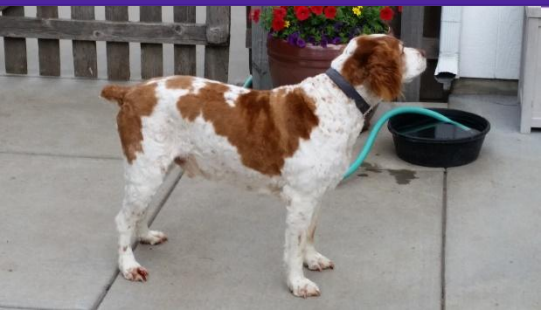

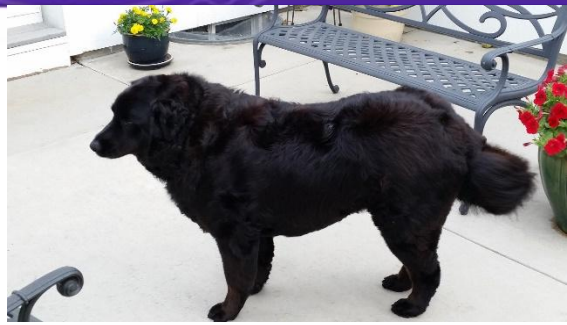

Is Sorghum a Superfood for Modern Pet Food?

School of Animal Wellness SuperZoo 2015

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Kansas State University

Overview

- Pet Food Program at K-State
- Pet Food motivation and trends – Superfoods?
- Sorghum taxonomy, history, prevalence, sustainability
- Utility in pet food and extra-nutrient potential
- Summary and takeaway
- Save the date

KANSAS STATE UNIVERSITY | Department of Grain Science and Industry

Paradigm Shift

Barnyard security

Furry "child"

Pet food motivation & trends

- What is a superfood?
  - No set definition by any notable society or agency
  - ˈso͞opərˌfo͞od/ *noun :* a nutrient-rich food considered to be especially beneficial for health and well-being. (Google; accessed 20Jul2015)
  - Slang or colloquialism to describe
    - Nutrient dense foods
    - Foods with high levels of functional fibers
    - Foods with exceptionally high levels of antioxidants
    - Foods that carry novel “nutraceuticals”
    - All of the above

Superfood Examples

- Vegetables
  - Dark green veggies:
    - Spinach, Kale, Swiss Chard, Brussel Sprouts, Broccoli, Collards
  - Fruits:
    - Pomegranate, Blueberries, Acai, Beets
  - Legumes:
    - Peanuts, Beans, Lentils
  - Whole Grains:
    - Quinoa, Amaranth, Chia
- Animal
  - Salmon, Mackerel, Sardines
- Other
  - Chocolate/Cocoa
  - Hemp
  - Grapeseed
  - Green Tea/EGCG
  - Seaweed, Kelp

Is Sorghum a Superfood?

Sorghum: Taxonomy, History, Prevalence, Sustainability

- Sorghum (*Sorghum bicolor*) or milo originates from northeast Africa and Asia
  - close cousin to millet and (sugar) cane.
- Perennial grass commonly grown as an annual grain crop
  - arid climates where moisture and rainfall patterns are less conducive to the production of warm season crops like rice, corn, or soybeans.
- Globally it is the 5th most important grain (FAO, 2005)
  - 60 million tons produced annually
  - U.S., India, and Nigeria top three producing countries.

Nutrient Composition

- Starch the largest portion (around 75%).
  - Amylopectin (70-80%).
- Protein content slightly higher than corn at or above 9%
  - Gluten free – alcohol soluble prolamin: Kafirins – slow to digest
  - Lysine and threonine first and second limiting amino acids.
- Fat content about 3% - which lowers metabolizable energy.
  - Linoleic acid (C18:2n6) greater than half the total fatty acids
  - Omega-3 linolenic acid (C18:3n3) less than 3% of total FA.
- Crude fiber 2-3% - primarily insoluble.
- Minerals (ash 1-2%) and vitamin similar to other cereals

Nutrient Composition

Table 2. Chemical composition of grain flours incorporated into experimental diets fed to ileally cannulated dogs

	Flour					
Item	Barley	Corn	Potato	Rice	Sorghum	Wheat
Dry matter, %	91.9	90.1	93.5	90.8	90.9	90.5
	% DM					
Organic matter	97.2	99.4	95.5	99.4	99.5	99.3
Crude protein	11.9	5.6	9.8	8.2	9.2	13.1
Fat	4.4	3.2	1.6	2.8	2.6	2.6
Starch	61.0	88.3	77.9	87.4	84.8	78.1
TDF[a]	18.9	3.0	6.4	1.0	2.7	3.4

[a]Total dietary fiber.

Murray et al., 1999

Composition of Starch and Fiber in Various Substrates

Substrate	%RDS	%SDS	%RS	TS	TDF	I	S
Peas	22.3	17.8	24.5	64.7	33.1	31.3	1.8
Corn	37.1	15.6	25.2	77.9	19.6	16	3.6
Sorghum	29.2	13.9	36.1	79.2	4.6	4.2	0.4
Corn Flour	73.2	0	11	84.3	2.9	2.9	0
Sorghum Flour	63.5	24.6	1.6	89.7	1.3	1.1	0.2

(Bednar, 2001)

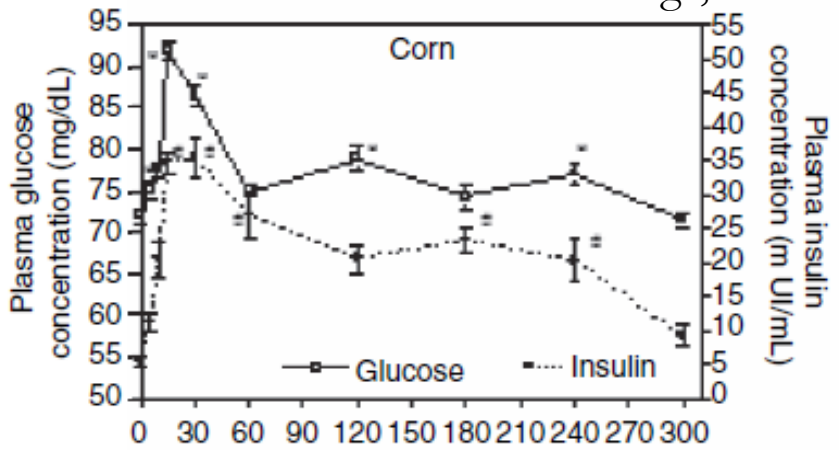
Digestion (ileum, %) in dogs fed diets differing in carbohydrate type

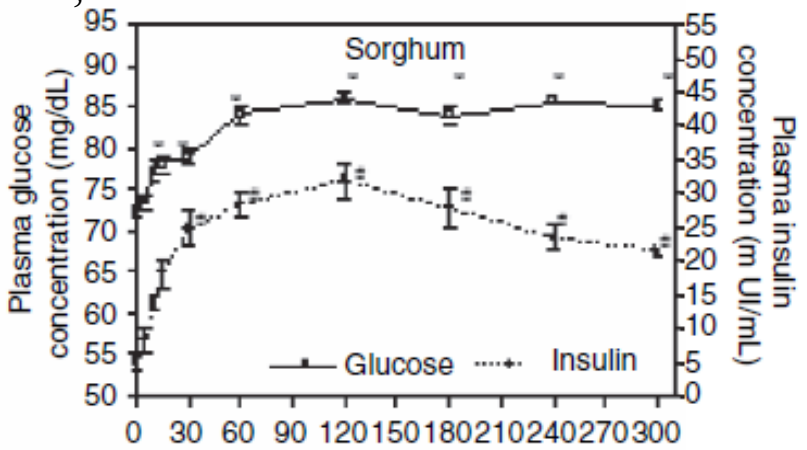
Item	Corn	Rice	Potato	Barley	Wheat	Sorghum
Dry Matter	73.5	77.5	66.7	74.9	81.2	74.1
Organic Matter	79.8^{ab}	83.1^{b}	73.6^{a}	80.9^{b}	85.7^{b}	79.5^{ab}
Crude Protein	72.5^{ab}	76.2^{b}	63.6^{a}	81.1^{b}	81.5b	76.9^{b}
Fat	91.3	92.9	89.8	89.9	94.2	90.9
Starch	99.5^{ab}	99.8^{c}	99.5^{ab}	99.3^{a}	99.78^{c}	99.6^{bc}
TDF	-4.6	20.1	-9.7	12.2	5.1	15.1

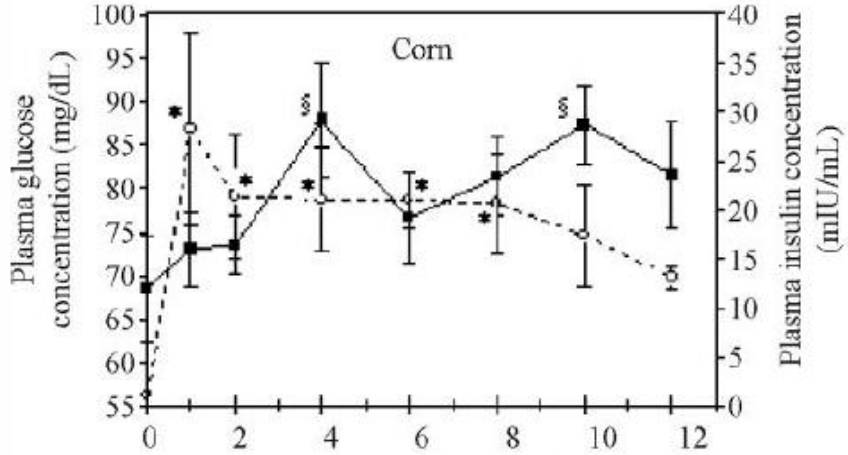
^{abcd} Means in the same row not sharing common superscript letters differ ($P < 0.05$)

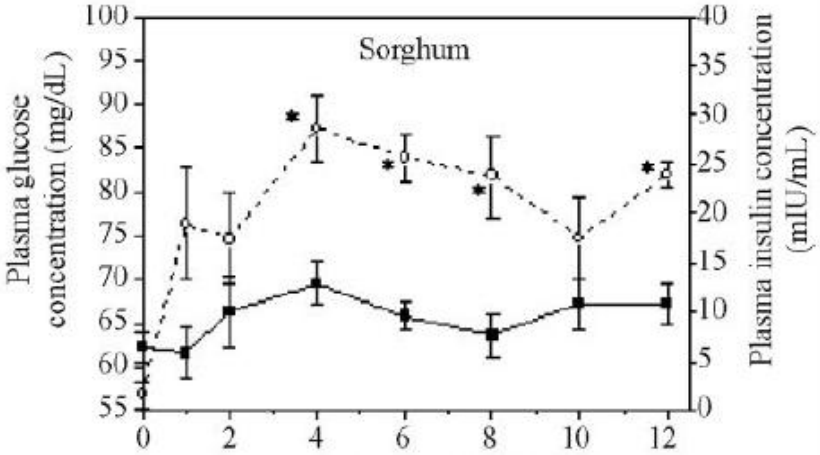
Postprandial Glucose & Insulin

Dogs; Carciofi et al., 2008









Cats; de-Oliveira et al., 2008

Utility in Pet Food and Extra-nutrient Potential

- The extent of starch digestibility similar to that of other grains like corn or rice (Carciofi et al., 2004; Twomey et al., 2002; Murray et al., 1999).
- Rate of starch digestion might be slower due to the composition of the sorghum starch (*in vitro;* Murray et al., 2001).
- Postprandial glucose lower, time to peak longer, and insulin response curve dampened (Intravenous glucose tolerance tests)
  - Dogs (Carciofi et al., 2004; Sunvold and Bouchard, 1998)
  - Cats (Bouchard and Sunvold, 2000)

Seed Coat: Challenge or Opportunity?

- Sorghum is classified into several groups based primarily on the seed coat (pericarp) color.
- Simple interpretation:
  - "tannin" (brown)
  - White
  - Incremental combinations
- The "tannins" not actually tannic acid
- Proanthocyanidins or "condensed tannins"

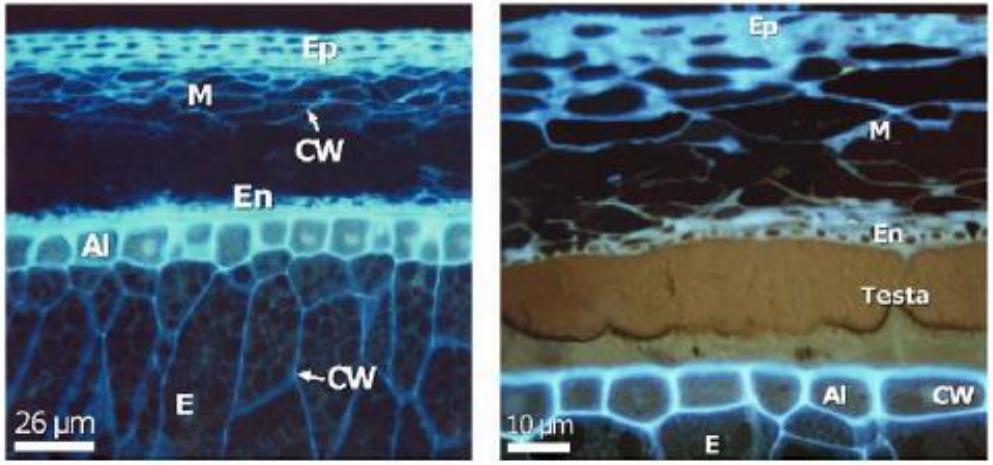


Fig. 1. Fluorescence photomicrograph of cross-sections of a non-tannin (left) and a tannin sorghum kernel (right). Al, aleurone; CW, cell wall; E, endosperm; En, endocarp; Ep, epicarp; M, mesocarp; T, pigmented testa (Adapted from Awika and Rooney (2004)).

Photos courtesy of Texas A&M University

Condensed Tannins

- All sorghums contain these condensed tannins – some more than others.
  - Condensed tannins are a variety of different poly-phenolic compounds produced as secondary metabolites by the plant.
  - They support the plant's natural defense system against insect predation and mold infestation.
  - Some sorghum varieties have been selected to better exploit these benefits (i.e. brown "bird resistant milo").
  - Condensed tannin sub-fractions precipitate proteins, inhibit digestive enzymes (amylase inhibitor, trypsin inhibitor), and bind (chelate) trace minerals.
  - Some consider condensed tannins as anti-nutritional factors to avoid, especially the "tannin" (brown) sorghums.

Hahn et al., 1983

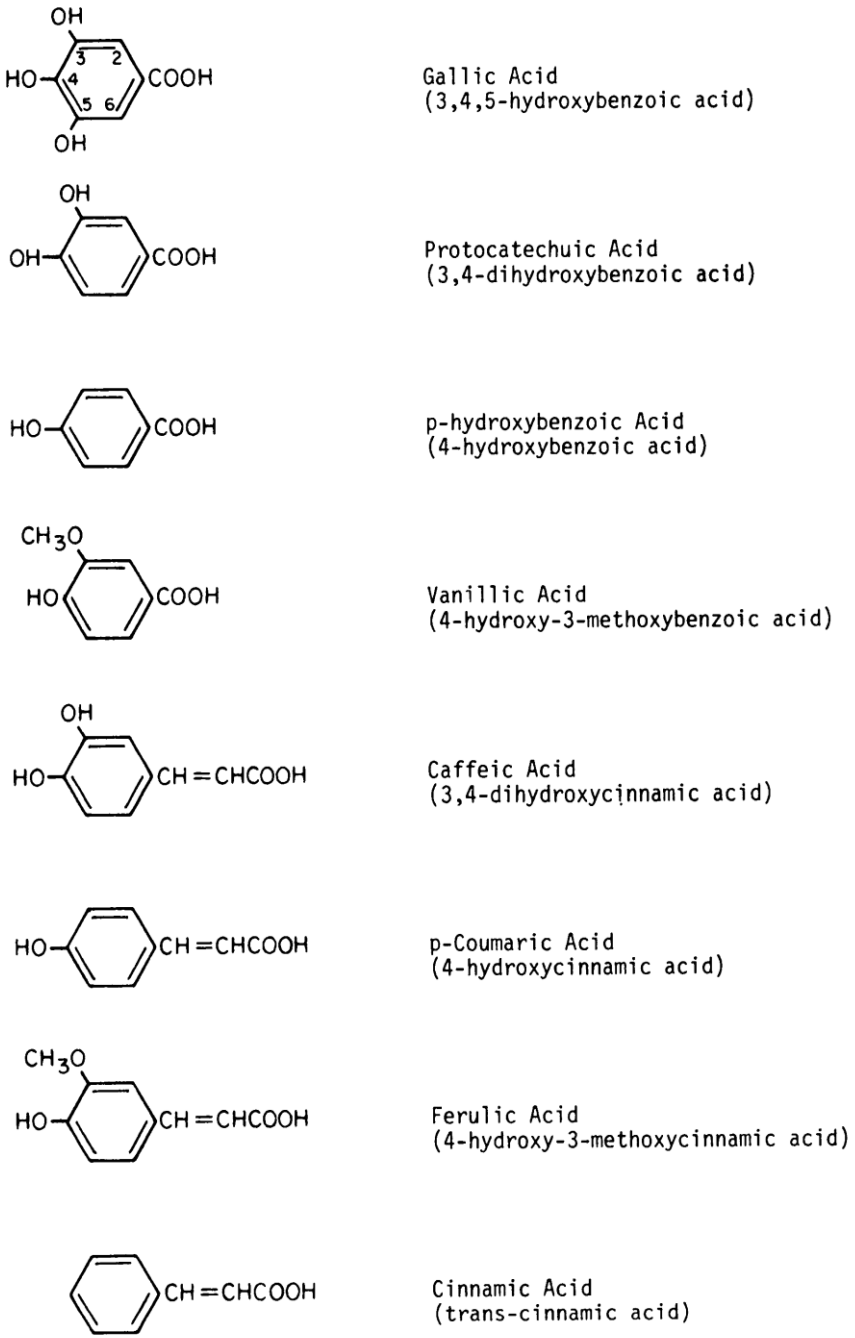


Fig. 2. The structural relationship of the benzoic and cinnamic acid standards to their elution order.

Proanthocyanidins & Health?

- Sorghum proanthocyanidins may impart health benefits.
- The hydroxycinnamic acid and flavonoid fractions of these condensed tannins have anti-tumor (esophageal, colon), anti-viral (HIV), melanogenic, and satiety effects.
- The flavonoid pigments (blues, purples, and reds) are process stable natural food colorings.
- Sorghum has a greater antioxidant capacity than found in some fruits and vegetables commonly thought to be antioxidant rich (e.g. plums, broccoli, carrots, etc.; Dykes and Rooney, 2005).
- Condensed tannins are not a single compound
  - Opportunity to identify and select sorghums for beneficial properties at the expense of the anti-nutritional properties.

Antioxidant activity (ORAC) of sorghum grain and bran compared to common fruits and vegetables

Commodity	ORAC (μmol TE/g, dry wt)	References
Tannin sorghum (grain)[a]	868	Awika et al. (2003b)
Tannin sorghum (bran)[a]	3124	Awika et al. (2003b)
Black sorghum (grain)	219	Awika et al. (2003b)
Black sorghum (bran)	1008	Awika et al. (2003b)
Red sorghum (grain)	140	Awika et al. (2003b)
Red sorghum (bran)	710	Awika et al. (2003b)
White sorghum (grain)	22	Awika et al. (2003b)
White sorghum (bran)	64	Awika et al. (2003b)
Blueberry, lowbush	842	Wu et al. (2004)
Strawberry	402	Wu et al. (2004)
Plum	495	Wu et al. (2004)
Watermelon	18	Wu et al. (2004)
Apple, red delicious	295	Wu et al. (2004)
Orange, navel	137	Wu et al. (2004)
Broccoli	173	Wu et al. (2004)
Carrot	108	Wu et al. (2004)
Onion, red	93	Wu et al. (2004)
Sweet pepper, green	105	Wu et al. (2004)
Radishes	217	Wu et al. (2004)
Potatoes, russet	63	Wu et al. (2004)

Dykes & Rooney 2006

Processing

- Sorghum processes much like corn or rice and expands well in extruded diets.
- For specialty markets, sorghum is gluten free and is currently non-GMO.

Hal Ross Flour Mill

Composition of Sorghum Fractions

Item	Moisture	Crude Protein	Crude Fat	Crude Fiber	Ash
Whole Sorghum	14.01	10.90	1.69	2.78	1.44
Sorghum Flour	12.82	9.23	0.03	0.88	0.94
Sorghum Bran	10.57	14.87	5.19	5.11	2.73
Sorghum Germ	10.68	16.26	6.18	2.36	2.79

Alvarenga & Aldrich, 2015

Takeaway

- Sorghum is a Superfood!
  - Rich in antioxidants
  - Low glycemic
  - Gluten Free
  - Non-GMO
  - Measurable dietary fiber
  - Carries a meaningful amount of minerals
  - Quality proteins when complemented with sources rich in lysine
  - Processes well into pet food applications
  - Sustainable and environmentally friendly

Save-the-date

- August 10
  - Pet Food Nutrition & Formulation Workshop
    - http://www.grains.k-state.edu/igp/
- August 11-14
  - IGP Extrusion Short course
    - http://www.grains.k-state.edu/igp/
- October 28-30
  - K-State Pet Food Experience & Petfood Innovation Workshop
    - http://www.petfoodindustry.com