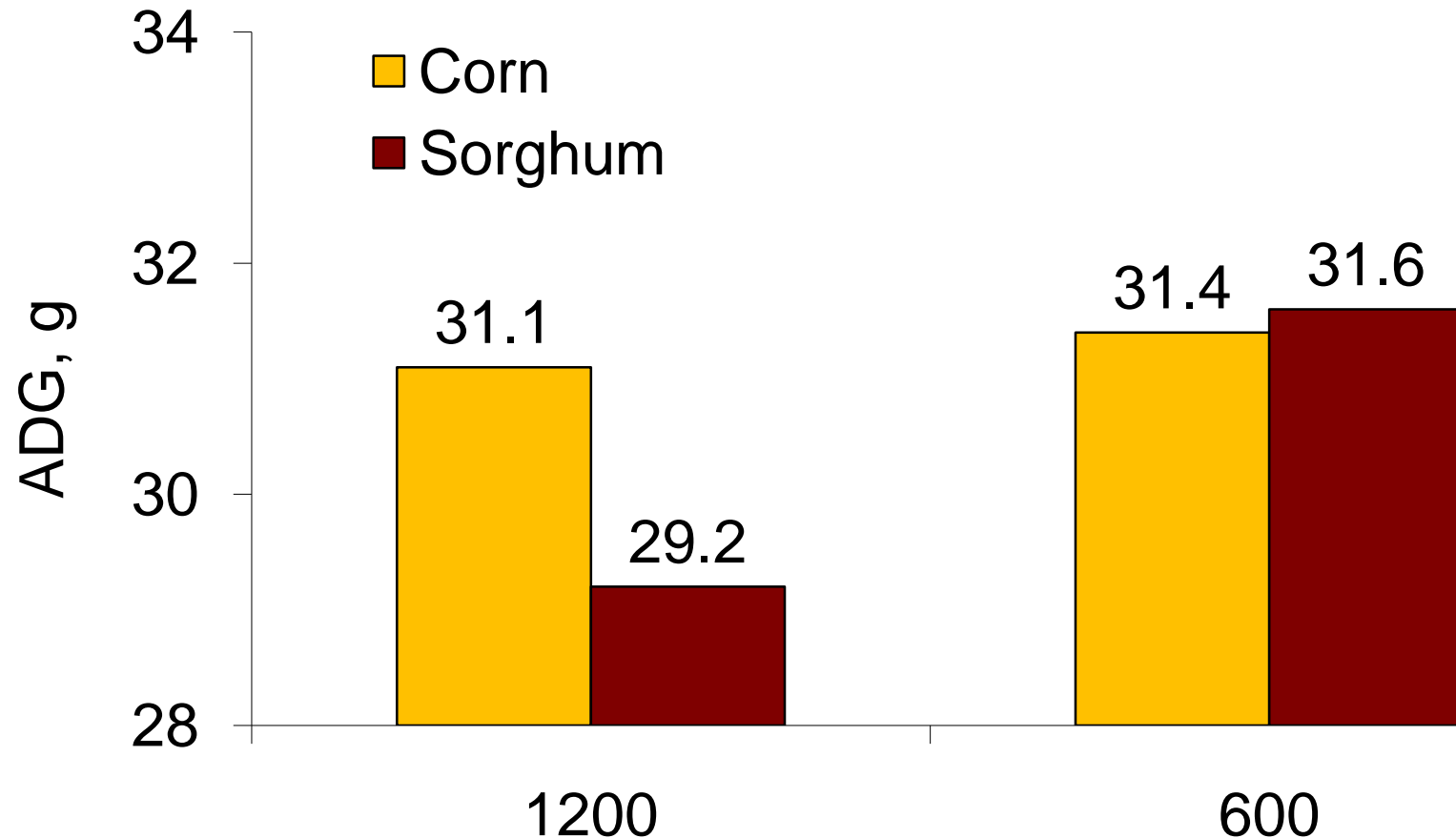
Other considerations:

- **Enzyme additives can increase amino acid digestibility and ME of sorghum diets**
- **Pelleted rations are common in the U.S.**
 - **Sorghum can be difficult to pellet**
- **Unprocessed sorghum can be included in rations**
- **Grinding can increase feeding value**

PARTICLE SIZE OF CORN AND SORGHUM EFFECT ON ADG IN BROILERS



GRAIN SOURCE AND PARTICLE SIZE EFFECT ON ADG IN BROILERS



Grain x Particle size (P < 0.04)

Grain (P < 0.06) & Particle size (P < 0.01)

FEEDING SORGHUM TO DUCKS



- **Differences in nutrient metabolism do exist between ducks and chickens**
- **Consequently, nutrient utilization and bioavailability from one species cannot be confidently applied to another**
- **Studies feeding ducks have compared corn to other grain sources, including sorghum**
- **Most have used a high-tannin sorghum**
- **(Bagliacca et al., 1997; Ragland et al., 1997; Elkin and Rogler, 1991)**
- **Creates a challenge for poultry nutritionists based on the sparse amount of information available specifically for ducks**



NUTRIENT METABOLISM AND ME_N DETERMINATION OF GRAINS FOR DUCKS

	Corn	Sorghum
N retained (apparent), g/54 h	0.094	0.381
N retained (true), g/54 h	0.555	0.842
AME, kcal/g	3.164	3.312
AME _n , kcal/g	3.151	3.260
TME, kcal/g	3.535	3.682
TME _n , kcal/g	3.459	3.567
Apparent DM utilization, %	78.05	77.11

Grain sorghum can be used in duck diets

- Protein retention and energy availability were not different between grains
- Sorghum protein retention numerically exceeded that of corn
- Energy availability of sorghum numerically exceeded that of corn

- There is a need for additional research on duck nutrient metabolism



SORGHUM FOR CATTLE



NUTRIENT COMPOSITION FOR RUMINANTS

	Grain	Beef NRC	Dairy NRC	Dairy One
CP, %	Sorghum	12.60	11.60	10.53
	Corn	9.80	9.40	9.20
ADF, %	Sorghum	6.38	5.90	7.90
	Corn	3.30	3.40	3.63
NE _m , Mcal/kg	Sorghum	2.01	1.94	2.11
	Corn	2.25	2.05	2.20
NE _g , Mcal/kg	Sorghum	1.34	1.30	1.43
	Corn	1.54	1.39	1.52
NE _l , Mcal/kg	Sorghum	---	1.80	2.00
	Corn	---	1.92	2.07
Ash, %	Sorghum	1.87	2.00	1.92
	Corn	1.46	1.50	1.55

Beef NRC, 1996; Dairy NRC, 2001; Dairy One, 2010



SORGHUM IN THE U.S. FEEDLOT INDUSTRY

Cereal grains are the most common energy source

- Comprise up to 95% of total diet

Item	Corn	Milo	Barley	Oats	Wheat
ADG, kg	1.43	1.39	1.42	1.50	1.38
DMI, kg	8.93 ^b	9.43 ^a	8.77 ^b	9.15 ^{ab}	8.65 ^b
Feed:Gain	6.32 ^b	6.88 ^a	6.24 ^b	6.12 ^{ab}	6.34 ^b

Owens et al., 1997; ^{a,b} ($P < 0.05$)

Compared to corn, milo

- Had similar ADG
- Processing ↓ DMI



PROCESSING SORGHUM

Milo must be processed for ruminant diets

Options include:

- Dry rolling
- Steam flaking
- Roasting



Primary reason to steam or roast:

1. Disrupt the protein matrix encapsulating starch
2. Damage starch granules that are compacted

PROCESSING SORGHUM

Mechanics of flaking:

- Hydrate starch with moist heat to create irreversible swelling (gelatinization) of granules
- Compress starch between rolls to rupture granules and shear the protein matrix

Heat + Moisture + Pressure = ↑ Starch Availability
Implemented alone = less impact on starch



PROCESSING SORGHUM BY METHOD

Compared to dry rolling sorghum, steam flaking:

- **ADG is similar**
- **DMI is reduced**
- **Resulting in a 15% increase in feeding efficiency**

Process	ADG, kg	DMI, kg/d	F:G	ME, Mcal/kg
Dry Rolled	1.43	10.47 ^a	7.43 ^a	2.94 ^a
Steam Flaked	1.40	8.68 ^b	6.33 ^b	3.56 ^b

Owens et al., 1997; ^{a,b} (P < 0.05)



DIGESTIBILITY OF STARCH IN SORGHUM

The added growth performance and feeding efficiency is due to the increase in starch digestion

Process	Rumen, % Intake	Post-rumen, % Entering	Total Tract, % Digestibility
Dry Rolled	60 +/- 12	62 +/- 11	87 +/- 5
Steam Flaked	78	90	98

Huntington, 1997

- The added rumen availability of starch increases microbial synthesis resulting in more bacterial protein available to the small intestine**

DIGESTIBILITY OF STARCH

Flake density is an important metric:

- **Medium thickness is ideal = 23 to 26 lb**
- **Thinner flakes cause acidosis (< 23 lb)**
- **Thicker flakes reduce starch availability (> 26 lb)**

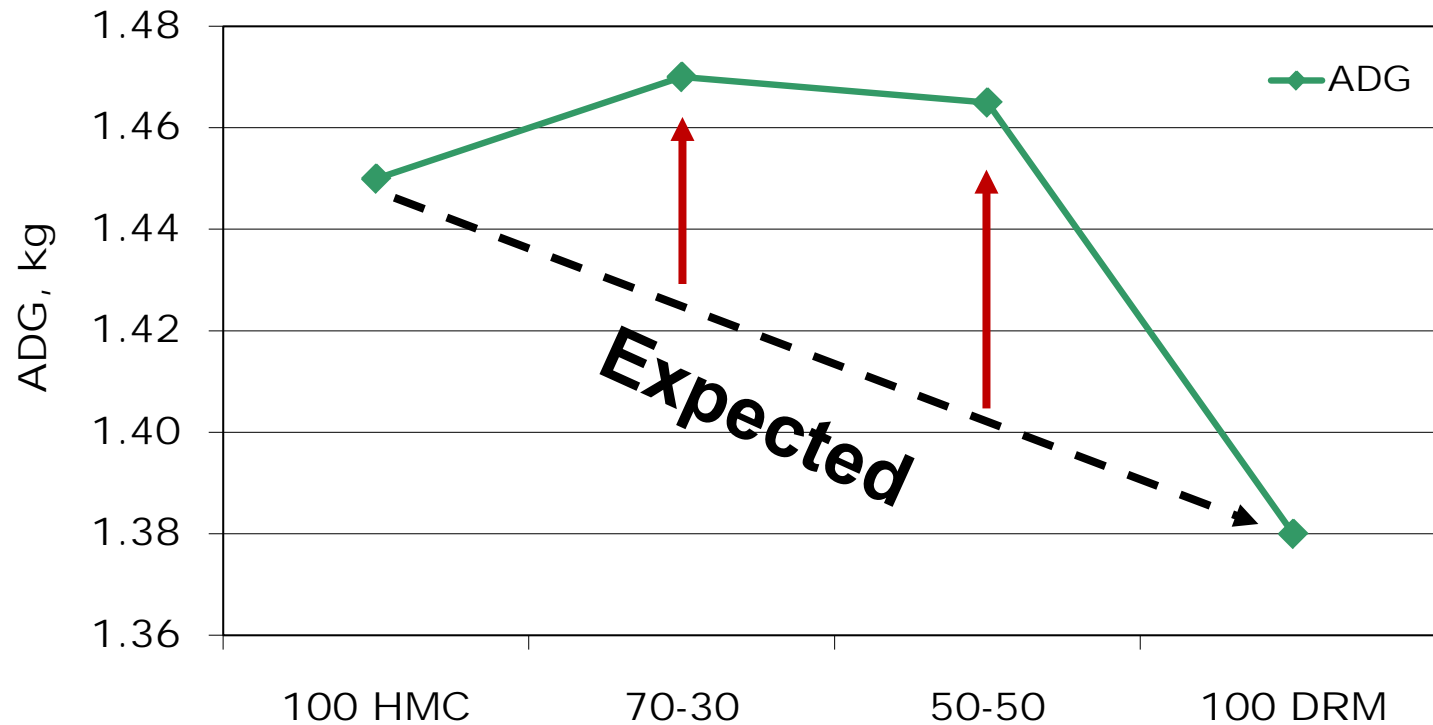
Monitor starch availability by fecal starch content.

- **2 – 4% = maximized digestibility**
- **4 – 6% = ↑ bypass and ↓ digestibility**

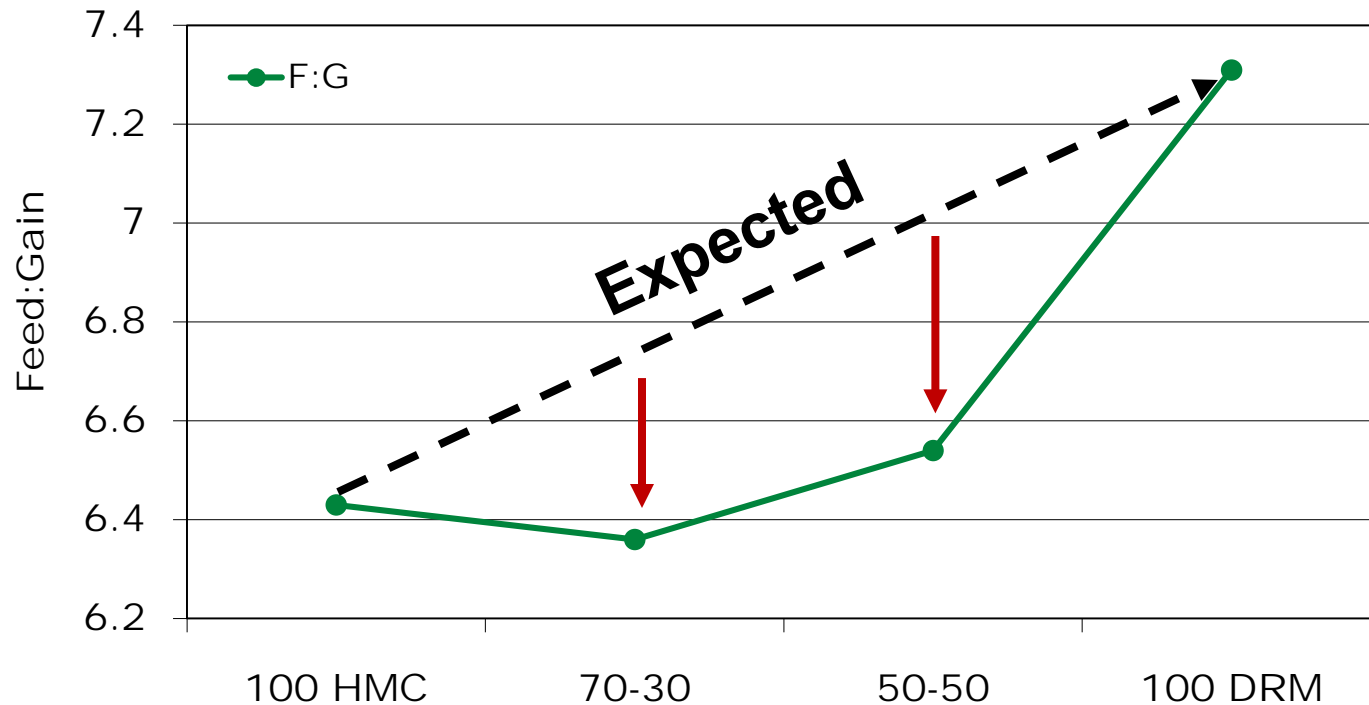
Positive ‘associative effects’

- **Can be paired with highly fermentable grains**

BLENDING DRY ROLLED MILO WITH HIGH MOISTURE CORN IN FINISHING DIETS



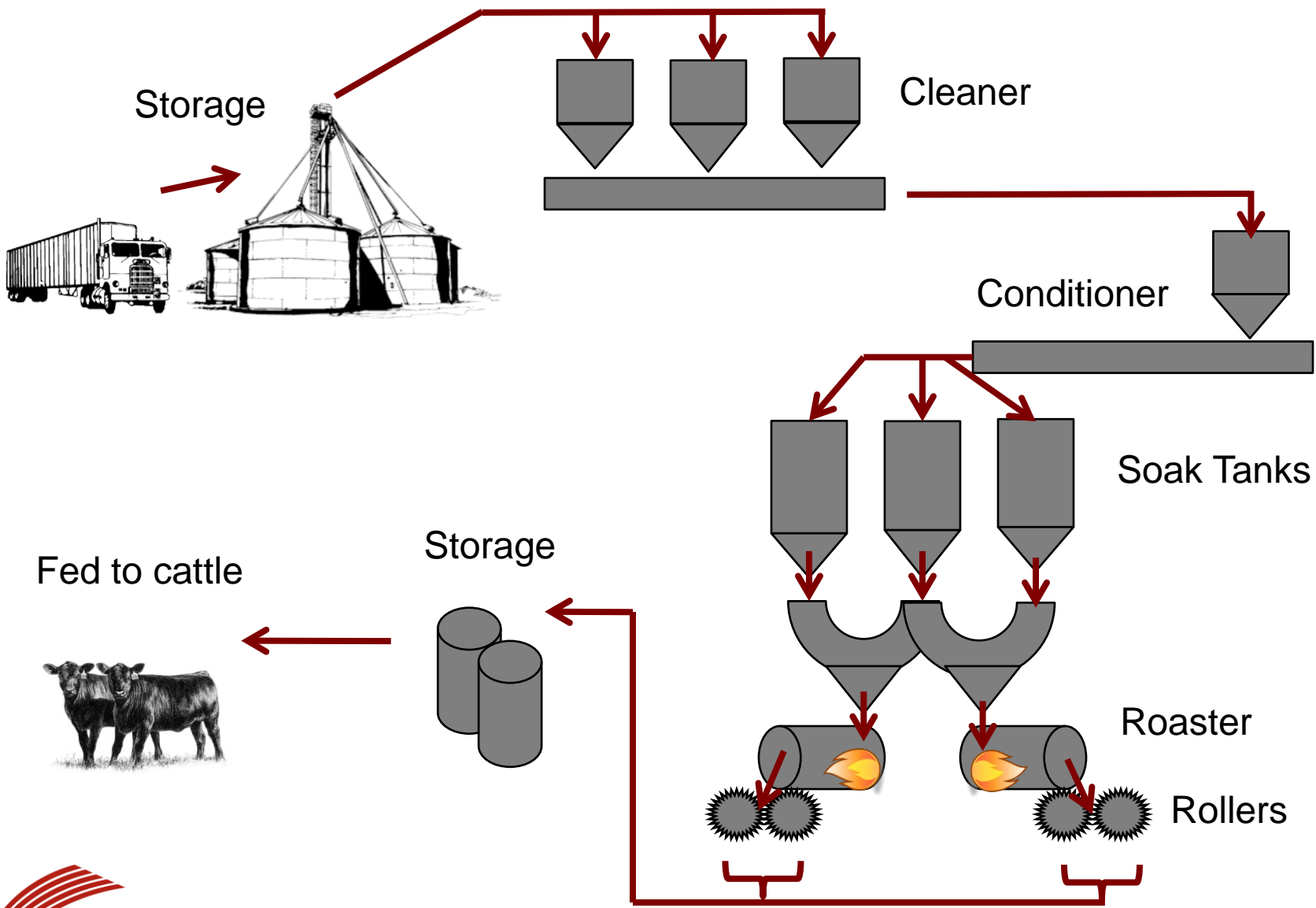
BLENDING DRY ROLLED MILO WITH HIGH MOISTURE CORN IN FINISHING DIETS



PROCESSING OPTIONS



Milo Roasting Process



ROASTING THE MILO

Design includes:

- Roasting drum at a decline
- Milo free falls through spinning drum
- Milo goes through a gas flame
- Temperature is 330-360°F

Moisture + heat = milo to swell

Goal is to swell, not pop



ROLLING THE MILO

Design includes:

- 2 rollers 2-3 mm apart
- Spring action in the rolls
- Flattens milo, but expands after rolling

Goal is a 24 lb/bu

- Flake check
- Adjust to maintain 24 lb/bu
- Must maintain 23 to 26 lb/bu
- Moisture is 9-10%



ROASTING VS FLAKING MILO

	Roasting	Flaking
Flake consistency	Can be variable	More consistent
Temperature	330-360°F	212°F
Cook time	0.5 – 1.0 minutes	1 – 1.5 hours
Rate	8-9 tons/hr	4-5 tons/hr
Cost	\$2/processed ton	\$7/processed ton
Starch availability	78 - 84%	72 - 78%
Feed conversion	5.2 – 5.6	5.5 – 5.8

Why not roast?

- 1 – Liability due to temperature & open flame
- 2 – Its not as 'pretty' for custom feeders

SORGHUM IN THE U.S. DAIRY INDUSTRY

Starch is the primary energy source when feeding dairy cows for high levels of milk production

- **Ruminal fermentation profiles vary based on grain**
- **Sorghum ferments slower than other grains**
- **A mixture of grains may be ideal**

Numerous studies report that sorghum can replace corn in dairy rations with no difference in: DMI, milk yield, milk fat %, and BW



PROCESSING SORGHUM FOR DAIRY CATTLE

Normal processing methods include:

- **Dry rolling, grinding, steam rolling, steam flaking and pelleting**

GOAL: increase ruminal starch digestion

- **Heat + Moisture + Pressure = ↑ Starch Availability**
- **↑ starch digestion**
- **= ↑ microbial protein production**
- **= ↑ available protein for milk production**

PROCESSING SORGHUM FOR DAIRY CATTLE

Steam-flaking of either corn or sorghum resulted in a 20% increase in NE_i as compared to dry rolled

- A review of 24 studies found steam-flaked corn and sorghum were similar in intake and lactation performance**

	SF-Sorghum	SF-Corn	P value
Dry Matter Intake, kg/d	25.9	26.1	0.82
Milk, kg/d	36.5	36.9	0.84
Protein, %	2.96	3.00	0.58
Fat, %	3.19	3.11	0.45
Total track starch digestion, %	98.6	97.9	0.86

Theurer et al., 1999

FORAGE SORGHUM

Different types and traits:

- Yield vs Quality

Different uses:

- Graze, Hay, or Silage

Different segments of the cattle industry

- Stocker cattle
- Feedlot cattle
- Dairy cattle



NUTRITIONAL CHARACTERISTICS

Type to consider:

- Target use will dictate type

Traits to consider:

- Brown midrib (BMR) – high in nutritional value
- Photoperiod Sensitive (PS) – high yielding



Characteristic	Non-BMR	BMR	PS
Yield, tons DM/ac	8.5 ^a	7.5 ^b	10.7 ^c
CP, % DM	7.3 ^a	7.9 ^b	6.0 ^c
NDF, % DM	46.6 ^a	45.5 ^a	64.4 ^b
ADF, % DM	28.0 ^a	27.0 ^a	39.4 ^b
IVTD, % DM	76.2 ^a	80.7 ^b	68.5 ^c

IN SUMMARY

Sorghum can replace corn (or other grains) in rations

- **Know the differences in nutritional value**
- **Species specific (non-ruminant / ruminant)**

Key differences:

- **Amino acid profile / Crude protein values**
- **Fatty acid profile / Fat content**
- **Phosphorus**

Advantages to processing

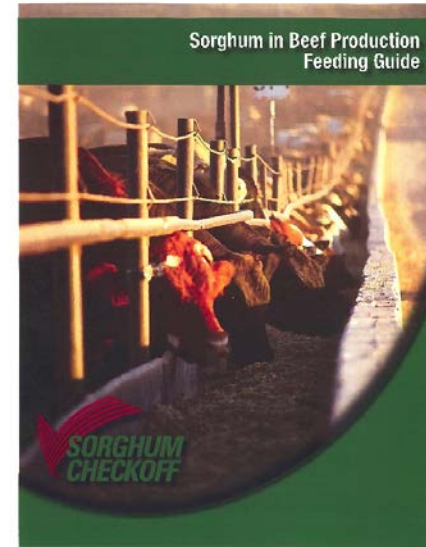
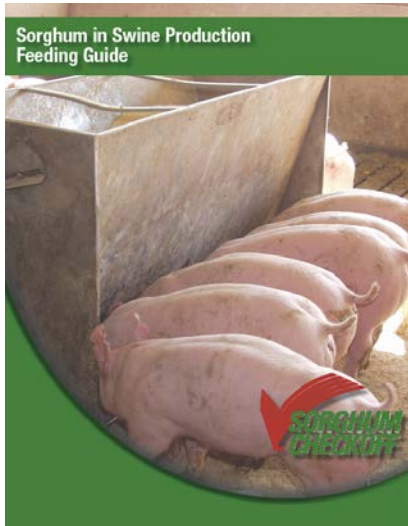
- **Grinding / Heat + Pressure**

TAKE HOME MESSAGES

- **Sorghum can replace other grains in rations**
- **Nutritionists have numerous ways to use sorghum due to processing options**
- **Process sorghum to optimize animal performance and milling efficiency**
- **Use U.S. sorghum with confidence that low tannin varieties will not affect animal performance**
- **Use current nutrient composition data**



THANK YOU!



Link to the livestock feeding guides:

<http://sorghumcheckoff.com/sorghum-markets/animal-nutrition/>



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