Sorghum Applications in the Poultry Industry

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Agenda

- **U.S. sorghum and tannins**
- **Complementary nutritional composition of sorghum and protein sources**
- **Antinutrient content in poultry diets**
- **Best formulation practices with sorghum and soybean meal**
- **Grain and diet processing**
- **Research with broilers and layers**

Sorghum

- **Cost-Effective Grain – Competitive alternative to corn in poultry diets**
- **Tannin-Free – U.S. sorghum ensures high digestibility and consistent quality**
- **Proven in Poultry – Backed by global research with broilers and layers**
- **Reliable Supply of U.S. sorghum for export**

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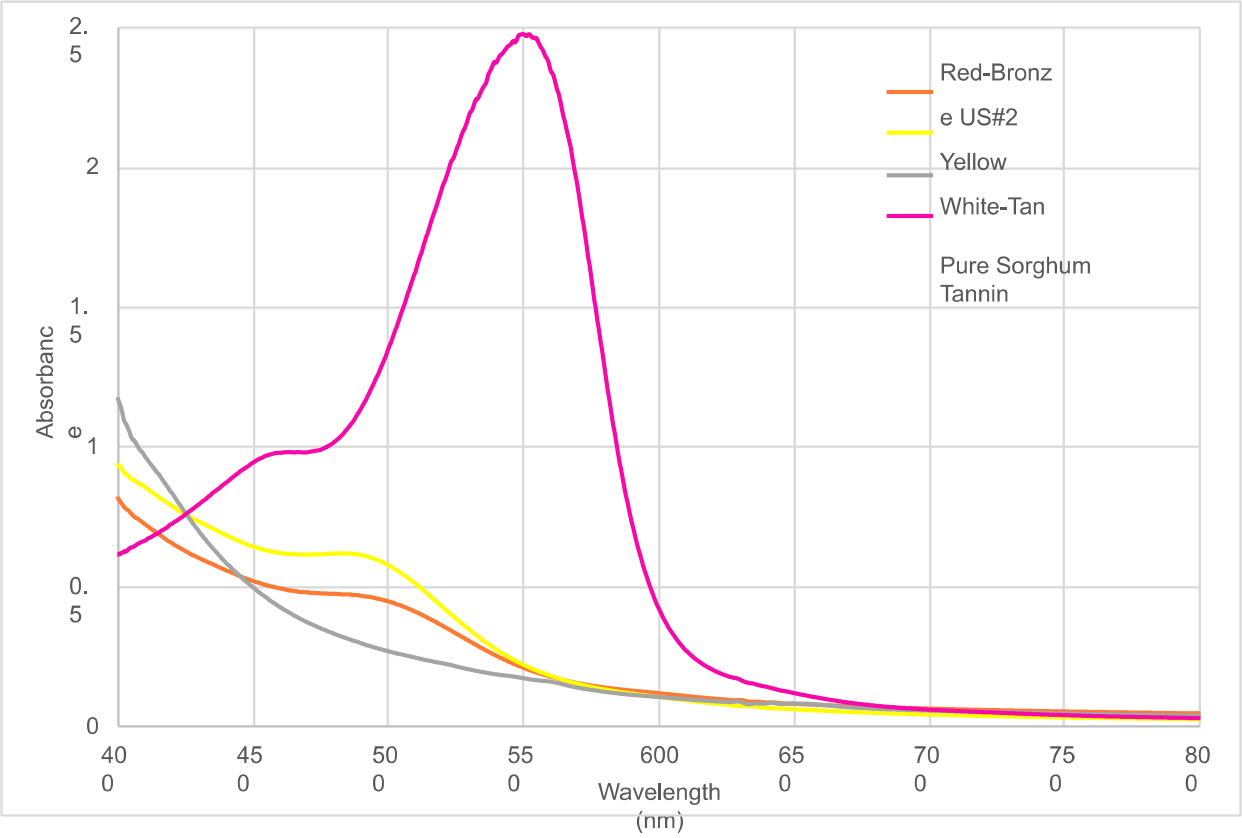
Key Fact #1:
U.S. Sorghum, tannins and non-GMO status

Virtually all sorghum (~99%) produced in the USA comes from tannin-free hybrids (Taylor, 2019).

Butanol acid test results



Butanol acid test shows that high-tannin sorghum produces a peak at 550 nm (cyanidin, pink spectrum).

None of the three sorghum grain samples showed this peak, confirming they did not contain tannins.

Some pigments absorbed light at lower wavelengths, but these were unrelated to tannins.

-Dr. Ann Hagerman

Miami University Hughes Laboratories

Table 1. Nutrient and antinutrient analyses of sources of corn and US No. 2 grain sorghum

		Sorghum		
Component[1] (as is)	**Corn**	**Texas**	**Kansas**	**Soybean meal**
DM, %	86.2	87.88	86.51	87.90
Crude fat, %	3.66	1.74	1.52	0.90
Crude fiber, %	2.21	1.57	1.39	3.80
CP, %	7.06	8.88	8.2	45.06
Phosphorus, %	0.25	0.242	0.225	0.65
Calcium, %	0.05	0.019	0.015	0.32
Methionine, %	0.15	0.23	0.18	0.54
Lysine, %	0.16	0.22	0.19	2.44
Threonine, %	0.25	0.29	0.26	1.56
Phytate, %	0.68	0.59	0.48	1.41
Estimated ME,[2] kcal/kg of DM	3,939	3,700	3,700	2,821
Tannins,[3] %	—	0.07	0.06	—

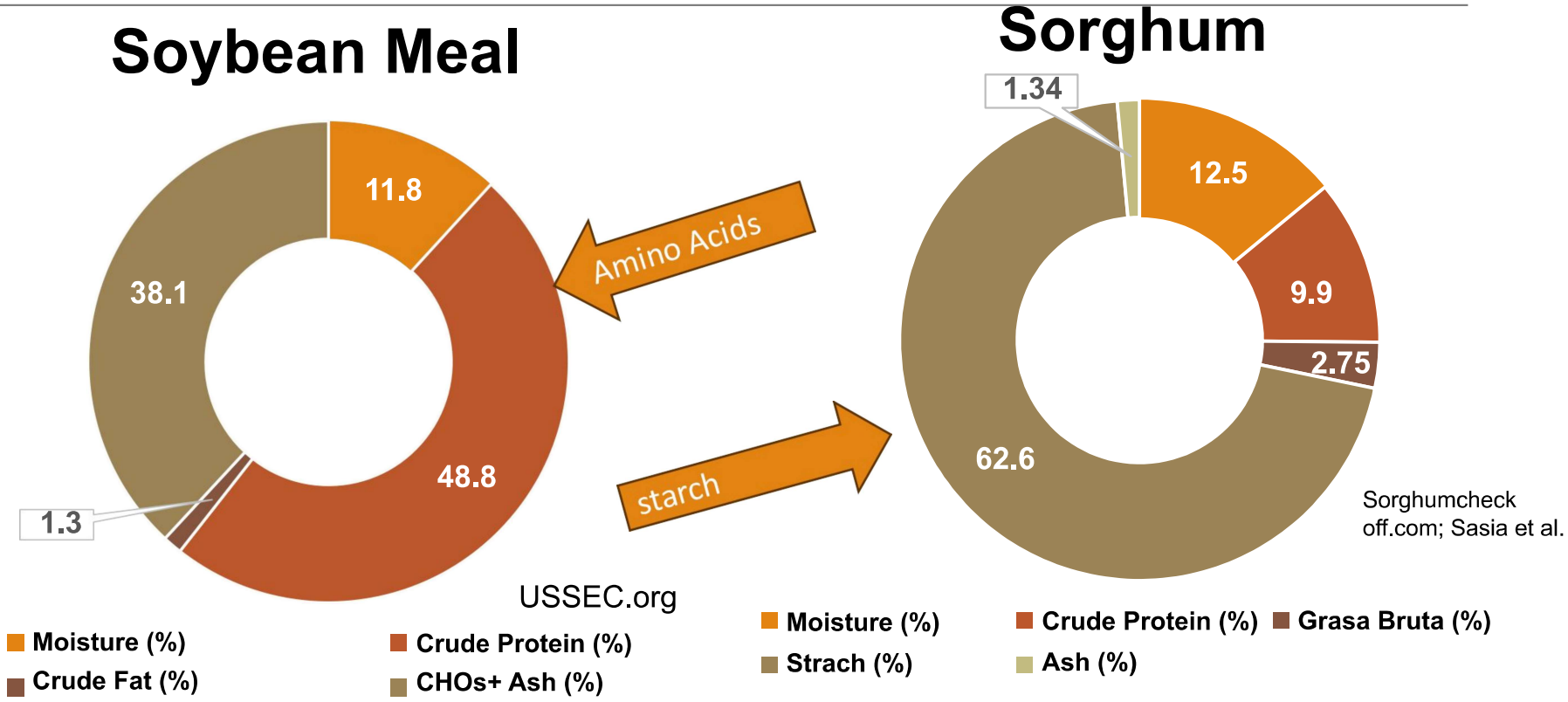
[1]Proximate analyses, AA, and phytate content were determined using AOAC official methods, and calcium and phosphorus were determined by inductively coupled plasma–mass spectrometry (University of Missouri Agricultural Experiment Station Chemical Laboratories, Columbia, MO).

[2]The ME value estimations were based on 4 previous experiments conducted by our laboratory.

[3]Tannin content was expressed in milligrams per gram of dry powder as (−)-epicatechin equivalent.

Sasia et al., 2023

Key Fact #2: Complementary Nutritional Composition with Protein Sources



Nutritional composition of sorghum and corn grain

(Sasia et al., 2025; Feedstuffs, 2016; Huang et al., 2016)

Item, %	Sorghum (89% DM)				Corn (86% DM)			
ME, kcal/kg	3310				3373			
Crude Protein	11				7.5			
Calcium	0.04				0.01			
Available Phosphorus	0.10				0.12			
Crude Fat	2				3.5			
Amino acids (total, coefficients DIAA)	AA	*Broiler*	*Layer*	*Rooster*	AA	*Broiler*	*Layer*	*Rooster*
Lysine	0.27	0.83	0.80	0.81	0.24	0.79	0.75	0.73
Methionine	0.20	0.88	0.80	0.84	0.18	0.91	0.87	0.92
Met+Cys	0.40				.36			
Threonine	0.29	0.71	0.67	0.67	0.29	0.67	0.61	0.63
Tryptophane	0.09				0.07			
Valine	0.53	0.84	0.78	0.81	0.42	0.83	0.77	0.80

Use of sorghum in poultry

- **Sorghum has good threonine, tryptophan, and valine content**
- **Use of sorghum could lead to an increase in the use of synthetic amino acids (lysine and methionine)**

Use of sorghum in poultry diets

- **Source of energy in poultry diets**
  - **It comes mostly from the high starch content (70 – 84% DM**
- **Starch ileal digestibility coefficient - 0.883**
- **Sorghum has a low glycemic index**
  - **Suggests that sorghum starch could be digested slowly or incompletely**

Use of sorghum in poultry

- **Can provide ~30% of crude diet protein**
  - **The <u>quality and concentration</u> of amino acids are of importance for the formulation of diets**

Key Fact #3:
Antinutrient content

Problem:

Feed could contain

- **Phytates (sorghum, corn SBM)**
- **Kafirin (sorghum)**
- **Some phenolic compounds (sorghum)**

Use of sorghum in poultry

- **Sorghum contains phytate**
- **In a study with 15 varieties**
  - **0.29% Total P => 83% of the P associated with phytate molecules (Selle et al., 2003)**
- **The anti-nutritional properties of phytate:**
  - **reduced energy utilization (Selle et al., 2012a; Moss et al., 2018)**
  - **reduction in the availability of P, Ca, trace minerals, proteins/amino acids**

Key Fact #3:
Antinutrient content

Problem:

Feed could contain

- Phytates (sorghum, corn SBM)
- Kafirin (sorghum)
- Some phenolic compounds (sorghum)

May affect the digestibility of starch, minerals, and other nutrients

Solution:

Enzymes

- Phytases
- Proteases
- Carbohydrases

Key Fact #4:

Good Poultry Feed Formulation Practices

- **Formulate using values of analyzed samples (e.g. chemical, NIR)**
- **Formulate based on digestible amino acids, using the ideal protein concept**
- **The concentration of N in the feces is reduced, benefiting the environment**

Key Fact #5:
Grain and diet processing

- **Sorghum can replace 100% of the corn or wheat in diets**
- **Factors that affect nutrient digestibility:**
  - **Method of grinding**
  - **Pelleting - temperature, humidity and pressure**
- **Use pelleting temperatures as low as possible without compromising the quality of the pellet**

Key Fact #5:

Grain and diet processing (cont.)

- **Optimal particle size**
  - **500 and 600 µm**
- **Depending on the type of sorghum, the age of the birds and the production costs/energy of the mill (Douglas et al., 1990; Parsons et al., 2006; Selle et al., 2016)**
- **A lot of research is still needed in this area.**

Recent Research

Effect of dietary inclusion of U.S. sorghum with or without phytase superdoses on broiler productive performance (Sasia et al., 2023)

- **Objective: To study the influence of replacing corn with U.S. sorghum with or without phytase superdoses on broiler performance**
- **1500 Ross 708 males (10 cages/treatment; 50 birds/cage)**
- **Treatments**
  - **Corn + 550 FTU/kg**
  - **Sorghum US #2 + 550 FTU/kg – (US#2)**
  - **Sorghum US #2 + 2000 FTU/kg – (US#2-SD)**
- **Feeding Program: Start (Crumble), Grower (Pellet), Finisher (Pellet)**

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Sasia et al., 2023

Ingredient Composition per feeding phase

Ingredient, %	Starter			Grower			Finisher		
	Corn	US#2	US#2-SD	Corn	US#2	US#2-SD	Corn	US#2	US#2-SD
Corn	53.53	----	----	58.98	----	----	61.07	----	----
Sorghum, US#2	----	54.35	54.29	----	59.97	59.91	----	61.40	61.35
Soybean meal	42.30	39.74	39.75	34.28	31.41	31.42	31.57	29.48	29.49
Dical. Phos.	1.82	1.86	1.86	1.00	1.04	1.04	0.85	0.89	0.89
Ca Carbonate	0.61	0.65	0.65	0.83	0.88	0.88	0.78	0.82	0.82
Salt (NaCl)	0.51	0.52	0.52	0.52	0.53	0.53	0.52	0.53	0.53
Vegetable oil	0.05	1.47	1.49	2.52	4.07	4.09	3.79	5.42	5.44
L-Lysine	0.33	0.37	0.37	0.41	0.45	0.45	0.35	0.37	0.37
DL-Methionine	0.34	0.35	0.35	0.39	0.40	0.40	0.34	0.34	0.34
L-Threonine	0.18	0.21	0.21	0.19	0.22	0.22	0.15	0.17	0.17
Choline Chloride	0.11	0.11	0.11	0.36	0.36	0.36	0.34	0.34	0.34
Pmx minerals	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Pmx vitamins	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Amprol	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
BMD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Phytase	0.01	0.01	0.04	0.01	0.01	0.04	0.01	0.01	0.04

Calculated nutritional composition

Calculated Composition			Starter			Grower			Finisher	
	Unit	Maíz	US#2	US#2-SD	Maíz	US#2	US#2-SD	Maíz	US#2	US#2-SD
ME	kcal/kg	2910	2910	2910	3120	3120	3120	3230	3230	3230
Dry Matter	%	87.46	88.18	88.18	87.63	88.42	88.42	87.66	88.46	88.47
Crude Protein	%	24.00	24.00	24.00	20.95	20.95	20.95	19.50	19.50	19.50
Crude Fat	%	2.39	2.71	2.72	4.96	5.29	5.31	6.28	6.63	6.65
Calcium	%	0.80	0.80	0.80	0.68	0.68	0.68	0.62	0.62	0.62
Phos. Available	%	0.43	0.43	0.43	0.27	0.27	0.27	0.24	0.24	0.24
Sodium	%	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Dig. Lysine	%	1.26	1.26	1.26	1.15	1.15	1.15	1.05	1.05	1.05
Dig. Threonine	%	0.86	0.86	0.86	0.77	0.77	0.77	0.70	0.70	0.70
Dig. Met+Cys	%	0.88	0.88	0.88	0.87	0.87	0.87	0.80	0.80	0.80

Effect of the inclusion of US sorghum with or without phytase superdose (SD) on broiler body weight

No significant differences in body weight were observed.

	Age					
Treatment	0-7	0-14	0-21	0-28	0-35	0-42
	kg					
Corn	0.112	0.346^{y}	0.767^{y}	1.374	1.995	2.658
US #2	0.114	0.357^{xy}	0.785^{xy}	1.373	2.002	2.665
US #2 + SD	0.119	0.368^{x}	0.799^{x}	1.403	2.010	2.658
SEM	0.003	0.063	0.009	0.016	0.023	0.027
	P-value					
Diet	NS	0.06	0.07	NS	NS	NS

Table. Effect of the inclusion of U.S. sorghum with or without phytase superdose (SD) on broiler weight gain, feed intake, and feed conversion

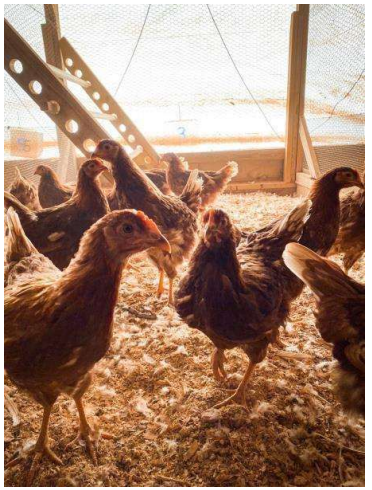
No significant differences were observed in body weight gain, feed intake, or feed conversion at the end of the experiment.

Treatment	Body Weight Gain						Feed Intake						Adjusted Feed Conversion Ratio					
	0-7	0-14	0-21	0-28	0-35	0-42	0-7	0-14	0-21	0-28	0-35	0-42	0-7	0-14	0-21	0-28	0-35	0-42
	kg						kg						kg:kg					
Corn	0.112	0.346^{y}	0.767^{y}	1.374	1.995	2.658	0.129	0.440	1.007	1.833	3.330	5.119	1.155	1.273^{x}	1.313^{a}	1.324^{a}	1.643	1.825
US #2	0.114	0.357^{xy}	0.785^{xy}	1.373	2.002	2.665	0.134	0.449	1.025	1.815	3.290	5.218	1.172	1.254^{xy}	1.305^{a}	1.320^{a}	1.630	1.822
US #2 + SD	0.119	0.368^{x}	0.799^{x}	1.403	2.010	2.658	0.133	0.452	1.032	1.844	3.331	5.189	1.123	1.230^{y}	1.284^{b}	1.301^{b}	1.636	1.836
SEM	0.003	0.063	0.009	0.016	0.023	0.027	0.003	0.006	0.010	0.017	0.029	0.075	0.021	0.012	0.006	0.005	0.008	0.010
	P-value																	
Diet	NS	0.06	0.07	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.055	0.01	0.013	NS	NS

Effect of dietary inclusion of US sorghum varieties on the productive performance of brown pullets

(Sasia, Johnson, Anderson, Arguelles-Ramos, Ali)

- **Objective: To study the influence of partial corn replacement by U.S. sorghum on the growth of brown pullets**
- **840 Hy-line Brown (10 cages/treatment; 28 birds/cage)**
- **Treatments**
  - **Corn**
  - **Corn: Sorghum US #2 (US#2)**
  - **Corn: High Protein Sorghum (HPS)**
- **Feeding Program: Starter 1 & 2, Grower, Pre-Lay, Pre-Peak, Peak Laying**
- **Measurements: Daily Feed Intake (ADFI), Body Weight (BW), Daily Weight Gain (ADG), Uniformity**



GROWER DIETS			
	Corn	US#2	HPS
Ingredient Name		%	
CORN	61.58	31.38	32.20
SORGHUM	0	31.38	32.20
SOYBEAN MEAL 45%	21.97	19.94	17.85
WHEAT MIDDS	12.40	12.55	13.36
MONO-DICAL PHOS.	1.39	1.41	1.37
CALCIUM CARBONATE	1.36	1.37	1.43
FAT, VEGETABLE	0	0.51	0
SALT, PLAIN (NaCl)	0.45	0.45	0.45
Choline Chloride 60%	0.40	0.40	0.40
DL-METHIONINE	0.19	0.20	0.21
MINERAL/VITAMIN PMX W/PHYTASE	0.15	0.15	0.15
L-Threonine	0.05	0.07	0.08
L-LYSINE	0.05	0.12	0.17
ARGININE - CJ BIO	0	0.05	0.09
TRYPTOPHAN - CJ BIO	0	0.02	0.02
ISOLEUCINE - CJ BIO	0	0	0.01
VALINE - CJ BIO	0	0	0.01

PEAK DIETS			
	Corn	US#2	HPS
Ingredient Name		%	
CORN	55.03	26.62	26.43
SORGHUM	0	26.62	26.43
SOYBEAN MEAL 45%	28.11	25.87	23.82
CALCIUM CARBONATE	9.09	9.11	9.17
WHEAT MIDDS	2.00	4.85	7.25
FAT, VEGETABLE	2.66	3.65	3.56
MONO-DICAL PHOS.	1.41	1.41	1.36
SALT, PLAIN (NaCl)	0.44	0.44	0.44
Choline Chloride 60%	0.36	0.36	0.36
DL-METHIONINE	0.34	0.34	0.35
MINERAL/VITAMIN PMX W/PHYTASE	0.10	0.10	0.10
L-LYSINE	0.04	0.11	0.15
L-Threonine	0.12	0.13	0.15
VALINE - CJ BIO	0.11	0.11	0.12
ISOLEUCINE - CJ BIO	0.10	0.11	0.12
TRYPTOPHAN - CJ BIO	0.09	0.11	0.11
ARGININE - CJ BIO	0.00	0.05	0.08

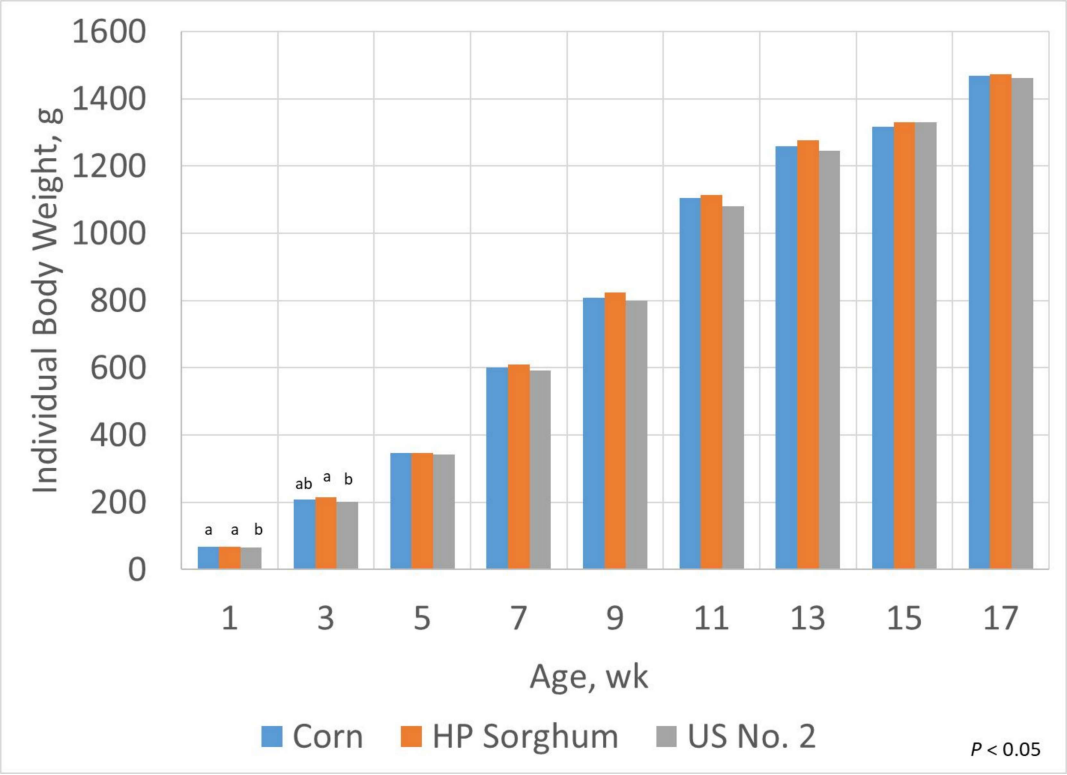
Diet Examples

Nutrient Content (calculated)

Nutrient Name, Units		GROWER DIETS		
		Corn	US#2	HPS
MOISTURE	PCT	12.44	11.78	11.82
PROTEIN, CRUDE	PCT	16.80	16.81	16.85
FAT, CRUDE	PCT	1.89	2.31	2.04
FIBER, CRUDE	PCT	2.91	2.83	2.87
CALCIUM	PCT	0.90	0.90	0.90
ASH	PCT	5.11	5.07	5.06
PHOS., AVAILABLE	PCT	0.34	0.34	0.34
M.E. POULTRY	KCAL/KG	2888	2888	2888
CHOLINE	MG/LB	816	816	816
SODIUM	PCT	0.18	0.18	0.18
CHLORIDE	PCT	0.28	0.28	0.28
DIG. METHIONINE	PCT	0.43	0.43	0.43
DIG. CYSTEINE	PCT	0.23	0.23	0.23
DIG. LYSINE	PCT	0.82	0.82	0.82
DIG. TRYPTOPHAN	PCT	0.19	0.19	0.19
DIG. THREONINE	PCT	0.55	0.55	0.55
DIG. ISOLEUCINE	PCT	0.66	0.65	0.66
DIG. VALINE	PCT	0.71	0.71	0.71
DIG. ARGININE	PCT	0.93	0.93	0.93
DIG. MET+CYS	PCT	0.66	0.66	0.66
PHYTASE	FTU/LB	272.16	272.16	272.16

Nutrient Name	Units	PEAK DIETS		
		Corn	US#2	HPS
MOISTURE	PCT	11.05	10.39	10.37
PROTEIN, CRUDE	PCT	17.82	17.82	17.82
FAT, CRUDE	PCT	3.96	4.92	5.07
FIBER, CRUDE	PCT	2.18	2.27	2.40
CALCIUM	PCT	3.87	3.87	3.87
ASH	PCT	12.43	12.44	12.46
PHOS., AVAILABLE	PCT	0.33	0.33	0.33
M.E. POULTRY	KCAL/KG	2843	2843	2843
CHOLINE	MG/LB	726	726	726
SODIUM	PCT	0.18	0.18	0.18
CHLORIDE	PCT	0.27	0.27	0.27
DIG. METHIONINE	PCT	0.57	0.57	0.57
DIG. CYSTEINE	PCT	0.23	0.23	0.23
DIG. LYSINE	PCT	0.90	0.90	0.90
DIG. TRYPTOPHAN	PCT	0.30	0.30	0.30
DIG. THREONINE	PCT	0.65	0.65	0.65
DIG. ISOLEUCINE	PCT	0.80	0.80	0.80
DIG. VALINE	PCT	0.85	0.85	0.85
DIG. ARGININE	PCT	1.00	1.00	1.00
DIG. MET+CYS	PCT	0.80	0.80	0.80
PHYTASE	FTU/LB	181.44	181.44	181.44

Effect of the inclusion of US sorghum on the body weight of brown pullets



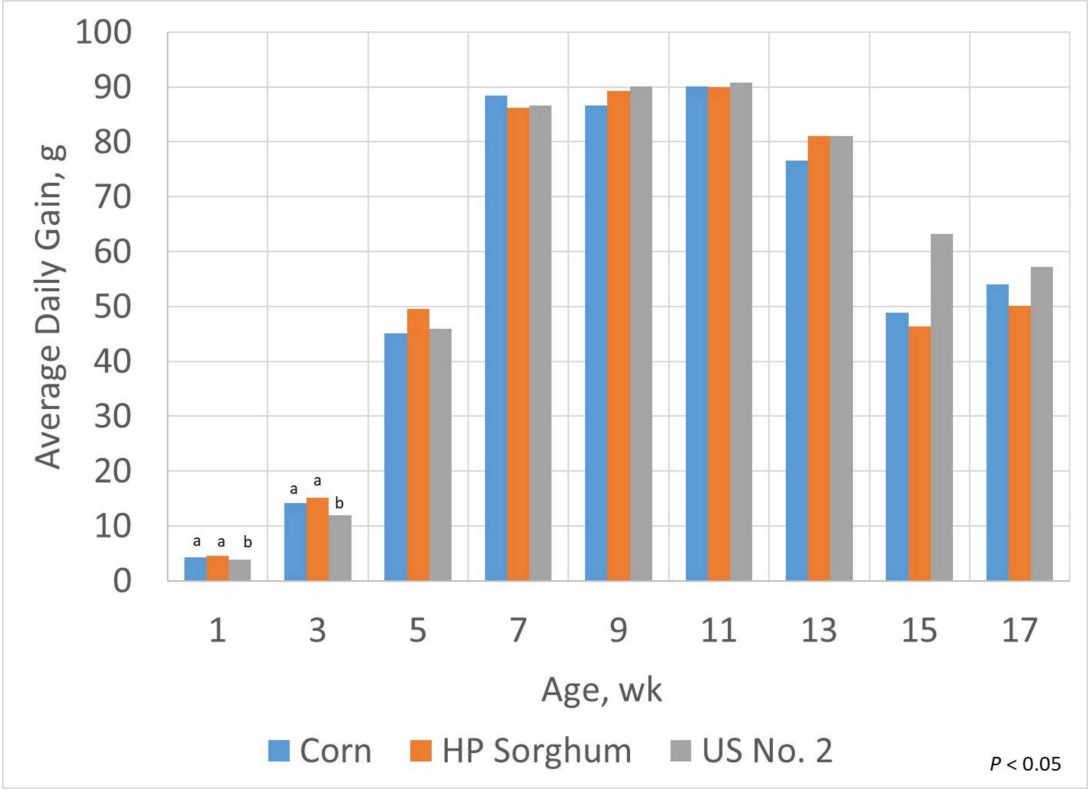
No significant differences in body weight were observed after 5 weeks of age.

The differences observed at weeks 1 and 3 were due to an error in the value of the metabolizable energy assigned to US#2 sorghum. As soon as the value was corrected (3,700 kcal ME/kg DM) no differences were observed between treatments.

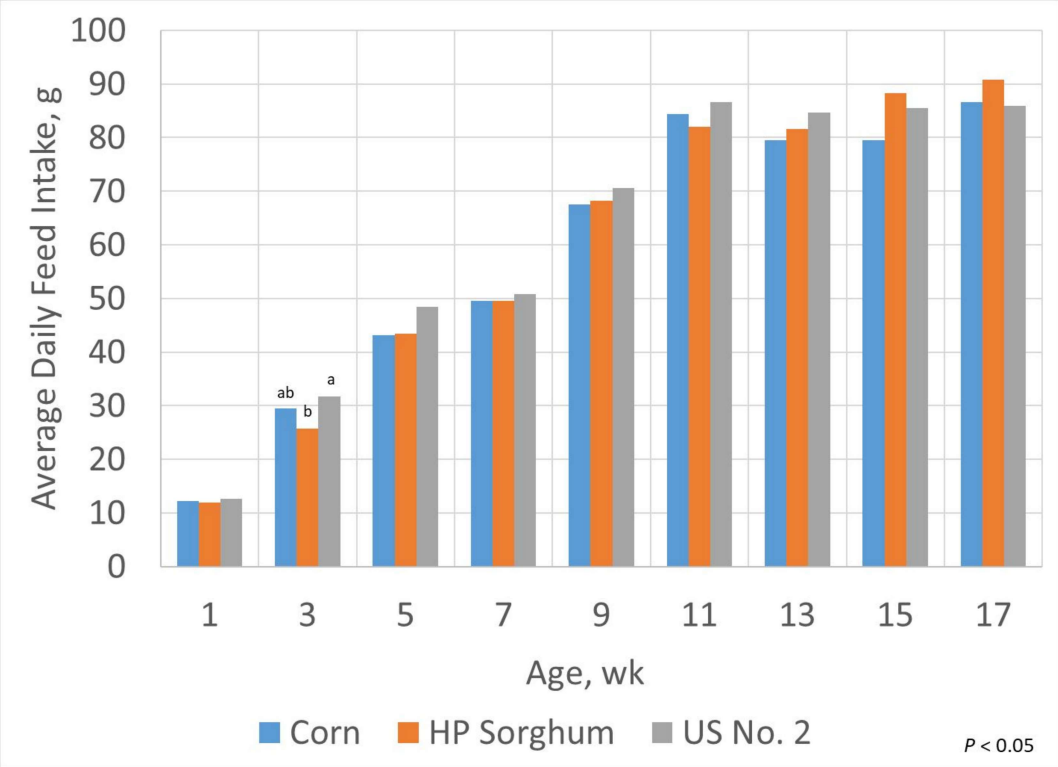
Effect of the inclusion of US sorghum on the daily weight gain of brown pullets

No significant differences were observed in daily weight gain from 5 weeks of age.

The differences observed at weeks 1 and 3 were due to an error in the value of the metabolizable energy assigned to US#2 sorghum. As soon as the value was corrected (3,700 kcal ME/kg DM) no differences were observed between treatments.



Effect of the inclusion of US sorghum on the daily feed intake of brown pullets



No significant differences were observed in daily intake from 5 weeks of age.

There were also no significant differences between treatments in flock uniformity (6, 8, 10, 12 and 14 weeks of age).

Study Continued: Effect of Dietary Inclusion of U.S. Sorghum Varieties on the Productive Performance of Brown Layers (Alvarenga et al.)

- **Objectives: To determine the influence of diet on productive performance, health and egg quality**
- **840 Hy-line Brown (10 cages/treatment; 28 birds/cage)**
- **Treatments**
  - **3 diets – Corn, Corn: Sorghum US #2 (US#2) or Corn: High Protein Sorghum (HPS)**
- **Feeding Program: Pre-peak, Peak**
- **Measures: feed intake, feed conversion, egg production, external and internal egg quality, protein content and antioxidant capacity in blood, and tibiotarsal health.**

- Birds fed diets based on the combination of corn and sorghum (1:1) from 17 to 40 weeks of age showed:
- Productive performance (egg production, feed conversion and feed intake) similar to birds fed corn- based diets
- Better internal egg quality (albumen weight, Haugh units)
- Higher protein and antioxidant content in the blood
- Improved tibiotarsal health

Comparative Study of the Efficacy of U.S. Sorghum in the Control of Necrotic Enteritis in Broilers (Moritz et al., 2023)

- **Objective: To study the efficacy of American sorghum in the control of necrotic enteritis in broilers**
- **512 Cobb 500 male chicks (8 cages/treatment; 8 birds/cage)**
- **Treatments (8 treatments; diet x challenge)**
  - **4 Diets - Corn, Red/Bronze Sorghum, White/Tan Sorghum, Sorghum US #2**
  - **2 Eimeria maxima/C. perfringens challenge levels – challenge or no challenge**
- **Feeding Program: Starter (mash), Grower (mash)**

			Age		
			21	21	14 to 28
Grain	Trt	Challenge	Lesion score	NE Mortality, %	Mortality, %
Corn	T1	--	0.00[d]	0.00	1.56
R/B Sorghum	T2	--	0.00[d]	0.00	3.13
W/T Sorghum	T3	--	0.00[d]	0.00	1.56
U.S. No. 2 Sorghum	T4	--	0.00[d]	0.00	1.56
Corn	T5	EM/CP	1.21[a]	6.25	9.38
R/B Sorghum	T6	EM/CP	0.71[c]	0.00	1.56
W/T Sorghum	T7	EM/CP	0.63[c]	7.81	10.93
U.S. No. 2 Sorghum	T8	EM/CP	0.96[b]	3.12	7.81
SEM[4]			0.064	2.16	2.591
Main Effect of Challenge					
No EM/CP			0.00	0.00	1.95
EM/CP			4.30	4.30	7.42
Source of Variation					
Trt			0.0001	0.2963	0.4846
Challenge			< 0.0001	0.0075	0.0049
Trt x challenge			0.0001	0.2963	0.1759

Differential gene expression analysis showed: upregulation in defense response to bacteria and biotic stress in the challenged red/bronze treatment compared to the challenged corn.

Studies conducted in Kenya (Unga Farm Care)

BROILERS

Objective: To evaluate the performance of broilers fed sorghum-based diets

- **4,992 Cobb 500 chicks (as-hatched)**
- **12 cages/treatment, 208 birds/cage**
- **Duration: 1 – 31 days**
- **Treatments**
  - Corn-Based Diet (White)
  - Sorghum-Based Diet (U.S. #2)
- **Results: There were no significant differences in body weight, weight gain, daily weight gain, feed intake, feed conversion or mortality at 31 days of age.**

PULLETS AND LAYERS

Objective: To evaluate the performance of pullets/layers fed sorghum+corn-based diets

- **3,016 Hy-line Brown; 4 pens/trt; 377 birds/pen**
- **Duration: 9 – 51 weeks of age**
- **Treatments**
  - Corn-Based Diet (White)
  - Corn-Based Diet (White):Sorghum (U.S. #2) (1:1)
- **Results: No significant differences were observed in body weight (at the end of the pullet phase and all laying phases), egg production and egg weight**

Key takeaways!

Sorghum is an excellent source of energy and a good source of amino acids for poultry

When formulating diets, we must use values from analyzed samples

We must formulate based on digestible amino acids

Avoid over-processing of sorghum grain to avoid anti-nutritive effects

Credit: Clemson University

Questions?

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